Infant-toddler (10 months to 36 months) development of scientific concepts through everyday activities as part of family practices

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Part A: General Declaration

General declaration

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This thesis includes four original papers. Two papers that are submitted awaiting the outcome of the review process in peer reviewed journals, one unpublished Manuscript that is currently accepted for publication in a peer reviewed journal, one unpublished manuscript that is currently accepted for publication in a Springer book series.

The core theme of the thesis is infant-toddler's development of scientific concepts through everyday activities as part of family practice. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the candidate, working within the Monash University Faculty of Education under the supervision of Professor Marilyn Fleer.

In the case of Publications 1, 2, 3 and 4 (in Chapters 4, 5, 6, and 7), co-authored publications, my contribution to the work involved the following:

Thesis chapter	Publication title	Publication status	Nature and extent of candidate's contribution

Chapter 4 (Publication one)	*Small Science*: Infants and Toddlers Experiencing Science in Everyday Family Life	Under review	Conception, key ideas, research investigation, development, write-up (80%)
Chapter 5 (Publication two)	The relations between ideal and real forms of small science: conscious collaboration among parents and infants-toddlers	Accepted	Conception, key ideas, research investigation, development, write-up (90%)
Chapter 6 (Publication three)	Relationship of dynamic aspects of motives in infant-toddler's play: Enhancing the development of small science concept formation	Accepted	Sole author
Chapter 7 (Publication four)	Social situation of development: Parents perspectives on infants-toddlers' concept formation in science	Under review	Sole author

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

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Part B: Suggested Declaration for Thesis Chapter

In the case of Chapter [4, 5, and 6], the nature and extent of my contribution to the work is as follows:

Nature of contribution	**Extent of contribution (%)**
1. Chapter 4 (Publication One)- I have contributed 80% for writing this paper 2. Chapter 5 (Publication Two)- I have contributed 90% for writing this paper	1. Shukla Sikder 80% 2. Shukla Sikder 90%

The following co-authors contributed to the work. If co-authors are students at Monash University, the extent of their contribution in percentage terms must be stated:

Name	**Nature of contribution**	**Extent of contribution (%) for student co-authors only**
[Marilyn Fleer**]**	Chapter 4 (Publication One)- Marilyn Fleer contributed 20% of the writing and overall guidelines to develop the paper	1. Marilyn Fleer 20%
[Marilyn Fleer**]**	Chapter 5 (Publication Two)- Marilyn Fleer contributed 10% of the writing and overall guidelines to develop the paper	2. Marilyn Fleer 10%

The undersigned hereby certifies that the above declaration correctly reflects the nature and extent of the candidate and co-authors' contributions to this work*.

Candidate's Signature	[redacted]	**Date** **10/09/2015**
Main Supervisor's Signature	[redacted]	**Date** **10/09/2015**

Ethics

The research for this thesis received the approval of the Monash University Human Research Ethics Committee (Approval number: CF12/1569 -2012000846)

Dedication

To my loving family

Acknowledgements

"এই লভিনু সঙ্গ তব, সুন্দর হে সুন্দর।

পুণ্য হল অঙ্গ মম, ধন্য হল অন্তর,

সুন্দর হে সুন্দর" ।।

(Rabindranath Tagore, Gitabitan)

"Here you have come to me, my beauty!
My limbs filled with blessedness,
My heart humble with grace
I am transformed, o sublime"!

(Translated by A. Majumdar & R. Sengupta, 2009)

It is an exciting moment to talk about the people who have provided a great contribution to my PhD life. My supervisor Professor Marilyn Fleer is my Idol. My words are not enough to explain her contribution to my PhD journey. She creates academic conditions for training PhD students so her students can achieve all kinds of academic qualities after completing candidature. These opportunities include research training, co-writing in top ranked journals, providing teaching opportunities, arranging lots of seminars and workshops for improving students' intellectual knowledge and promoting leadership qualities by involving students in a range of university activities. I was transformed into an Academic day by day with this vast experience initiated by Marilyn.

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your PhD studies". The words seem very simple but they are very meaningful to me. I had a stress free happy PhD life because of Marilyn. I salute you Marilyn, my Ideal Form.

A loving memory of Marilyn and Aarjaw

My son Aarjaw Ion Josh was about six months old at the beginning of my Doctoral journey. I have enjoyed every moment of raising Aarjaw. Each day, I would spend eight hours for study and the rest of the time I spent quality time with Aarjaw. We have done everything together such as playing, shopping, cooking and all the other household work. His smile, his babbling, his small sentences, his loving eyes, his caring attitude make my heart full of joy and I get inspiration to continue my study from him. Love you Aarjaw. Aarjaw is also very happy because of his carer Mrs. Dilara Syeda. Thank you aunty for your safe and careful support of Aarjaw, which helped me to study with a peaceful mind.

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List of Publications

Journal Publications

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International and national Conference papers

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Sikder, S. (2014, September). *Conscious collaboration among parents and infants-toddlers for developing small science concepts in everyday life.* Paper presented at Symposium Presentation, International Society for Culture and Activity Research Congress (ISCAR), Sydney, Australia.

Sikder, S. (2014, September). *Progression of science concepts over time in toddler's play.* Paper presented at International Society for Culture and Activity Research Congress (ISCAR), Sydney, Australia.

Sikder, S., & Fleer, M. (2014, July). *Infants and toddlers experiencing science in everyday family life.* Paper presented at Australasian Science Education Research Association (ASERA) Conference 2014, Melbourne, Australia.

Sikder, S. (2014, July). *Small science in Infants-toddlers everyday family life.* Paper presented at Monash Education Research Conference (MERC), Monash University, Australia. Received MERC Award for this paper presentation.

Sikder, S. (2013, August). What are the scientific concepts in everyday life of Toddlers? Toddler's everyday play and learning of scientific concepts are dialectically related. Paper presented at European Early Childhood Education Research Association Conference, Tallinn, Estonia.

Sikder, S. (2012, November). *"How is knowledge created through practice?" Toddlers' development of scientific concepts through play activities as part of everyday family practices*. Poster session presented at The World Association of lesson studies, International Conference, Singapore.

Sikder, S. (2012, July). *Bridging scientific concepts and play activities in everyday family practices: A case study of toddlers through the cultural-historical perspective*. Paper presented at Monash Education Research (MERC) Conference, Australia.

Papers in progress

Sikder, S. & Banu, A. (2015). Early childhood education in Bangladesh. In M. Fleer & B. Van Oers (eds.), *International Handbook of Early childhood Education and Development.* Springer: Dordrecht Heidelberg New York London.

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Abstract

Over the past three decades more attention has been directed to research in early year's science education. This is because science activities can provide rich possibilities for supporting children's learning and development. In addition, research has shown how science related activities at a young age support children to develop positive attitudes towards science. However, most of the studies that have been undertaken focus on children's science learning in formal settings, such as preschool or childcare settings. There is limited research on how families can support very young children's science learning at home where parents are the child's first teacher. Compared with research generally in science education, empirical research of children aged from birth to three has received limited attention worldwide, particularly for the infant-toddler age group. Thus, this thesis investigates the conditions that are created in everyday family life for the development of infants-toddlers' science concept formation. The aim of the study reported in this thesis is to fill this gap, by determining how play and regular activities lead to the development of infants'-toddlers' scientific concept formation within everyday family practices. Specifically, the study investigated the involvement of parents, other adults and peers, in everyday contexts for supporting the development of infant-toddler's scientific concepts.

Over the past two decades, the trend in researching science learning in the early years has developed interest to a socio-cognitive approach, with an emerging number of studies that draw upon cultural-historical theory. A cultural-historical reading of science education positions science as a form of cultural knowledge that is historically and collectively formed and understood, rather than as something that is located within the individual. Following a cultural historical point of view, children develop concepts as part of their everyday context. Concepts develop gradually and the process of

conceptual development starts in early childhood. For young children Vygotsky's theory of concept formation foregrounds the value of context in combination with the dynamic and evolving nature of concept formation. Children learn scientific concepts, through adult mediated processes for developing understanding, learning and comprehension. Adults assist children to develop scientific concepts in everyday life. Everyday concepts and scientific concepts are dialectically related. That is, the everyday concept is learned in the everyday context where a personal motive for engaging with scientific concepts can emerge and scientific concepts learned during interactions with adults as abstract concepts, help explain everyday practices for the child. Considering infants-toddlers science learning through social interactions in everyday context, Vygotsky's cultural-historical research has been drawn upon as the theoretical framework for this research.

A cultural historical methodology encompasses a unique system of interconnected instruments for realising the analysis of the process of development in its wholeness and complexity. Studying children's development in science examines the individual trajectories within sociocultural contexts. From the point of the whole exposition of the child, cultural-historical theory refers to the complex process of development of higher mental functions where development is always a complex and contradictory process but first of all, it is a dialectical process of qualitative change. In order to understand children's science learning, the study design must be framed to include the science learning context of the family home. In the study reported in this thesis, three children from three Bangladeshi families in Australia and Singapore were followed in everyday family life. All three children (age 10 to 36 months) were born abroad and in each of the family homes they practice their Bangladeshi culture. Digital video observations were the tools used for data collection. Approximately 30 hours of video data and approximately 3 hours of interviews data were gathered from infant's-toddler’s everyday life over one year. This study focused only on three Bangladeshi families’ everyday context in Australia and in Singapore and it does not seek to represent the Bangladeshi context. Dialectical-interactive approach from cultural-historical research methodology has been applied for analysing the data.

It is argued that science learning is possible from infants-toddlers age where parents or other adults or more competent peers act as mediators to support young children to develop *small science* concepts in play and other everyday activities. *Small science* is a new way of understanding science at the infant-toddler age. *Small science* has been defined as simple scientific narration of the everyday moments that infants and toddlers experience at home with their families. *Small science* moments are created through parent-child conscious collaboration and social interactions are the main criteria to learn *small science* concepts in the infants-toddlers life. In order to achieve a successful outcome from these play moments, one might consider the dynamic aspects of a play motive, and the successful play motives that create the rich possibilities for infant-toddler’s development of *small science* concept formation in their everyday culture. Parents think that possibilities of science concept formation during the infants-toddlers age do not entail extra effort for parents; rather, the science concepts could be advanced as part of the social situation of development in the infant-toddler’s everyday context. This study contributes to the theoretical knowledge, methodological understanding and the development of pedagogical approaches for science learning, as well as practices in early childhood science education.

Part I: Framing the Research

Chapter 1: Introduction

“Before studying development, we must explain what is developing”.

(Vygotsky, 1997b, p. 44)

Introduction

This study seeks to find out about the everyday activities that occur in the home as part of family practices and to determine how children aged 10 to 36 months develop their scientific concept formation through regular activities. I have chosen children aged from 10 to 36 months because the research tradition which documents the voices of very young children is limited (Johanson, 2011). Being an early childhood researcher it is a great opportunity to work with infants and toddlers because little is known about the knowledge base of this particular age group within the field of early childhood science education (Johanson, 2011).

Children aged to three years are mostly dependent on adults, especially parents or other adults in the family. My interest centres mostly on family practices during this age because children generally engage in regular activities where they develop concepts about everyday life. Additionally, it can be argued that it is important for young children to know scientific concepts for coping with a modern life style and if children grow with scientific concepts from an early age, they will more easily manage this contemporary lifestyle.

“Until now we know very little about young children’s scientific experience and understandings of their everyday life and the impact that centre or family practices might have on children’s development and well being” (Johanson, 2011, p. 2). Therefore, I feel children’s regular activities and play in everyday family life either at home or outside the home contributes towards the development of their everyday concepts and as Vygotsky (1987) notes, scientific concepts are also developed from everyday concepts. From this understanding, I conceptualised my research to investigate how children develop their scientific concepts through everyday life. I have examined this topic with a small sample of Bangladeshi-Australian and Bangladeshi-Singaporean families because I am from Bangladesh and my cultural understandings will facilitate a deeper understanding of the research context. In addition, I seek to draw upon both cultural-historical theory and my cultural background to determine what kinds of daily practices lead to young children's scientific development.

In this chapter I sketch out my motivation for undertaking educational research in general and this study in particular, followed by the research questions that emerged from the literature review. I have explained the definition of terms in relation to the research detailed further in this chapter. I have provided a brief background of cultural-historical theory that I believe will lead my exploration into the formation of scientific concepts of infants-toddlers life through everyday practices in the family. The final part of this chapter, discusses the thesis structure.

Situating myself in the research circumstance

I would like to share my personal story to locate myself in the research context. I started my PhD journey in Australia, I came here with my first child who was a six month old baby boy. I was more excited about my son rather than studying. During the first few months (about six/seven months) I followed him with lots of curiosity as a new mother and tried to understand each and every single step of his cultural development. In the meantime, I was reading Vygotsky's cultural-historical theory and thinking about research questions. My readings on the cultural-historical theory of Vygotsky were both an amazing and painful journey to discover and understand cultural-historical theory. Knowing and learning cultural-historical theory is a wonderful experience although the language in the books of Vygotsky, is challenging. As I read Vygotsky I could relate the content to my baby's activities, which gave me extreme joy. My baby followed me because he liked to imitate all of my activities and I also followed him because it helped me with my understanding of the readings (in addition to supporting his development). Both of us enjoyed these activities and I now feel even more interested in my baby's activities because of my theoretical understanding.

In addition, I have a science background and I was never satisfied with the explanations of the science teachers in my life who demotivated my attitude towards science. However, I always felt that a positive attitude towards science is an important endeavour in the modern world. Then I wondered how a child could develop a positive attitude towards science from early childhood as the family is where a child's learning begins, it is the first institution (Hedegaard & Fleer, 2008). For example, I recognised that I used simple verbal narration scientific explanation in each context when interacting with my son. My son is curious about my scientific explanations and I have noted that he applies his learning to other contexts. These moments helped me start my research journey because in the back of my mind was my own child and our positive science experiences together. I wondered if parents used simple scientific narration of each context to their children at home, and if their children developed a scientific attitude to enrich their future life.

As a result of my personal experiences, I decided to study the development of three infants-toddlers and now I feel my research journey is not only joyful but also brings great excitement and happiness to me. In my research I worked not only as a researcher but also as an active participant observer which provided me with in- depth knowledge on my topic.

Statement of the research problem(s)

Research questions.

The aim of the study was to determine what kind of family practices were associated with the development of scientific concepts during children's everyday activities and play. The study investigated play, regular activities of families at home and outside of the home where parents, other adults, siblings and peer groups were involved.

The research problem has been derived from the gap in the literature located around early childhood science education. The study draws on cultural-historical theory to shape the study design that was developed to answer the research questions.

The main research question of the study:

What conditions are created in the everyday family life for the development of infants-toddlers' (10 to 36 months) science concept formation?

The central focus of this research question is about examining the conditions that are created for supporting the development of science in the infant-toddler period. According to the dialectical-interactive approach, "the aim is to research the social and material conditions as well as how children participate in these activities" (Hedegaard & Fleer, 2008, p. 35). The subsidiary research questions have been narrowed down to find out the specific conditions of the research outcome through four papers as part of my thesis including publications.

Subsidiary research questions of the study:

Paper one:

In Paper one (Chapter 4), the research questions are:

1. What are the everyday concepts that families developed during everyday interactions and activities with infants and toddlers that are foundational for later science learning?

2. What are the possibilities for scientific development in everyday family practices at home for infants and toddlers?

Paper two:

The second paper (Chapter 5) responds to the following research questions:

1. How do parents in everyday family life support infants-toddlers to develop their small science concepts?

2. What kind of social interactions support the development of small science concept in infants-toddlers life?

3. What are the social relations between real forms and ideal forms of science for the development of small science concepts of infants-toddlers?

Paper three (Book chapter):

Paper three (Chapter 6) investigates the dynamic relationship between a child's science motives and the learning of science concepts during infant-toddler's play where the research question is:

1. How do the dynamic aspects of motives create the conditions and potential for developing *small science* concepts in play contexts at the infant-toddler age?

Paper four:

Paper four (Chapter 7) focused on parents' perception of infant-toddler science concept formation. The study reported in that paper sought to examine:

1. What are the parents' perceptions of the development of scientific concepts in everyday family life for infants and toddlers?

Definition of terms.

Infant-toddler:

Infant-toddler is defined in this paper to mean the age group of children from 10 to 36 months.

Every day activities and play of Bangladeshi-Australian and Bangladeshi-Singaporean families:

Children usually take part in regular activities and play within the home as part of taken-for-granted established family practices. In this study, I have collected data from infants-toddlers everyday activities such as meal time, sleep time, shower time, wake up time, transitions time, story time and play activities such as individual play (e.g. puzzle play) and collective play (e.g. play with parents, peer play). Play is one of the leading activities in early childhood (Vygotsky, 1966). I have found varieties of play in infants-toddlers routines which are: play with play dough; puzzle play; water play; play in playground; football; kite play; cooking play; pretend play. Kravtsov & Kravtsova (2010) divided children's play in different ways, such as Director play, Image play, Plot role-play, Games with rules, Literature play and Theatre performance play. Yet what these everyday play practices afford for scientific learning is not well understood. I seek to examine within children's everyday activities along with play, the link between regular activities and play and scientific concepts that occur during everyday family practices. My focus is the regular activities and play of children growing up in Bangladeshi-Australian and Bangladeshi-Singaporean families. As play is one of the regular and enjoyable activities children experience at young age, play is outlined as a leading activity (Vygotsky, 1966) in this thesis.

Everyday Concepts and Scientific concepts:

According to Vygotsky (1987) everyday concepts and scientific concepts have been defined in the following way:

Everyday concepts are developed through practical activity and focus on a more conscious awareness of the object rather than the concept. Scientific concepts develop more conscious awareness of the concept than of the object. The concept develops through the systematic cooperation between the teacher and the child in educational settings, informally, it occurs through the adult's assistance and participation. "Everyday concepts help to progress development of scientific concepts and the scientific concept blazes the trail for the everyday concepts" (Vygotsky, 1987, p. 169). Scientific concepts could be any kind of academic concept, originating from the disciplines of mathematics, language, science and so on. This study mainly focuses on science concepts.

For example, a young child is trying to learn how to swim in the swimming pool with his/her parents. In this everyday activity, the child is learning the rules of swimming as part of everyday concepts and scientific concepts in this context are floating, sinking, pushing, pulling and spinning. The child is experiencing some small science moments (e.g. push, pull, spin) which I have termed as *small science* concepts. These small science concepts are the basic foundation for future academic concepts (e.g. force, density). I have defined small science as capturing the simple scientific narration that we see accompanying the everyday scientific moments that infants and toddlers experience at home with their families through regular activities.

Background of cultural-historical theory and relevance to my study

Lev Semenovich Vygotsky (1896-1934) is known as the greatest and most gifted Soviet Psychologist who wrote overall 200 scientific works (Levitin, 1982) and through these works he initiated and led cultural-historical theory from early in the twentieth century (Rogoff, 2003).

Cole and Gajdamaschko (2007) identify three distinctive forms of culture in Vygotsky's works. First, culture defined as artistic products and the process of creation which appears in *The psychology of Art,* second, *The development of higher psychological functions focus* on the term as "cultural-historical" and "cultural-development" and third as "cultural people" in relation to the term "primitive" people during the period of Vygotsky's writing dominant in Western European tradition. These conceptions of culture prejudiced theoretical and empirical research studied by Vygotsky and his colleagues Luria, Davydov, Leontev (Cole & Gajdamaschko, 2007). Cultural–historical theory has been influential, not only among developmental psychologists but also it has become increasingly important to other disciplines, such as anthropology and sociology and in the application of psychology, in such areas as education, human-computer interface design and the organization of work (Vygotsky, 2004a). But what does Cultural-historical theory mean?

"Cultural–historical theory foregrounds those contexts which shape social relations, community values and past practices which have laid the foundations of what participants pay attention to in their communities" (Fleer, 2008a, p. 4). Rogoff (2003) states similarly, the cultural-historical approach assumes that individual development must be understood in and cannot be separated from, its social and cultural-historical context. Moreover, in the emerging sociocultural perspective, culture is not an entity that influences individuals, instead people contribute to the creation of cultural processes and cultural processes contribute to the creation of people (Rogoff, 2003).

"During the period between the late 1920s and early 1930s, Vygotsky worked within the course set by the general assumptions of Vygotsky's cultural-historical theory, and together with his colleagues, undertook broad and novel experimental investigation of child psychology and educational psychology which was later published as numerous scientific studies" (Vygotsky, 1997a, p. xxix). In the child's cultural development, every function appears on the scene twice, in two different contexts, first as social and then as psychological (Vygotsky, 1997a). Veresov (2014b, p. 219) extends this, stating that, "cultural-historical theory provides a powerful conceptual framework to investigate socially and culturally constructed pathways, milestones and transitions". According to Vygotsky, children build up higher order mental functions such as the ability to compare, to order, to analyse, to remember and to generalise (Smidt, 2009) which are psychological. My study mainly focuses on social and cultural development in relation to science concepts through everyday activities.

In addition, Vygotsky (1987) writes about scientific concept development in school age children and proves that scientific concepts can be developed in everyday contexts. Then what does this mean for the scientific learning of infants and toddlers? This study will find out about science for infants-toddlers in the context of family homes.

"Though Vygotsky did not write much about child's play, Vygotsky's approach to the activity of play allows not only to understand the basic characteristics of the cultural-historical approach but also, with the example of play, to single out specific traits and features of non classical psychology" (Kravtsov & Kravtsova, 2010, p. 25). This study focuses not only on infants-toddlers everyday activities but also their play in the family home. Thus, in this research, everyday activities and play in family practices are analysed from the cultural-historical perspective for a child's scientific concept development. Cultural historical theory allows for the understanding of the process of child development not the product (Veresov, 2014a, 2014b) and my study looked at the process of scientific development of infants-toddlers because it is challenging for children within this age period to develop abstract science concepts.

In developing my theoretical understanding in relation to cultural-historical research, I have reviewed the longstanding research, this focuses the rationale of my research. "The reading of historic works is inevitably done on the basis of present-day and personal knowledge and possibly with an eye to the future" (Van Oers, Wardekker, Elbers, & Van De Veer, 2008, p. 20). Therefore, my theoretical perspective is concentrated on Vygotsky's work and other research related to this. Vygotsky's (1966) work on play, which was presented by Vygotsky in 1933, provides the main theoretical ideas for this research. Other works of Vygotsky, for example Vygotsky (1987), Vygotsky (1998), Vygotsky (1997a, 1997b), Vygotsky (2004b), have also been used to develop my understanding of his work. To support my research, I have also studied other relevant research on play, learning and development from Vygotsky's era, for example, Elkonin (1971, 2005 a, b, c, d), Parten (1933, 1932), Piaget (1962), Leontev (1965) and Levitin (1982).

Furthermore, Vygotsky's work has prompted several contemporary interpretations (Van Oers et al., 2008). Thus, careful consideration regarding other's understanding and interpretation of Vygotsky's work which is related to my topic has been reviewed, the main authors are as follows: Kravtsov and Kravtsova (2010), Kravtsova (2006), Karpov (2005), Van Oers (2008, 2010), Bodrova (2008), Bozhovich (2009), Dockett and Fleer (1999) , Fleer (2009a, 2010, 2011b, 2011d), Hedegaard (2002, 2009), Hedegaard and Fleer (2008), Holzman (2009), Gredler and Shields (2008), Polivanova (2001), Rogoff (2003), Smidt (2009), Davydov (2008), Nixon and Gould (1999) and Veresov (2006). These authors' interpretations of Vygotsky's theory are relevant to my research and my theoretical understanding has been shaped during reading their interpretation of Vygotsky's work.

Configuration of the thesis

In a break from the traditional thesis format, this thesis follows Monash University's framework of 'thesis including published works'. In following this thesis format, I have framed the research context. I have divided my project into three parts. Part one contains the Introduction, General Literature and Methodology (Chapter 1, 2, and 3). The second part discusses findings through the presentation of four papers (Chapter 4, 5, 6 and 7) and the third part is the Concluding Chapter (Chapter 8), which finalizes the thesis.

Therefore, this thesis comprises of eight chapters starting with this introductory chapter, which introduces the research topic, motivation for the study, the research questions, the rationale for drawing upon cultural-historical theory for framing the research and the definitions of the terms relevant to this study. The second chapter discusses why this research is important for the field of early childhood education, where an overview of the literature is presented; specifically it gives a general literature review of science learning in early childhood science education and a rationale for a cultural-historical study of child development. The third chapter explains the methodological framework of my study. This chapter draws connections between the cultural-historical theory and methods, bringing new insights in understanding the cultural-historical research methodology that animate Vygotsky's philosophy.

In part two, I have discussed four papers as four chapters where the subsidiary research questions have been answered in line with the main research question. Findings have been revealed through these four chapters (Chapter 4, 5, 6 and 7). According to the guidelines for a thesis including published works, each paper contains a theoretical framework, literature review, methodology, data analysis, findings and conclusion. In the theoretical framework, a system of concepts has been derived from cultural-historical theory for explaining the data in each paper. The literature review identifies the gap in each paper and the findings of the study attempt to fill the gap through addressing the research questions of the paper. The method section provides knowledge about the details of data collection procedure such as hours of digital video data used in the paper, participants' particulars, role of the researcher and the research context. The research data have been analysed through a dialectical-interactive research method, which follows the cultural-historical paradigm. Each paper concludes with the result of the study.

Finally, chapter eight concludes the thesis, presenting an integrated discussion of the thesis. I have discussed and summarized the four papers, provided the significance of the study, followed by future research suggestions. I present the challenges that I have faced during the study period. I have ended the thesis with my insights as a set of concluding remarks.

Chapter 2: Literature Review

"The future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind; and that the problem of problems in our education is therefore to discover how to mature and make effective this scientific habit".

(Dewey, 1910, as cited in Howe, 1975, p. 95)

Introduction

The first chapter presented the researcher's inspiration to study science concept formation in everyday family life in three Bangladeshi families who live abroad (Singapore and Australia). The central research question emerged from the gap in the literature. The reviewed literature helps the researcher to identify the research aim. The aim of this thesis is to contribute to an understanding of how science learning can be studied from an institutional (family) perspective using digital methodologies (i.e. video observations).

The literature review provides the justification or rationale for the research or technique to be described - or to put it another way - the review characterizes the empty space in the relevant literature that the results will seek to fill (Kremenak, 2010). In my research, I have completed a systematic review of the literature to understand the research gap that assisted me to develop my research questions in the field of early childhood science education. As described by Bennett, Lubben, Hogarth, & Campbell (2005):

> The benefits of systematic reviews lie in their potential to assist with the dissemination of research findings, to contribute to establishing a culture of evidence-enriched practice, to point to areas that require further research, to improve the comprehensiveness, clarity and rigour of research reports, and to make a valuable

contribution to informed debate about the nature, purpose and quality of educational research. (p. 405)

By doing a systematic literature review, I have developed my understanding not only to reveal the gap in the research area but also to learn the trends in the research culture that are significant and important for undertaking quality research in early childhood education.

In each of the publication chapters (Chapter 4, 5, 6, & 7) individual and specific literature reviews are presented, the focuses of these reviews are on the subsidiary research questions. Each publication is self-sufficient. That is, each publication has a systematic literature review on the relevant empirical studies and the relevant concepts from the theories that have framed the subsidiary research questions. Therefore, this chapter provides a general review of the existing literature in the field of early childhood science education to show how this study is situated within this literature and to demonstrate how this study is able to make a significant contribution to our understanding in Early Childhood Education.

Research trend in early childhood science education

In this section, the systematic literature review provides an outline of previous research to illustrate what knowledge and perceptions have been established on children's science learning and development and to identify the specific elements that constitute the gap which this study will fill. As there are broad variations in the literature on early childhood science education, I have chosen to categorize the published papers systematically to reveal the gap and trends that informed my research.

Significance of research on science learning in early years.

More than half a century ago, Craig (1956) argued that children come to school with scientific ideas, which could be alternative conceptions, superstitions and particular attitudes to learning science content. The author uses a developmental point of view, which suggests that parents are the first teacher of science in children's life. From birth, children experience many science concepts for example, smoothness, lightness, darkness, sharpness and acceleration. Craig (1956) claims that children do not learn the abstraction of the concepts but children's experience in relation to these concepts is fundamental for their life. He concludes that the human organism from birth, with its dynamic drives has the capacity for science learning. However, parents and teachers need to make certain that children can develop intelligent and democratic behavioural patterns for learning science.

Consequently, about forty years ago Howe (1975) claimed that there is very little attention paid to the meaning and place of science in the lives and education of children before school age. He argued for a rationale directed towards science in the early years. He found, logical thinking and experience were important factors for children that could effectively enhance the scientific habit of children's minds. Watts (1997) suggested that children from an early age engage in theorising about common phenomena that are key functions within the preparatory development of scientific thinking. In Mantzicopoulos, Patrick, and Samarapungavan's (2008) research, it is argued that science must be taught at an early age for developing children's feelings of competence and enjoyment of science, which motivates children to continue science learning in their future life. This literature has shown that historically researchers have recommended for the significance and need of learning science in the early years.

Therefore, I reviewed the Google Ngram Viewer to understand the trends in research regarding children learning science. According to the Google Ngram Viewer, there are many books (e.g. Aitken, 2012; Campbell & Jobling, 2012; Chittenden, Courtney, & Jones, 1997; Fleer & Pramling, 2015; Johnston, 2005; Harlan & Rivkin, 2000; Lind, 2005; McNair, 2006; Neuman, 1978; Riley, 2008; Roth, Goulart, &

Plakitsi, 2013; Saracho & Spodek, 2008; Smyth, 2007) found in relation to science learning at the early childhood level. However, the following figure shows the publication of research into children's learning of science gradually increased from 1988 and the status of book publications were uppermost between 1998 and 2004. After this the publication date, the trend has sharply decreased.

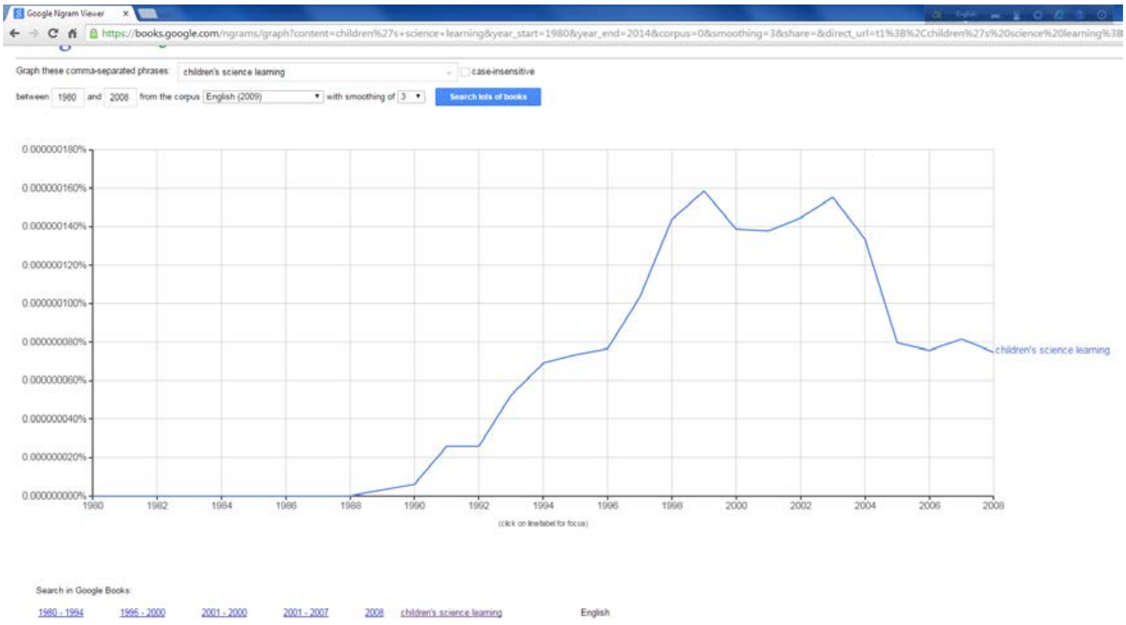

Figure 1. Graphs presenting the publication of children's science learning book. (Source: https://books.google.com/ngrams/graph)

The graph reflects that the recent book publications relevant to children's science learning is decreasing and this shows a corresponding growing gap in current research into science learning in the early years. Therefore, my project in relation to early year's science learning makes a significant contribution into early childhood science education.

We now turn to another potential gap in early years science education – the formal settings associated with the learning of science.

Science learning in formal settings:

In an important content analysis by Tsai and Wen (2005) of three science education journals, some interesting trends were noted. Tsai and Wen (2005) examined the International Journal of Science Education, Science Education and Journal of Research in Science Teaching from 1998 to 2002. At that time, the authors stated that the reviewed articles in these journals provide current and future trends in research to science educators. It was argued that research in science education at the time was getting increasingly more attention in the international research community. In particular, student learning contexts and social, cultural and gender relevant research topics received comparatively high attention. But an analysis of early childhood science education research did not feature in their work. An analysis of the research base for children's science learning in formal contexts such as Kindergartens, Pre-schools and childcare settings follows.

During the 1990s some studies on children's science concept formation featured in the literature. The studies found focused on the interactions between children and adult/teachers or child-child interactions in the social and cultural context of classroom settings. For instance, Fleer (1991) conducted a study of children's scientific understandings of electricity. The children were aged between three to five year olds and were attending a childcare centre. It was found that these young children could gain scientific understandings of electricity if a socially constructed approach to learning was used. In addition, the learning situations need to be carefully planned and applied, with a focus on sustained, shared and conceptually engaged adult-child interactions. Therefore, the development of scientific concepts can be attained in a young child's life if a learning situation is created to connect with their life experiences. In another study, Fleer (1992) investigated children's (five years to eight years) scientific understandings and noted the conceptual change that occurred during the teaching of science in kindergarten. Teachers were involved in science following an interactive teaching approach. The author founds teacher's interaction with students through social construction of learning scaffolds conceptual change in children's science learning.

In the following year, Fleer and Hardy (1993) investigated how children's (three to four years old) understanding about natural and processed materials could be extended and reinforced in the home. The authors designed the study in quite a different way. They developed four different interview schedules for children and parents. The researchers interviewed the children prior to experiencing the teaching of the concept in the childcare centre, followed by a final interview at the end of the teaching period. Parents were interviewed in a similar way. It was found that children's science learning was influenced by the children's life experiences, language skills, interest level and sense of social context. In the same year, Segal and Cosgrove (1993) examined kindergarten children's exploration of 'light'. Children explored shadows and shadow formation inside and outside of the classroom and shared their knowledge with peers. Finally children shared their understanding when exploring shadows in a small group with the researcher. It was found that sharing conversation with peers, small groups and other people provide insight into social and individual construction of knowledge that help children's abilities to be scientific. Next, Segal and Cosgrove (1994) undertook a small study on socio-dramatic play and science learning for primary aged children. In socio-dramatic play, there are two or more people involved in dramatic pretend play. They found that if the opportunity is provided in classrooms for socio-dramatic play in relation to science education, this play offers a scope for science learning in classroom settings. Further, the authors found that teachers need to incorporate these opportunities for children in classroom settings.

In longitudinal research by Tytler and Peterson (2000, 2003 and 2005), five-year-old children's scientific reasoning and achievement about specific science concepts (evaporation) in primary school classroom settings were examined. They sought to understand children's knowledge of evaporation and found that children held a range of conceptions that changed in complex ways across context and time. The authors used broader notions of language appropriation as a cultural tool, of personal and social narrative responses to features of the phenomena and the classroom setting and the nature of science explanations. The relationship between social and individual perspectives of learning by children was noted. The authors questioned some assumptions underlying conceptual change found in the literature and noted that alternative views can help children to develop scientific concepts. It was argued that the current science practices in primary schools need to be revised and recommend that the generation and explorations of ideas could be the key for scientific activity in primary school. The findings reveal the complexity and coherence of learning pathways relevant to learning about the concept of evaporation in educational contexts over time.

Extensive research into specific science concepts (e.g. light, friction, rain, cloud, day-night, rolling objects, gasification, thermal expansion and contraction of metals, gravity, the shape of the earth, and water) of preschool aged children in formal settings has been undertaken (Fleer, 1996a, 1993; Lidar, Almqvist, & Ostman, 2010; Ntalakoura & Ravanis, 2014; Ravanis, 2013; Ravanis & Bagakis, 1998; Ravanis, Christidou, & Hatzinikita, 2013; Ravanis, Papandreou, Kampeza, & Vellopoulo, 2013; Ravanis & Boilevin, 2009; Ravanis, Koliopoulos, & Boilevin, 2008; Robbins, 2005; Siry, 2013; Siry, Ziegler, & Max, 2012). These studies have featured as the main type of research in early childhood science education. In these studies, the researchers have applied intentional teaching programs in relation to the science concept (e.g light, friction, rolling objects, thermal expansion and contraction of metals) formation in pre-school to school aged children (three years to 10 years). The Australian Department of Education, Employment and Workplace Relations, (DEEWR) (2009) argues that intentional teaching involves educators being deliberate, purposeful and thoughtful in their decisions and action. Through intentional teaching, learning occurs in social contexts and these interactions and conversations are vitally important for learning (DEEWR, 2009). Studies found that children can develop science concepts at preschool age through teaching intervention where the children's social context is considered.

Through a sociocultural approach, for example the research could find out the depth and extent of understanding young children's thinking in science (Robbins, 2005). Robbins (2005) has studied the idea children (three to eight years old) develop of certain natural phenomena, such as rain, clouds, the sun, moon, day and light of children over an18 month time period. Using a socio cultural perspective Robbins (2005) acted as a part time participant in the research, arguing that traditional views of Piagetian constructivist approach in research needs to be challenged. The author found that "children's thinking about science is complex and fluid" (Robbins, 2005, p. 168) and it can be extended through the social context. This paper emphasizes thinking about the use of cultural historical methodology and the way it may create the extended thinking for the researcher as a participant. Children's science thinking can be studied in an alternative way to traditional developmental means, that is by using a socio cultural perspective, which moves from the individual to the social and community/institutional context (Robbins, 2005). In 2009(a), Fleer explored how preschool children's (four to five years old) concept formation could be theorised as a relation between their everyday thinking and their scientific thinking. The data showed that preschool children could learn scientific concepts in playful learning contexts. This study focused more on the teacher's role in developing the child's conceptual development.

I also found literature on the teacher's pedagogical role in relation to children's development in science learning. A collaborative project, namely 'Planting the seeds of science' is a new resource developed by academics, teacher educators and pre-service teachers in early childhood educational settings (Howitt, 2011). The resource is designed in such a way that teachers can use the modules in relation to the teacher's context, class, environment, and agency. The philosophy of the module follows five principles, which are:

> Consider young children as natural scientists, engage children through play and guided inquiry, consider socio-cultural contexts for children's learning, value on an integrated approach to children's learning experience, application of meaning-making practices for children to demonstrate their understanding and learning. (Howitt, 2011, p. 34)

The resource encourages teachers to engage with science ideas and activities in the teaching of three to eight year olds. In another research project by Howitt, Upson, & Lewis (2011) a case study methodology is used to investigate how four year old children learn about forensic science as part of a scientific inquiry in a preschool classroom. The researchers developed a forensic science module namely 'We are going on a (forensic) bear hunt'. Through the module, children learned about fundamental principles of forensic science such as, where every contact leaves a trace, allowing children to solve a mystery relating to a set of bear footprints found in the classroom. The study provided clear evidence that children eagerly participate in scientific inquiry (generating questions and predictions, observing, recording data, using equipment, using observations as evidence, and representing and communicating findings) through guided teaching and an appropriate context.

In the following year, Blake and Howitt (2012a) researched the opportunities of young children's (three months to four years) engagement in scientific enquiry and how these opportunities benefit the development of scientific concepts in early learning centres. The research context was set in two pre-kindergarten classes from two early learning centres and one community playgroup situated in an early learning centre (where parents were the educators). The researchers discussed the study aims with teachers and parents before they started the project and found that young children learn science through a balance of planning, flexibility, deliberate teaching and free play. Intelligent and thoughtful pedagogy can create harmonious and positive science learning environments for young children. In another study by Blake and Howitt (2012b) on developing pedagogical practices for science teaching and learning with three and four year old children, it was found that children continuously gain new knowledge and link their knowledge with their everyday experiences. If educators are thoughtful in pedagogy, they can create a positive learning environment linking children's prior experience to practise concepts (science) in a way that is suitable for young children.

In some research, it was found that teachers' science knowledge is important for student's science learning in formal settings. For example, Andersson and Gullberg (2014) investigated the purpose of science teaching in the classroom. Through an action research project, which was part of a professional development program for teachers on science and gender, data was collected from five preschool and primary school teacher's classroom experiences over fifty seven months. The authors found that teachers need to have subject matter knowledge as well as competence in teaching science in the classroom. This connects with the longstanding literature on teacher knowledge, confidence and competence to teach science generally. One research paper which has focused on teacher understanding of science concepts in childcare settings (Fleer, Gomes, & March, 2014), examined the everyday settings of a childcare centre to find the possibilities of science learning. Moreover, the authors researched the teacher's perception of science learning through the environment of the childcare. In this study, the authors discussed the possibilities for science learning through objects and the environment of the childcare through which the teachers could introduce science to children.

Children's science knowledge, interests and context have been considered in research for the development of science curricula in kindergarten and primary schools.

In a longitudinal study by Siry, Ziegler, and Max (2012) water was investigated with children (five to six year olds) as part of a three year project in kindergartens on children's (4 to 6 years old) processes and constructions of science within curriculum activities, the teachers' role was an integral part of the project. In particular, the researchers looked at the interconnectedness of scientific inquiry with the nature of science –related discourse during explorations. It was found that through the approach of science as a discourse, young children participate in general talk in relation to the more specific science objects at hand and science becomes more relevant through interaction. The findings indicate that children enact science collaboratively and through multimodal means within discourse and interaction. Through the same project, Siry and Max (2013) found that science curricula emerged from students' interest and insight through the integral role of teachers. The discourse-in-interaction process provides the opportunity for teachers to develop the pedagogical practices at the micro level, which in turn helps teachers to develop science curricula (Siry & Kremer, 2011). In addition, Siry (2013) argued that young children could produce the unprecedented science knowledge through collective experiences in the same project. It is found that science knowledge can be emergent from children's interactions with each other in open-ended situations through participatory approaches where teachers guide children to the open-ended doing of science. Danish and Saleh (2014) examined how teachers might efficiently integrate student created representations through unplanned informal tasks in their curricula. Their study has been designed to support students in learning about scientific topics through generating adhoc representations (images). Activity theory was used to analyse the data. The findings indicate that students (age six to nine years) perform better in science learning through students' cooperative strategies and teachers, parents, researchers' support while they develop images.

In addition to studies focused on science concept formation, there are also studies that investigate scientific vocabulary, problem solving, and attitudes to science and thinking through science in formal contexts. For example, Hong and Diamond (2012) examined preschool children's science concepts, vocabulary and scientific problem-solving skills in the context of two approaches of teaching science. Responsive teaching and combined explicit instruction were chosen as the two approaches for teaching science concepts and vocabulary related to floating and sinking and scientific problem solving skills. The authors found young children learned science concepts and vocabulary in both approaches. However, pre-schoolers learned more science concepts and vocabulary and more content-specific scientific problem solving skills in the combined explicit and responsive teaching approach, than when only responsive teaching or traditional teaching was used. Spektor-Levy, Baruch, and Mevarech (2013) have investigated pre-school teachers' attitude towards science and how teachers could foster natural curiosity of science in children. In this study, 146 pre-school teachers were involved in the survey. The study results show that most participants believe scientific activities in preschool can influence children's long-term attitudes towards science. The researchers found eight ways to foster scientific curiosity among children, framing learning by the teachers, which included the teachers being attentive and responsive, facilitating and participating in inquiry science. Similarly in a teaching intervention project by Venville, Adey, and Larkin (2003), children's cognitive acceleration in classroom settings was investigated. Four lessons out of 32 were analysed and intervention lessons in a Year one classroom were undertaken. Through intervention lessons, students were engaged in high level thinking through science. The findings indicate that teachers can nurture habits of good thinking through science: first by accepting difficulty as an integral part of the learning process, second, by encouraging children to explain and talk about their ideas and finally, by creating an environment where thinking is a valued classroom process.

In combination, these studies inform us about the teacher's role for developing science concept formation, how specific science concepts can be achieved in a formal context, the educator's pedagogical role for science concept formation in children's lives, the importance of educator's content knowledge in teaching science, the educators' intentional teaching for science learning, considering children's science knowledge for integrating the curriculum and scientific vocabulary, problem solving and thinking through science in formal educational settings in the early years context. However, not all of the aspects of science learning in early years' education are covered. There are many more features that still need to be revealed to understand early childhood science education such as science and technology in early years, science in informal contexts, science learning with parents and how younger children learn science.

Research into science learning has also been linked with technology. In the next section I examine the literature with regard to science and technology in the early years.

Science and technology in early years:

From the 1990s until the present, there have been many studies conducted regarding science and technology, particularly digital technology. In this section I focus on those studies that have provided understandings about science concept formation that utilise technology for learning science in early childhood. For example, Fleer (1990) examined gender issues in early childhood science and technology learning, where 25 pre-school children and 25 kindergarten children participated in a study with approximately equal number of boys and girls in each group. It was found that science and technology learning needed to be introduced in a socially contextualized manner so then gender stereotyping could be minimized. Further, Fleer and Beasley (1991) investigated how young children learn science and technology during the teaching of science in pre-school (year one, two, three classrooms). The purpose of the study was to understand whether young children hold alternative views on scientific and technological phenomena as generally recognized by the scientific community and second to determine the techniques which change young children's understanding of scientific and technological phenomena. Children were taught about torches over four weeks and the teacher actively worked towards children obtaining a conceptual understanding of electricity. The researchers collected video data of the lessons each child was interviewed about their learning on torches after completion of the unit. It was found, if young children get the opportunity to engage in scientific tasks they are able to conceptualize sophisticated ideas such as electrical flow. This research drew attention towards researchers and educational practitioners re-thinking their research interests and a re-examination of general expectations and curriculum content. It is clear that teacher’s active involvement is important for improving children’s learning science and technology.

In another study, Fleer (1995) researched the development of early childhood students scientific and technological ideas based on different types of teacher-child interactions in two early years classrooms. In this paper, it was examined how children’s scientific knowledge developed during a child’s life experience and interactions in the classroom. It was found that development of children’s scientific ideas were dependent on the variations in interaction. It was evident that the teacher’s role influences the teaching-learning process and the teacher’s individual approach to teaching science has an impact on conceptual change. When a constructive-destructive orientation in teaching is used, limited learning occurs. However, children learn science and technological concepts more readily when teacher-child interactions take place within a social context. Cosgrove and Schaverien (1996) designed a research context for year four and year six children for improving science and technology knowledge in a formal context. They found that extended conversations of teachers help children to learn science and technology.

The common ground for the studies reviewed is that children's science and technology learning mostly depends on children's engagement with the scientific task and the teachers' interactions with children in classroom. All these studies inform us about research during the 1990s, whereas it is important to know how science learning occurs with modern technology in recent years.

Science learning through digital technology is a relatively new dimension in preschool and kindergarten settings. Bers (2010) recommends that teachers and children use technology from the early years to teach science as this supports young children to become more capable users of technology. Therefore, it is understood that technology is important to introduce into the curriculum and can support useful pedagogies for learning science in early childhood education.

Slowmation is one form of technology that can be used for this teaching-learning approach in preschool and kindergartens (Hoban, 2007). Slowmation is used as a multimodal representation to explain a science concept by a student teacher or by a child (Hoban & Nielsen, 2012). It has been shown that teachers can apply slowmation as a form of intentional teaching to support children to explain science concepts (Fleer & Hoban, 2012). Many studies have shown that Slowmation as a research based teaching approach enhances children and teacher's science knowledge, as well as supporting children's learning regarding how to use digital technology in early childhood settings in general (Hoban, 2005; Hoban, 2007; Hoban, 2009; Hoban & Neilson, 2010; Hoban, Loughran, & Nielson, 2011). Engaging young children in making a Slowmation with early childhood teachers provides a context for supporting concept formation and Slowmation provides a sense of purpose for exploring scientific concepts.

What is common in the studies reviewed in the sections entitled, *Science learning and science and technology in early years*, is the growing research base regarding children's science concept formation in children's childcare centres, pre-schools and kindergartens, these are formal settings. However, the way children learn science in informal settings, where science is embedded in everyday life is less well researched and understood.

Science learning in informal settings:

Informal science education plays a significant role in developing scientific knowledge in students' lives (Baram-Tsabari & Yarden, 2005). For example, a case study conducted by Tytler (1998) investigated primary school children's informal science conceptions in a social context. Tytler (1998) discovered that it was possible to develop science conceptions such as air pressure, in a social context. In recent years, informal science learning has gained more attention, particularly in contexts and places outside the school classroom (e.g. Aubusson, Griffin, & Kearney, 2012; Avraamidou, 2014; Bell, Lewenstein, Shouse, & Feder, 2009; Fallik, Rosenfeld, & Eylon, 2013; Kearney, 2009; Osborne & Dillon, 2007; Stocklmayer, Rennie, & Gilbert, 2010), which is referred to as an informal science environment. Through informal science environments, teachers can link science to everyday life. The informal science environments offers an exciting, motivating and free-choice learning space that are rich in resources for teaching science to children/students from pre-schooler age to year 12 students.

There are some studies promoting young children's science learning through play based curriculum or play based settings. In a study by Baldwin, Adams and Kelly (2009), who examined how educators develop child friendly play based curriculum, they found that science concepts were more easily learned when introduced in a way that followed the children's interests. Fleer (2011a) developed a new theory of play namely conceptual play through analysing concepts from cultural-historical theory merged with an empirical study of three and half year old children. Fleer (2011a) argues that children's concept formation can be enhanced more if teachers apply conceptual play in their play-based programs. Cakici and Bayir (2012) designed a study on children's (10 to 11 years) role play in relation to science learning. The authors undertook a pre-test and post-test which included asking 16 open ended questions for understanding children's views on the nature of science. The researchers portrayed a scientist's life story through role play to the children after the pre-test. It was found that role play could be one of the exciting, informative and constructive ways of developing understanding of the nature of science among children.

In another study, Chang (2012a) designed a study in which pre-service teachers developed lesson plans on science concepts focusing on drawing (e.g. life cycle of frog, physical characteristic of a bug) and seventy young children (four – seven years) took part in this research. The findings show that drawing facilitates young children's acquisition of science concepts and the study also provides knowledge of how some young children feel less stressed during the acquisition of science concepts through drawing. More recently, Andree and Lager-Nyqvist (2013) investigated science learning through play in Year six classrooms, finding science learning is socially and culturally embedded in classroom and play and emerged as an integral aspect of classroom work in this study. Students through play can enact scientific identities in which they can transform and transcend classroom practice in their science learning (Andree & Lager-Nyqvist, 2013). Through this study, it can be argued that play can promote children's science learning and here it is argued that play is one of the leading activities in children's lives.

Some of the studies reviewed noted the importance of emphasizing children's scientific learning through linking science to everyday activities. Watts and Walsh (1997) that argued science could be linked with everyday explanations otherwise the lessons are remote, disembodied, unrelated and alien to the children. Teachers need to have confidence and motivation to teach science relevant to everyday life, thus new generations will have the similar motivation to learn science (Watts & Walls, 1997). Pramling and Pramling Samuelsson (2010) researched one young child's (three and half years) experiences with natural science. Interaction between the teacher and the child in the preschool environment were observed in relation to learning about natural science. It was assumed that a child gains experience in their regular natural context and this everyday experience will help to develop later scientific understanding. Wee (2012) provide evidence that there is a significant relationship between children's everyday ideas and implications for science teaching and learning. Teachers need to understand the regular socio-cultural context of the child for teaching science in classroom settings. Zimmerman and Bell (2014) examined the prevalence and social construction of science in the everyday activities of multicultural, multilingual children in one urban community. Children (10-12 years) participated in school science activities, namely science activity tasks (SAT) as part of the project and experienced science in everyday activities in school, home, community and media. Through participating in these science activity tasks (SAT), it was found that children could connect science across the everyday settings in which they participate. It has been evident in this review that science learning needs to link with everyday ideas, which is fruitful for supporting children to understand science concepts in depth.

Although the above studies provide vast knowledge on children's science learning, either formal or informal settings, these empirical researchers neglect the parents' role in children's science concept formation. Family is the first institution for children's learning and development (Hedegaard & Fleer, 2008). There is some research found on family involvement for supporting the development of science concept formation in the early years.

Families' involvement in science learning:

There are some studies on how the family can support children to develop their scientific knowledge. For example, Fleer (1996b) examined families who supported teaching science learning in childcare centres and found the linking between home and childcare for learning science is significant. Empirical data highlights the importance of parents' involvement when children (two years eight months to four years ten months) experience learning science concepts in their everyday family life. Children learning from home can be extended in teaching situations at childcare settings. In another study, Fleer and Rillero (1999) reviewed the literature on family involvement in student science learning. They also analysed an existing program, which supported the teacher to develop student learning in science through family involvement. Evidence shows that children's science achievement and attitude are more positive when supported by their parents or family involvement. One intervention project designed for primary school children and a corresponding family involvement in learning astronomy (Watts, 2000) found that children and family members were excited to attend this project and learn about astronomy. Parents and carers needed to learn about astronomy to help children succeed. In Riojas-Cortez, Huerta, Flores, Perez, & Clark's (2008) research, home cultural practices have been examined for developing scientific literacy of pre-schoolers. Parents were informed about scientific readiness knowledge that schools expect children to bring from home. Parents explained that they were involved with children in science related activities such as cooking, gardening and administering home remedies. It has been found that parents have an important role in the young child's scientific literacy development. The authors claim that culturally relevant activities enhance understandings of pre-schoolers' science conceptual development and the development of scientific vocabulary. All these studies focus on family involvement in children's science learning but parent's engagement is linked with pre-school, kindergarten or primary school research projects. However, the interest in this research is based on how the family can independently contribute to children's science learning.

Zimmerman, McClain, and Crowl (2013) have investigated how families can use magnifying glasses for children's science learning through nature walks in a nature centre. This research program is designed informally for visitors and the investigators suggest guided participation to support family activities while using magnifying glasses to learn about science concepts related to magnification. In guided participation, family members can help each other to use the magnifying glass specifically so that the young children can take part in the science practices with parents and elder siblings. They also focus on social interaction for learning science in these informal science learning activities. There are other studies regarding parents' role with children's (three to 15 years old) science learning in science centres and museum (Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2001; McClain & Zimmerman, 2014; Zimmerman, 2012; Zimmerman, Perin, & Bell, 2010; Zimmerman, Reeve, & Bell, 2010) where parents prior experience relevant to science concepts as a conversational epistemic resource or relate to the science activity presented. According to these studies, parents shape and support children's scientific thinking in their everyday life, parents promote children to display a form of science based knowledge. These studies show how parents contribute to their children's science knowledge in a pre-designed formal setting (e.g. museum, science centre) can be supported. Therefore what does it mean for children to be learning science in the home environment or in other informal settings?

In 2001, Hall and Schaverien (2001) conducted research on young Australian children who were six years old, the focus was on children learning to use science based concepts and technology at home. Learning about science concepts and technology might be more fruitfully afforded if families involved their children in science more by providing resources, discussing and exploring scientific concepts collaboratively (Hall & Schaverien, 2001). Unfortunately, an analysis of the many science activities potentially afforded in everyday life did not feature in this study. Cumming (2003) has studied four to seven year old children’s science related food concepts in informal settings. The data were gathered from diaries of nine parents of the children and 42 parents completed questionnaires. Children’s first-hand experience was considered, where relevant science concepts of food technology were introduced in this study. The study found that children might learn more scientifically correct information with digital technology through their friends and family, than when teachers were the only ones supporting the children. Children’s prior informal knowledge can support teachers for teaching science in the classroom. In Dewitt, Osborne, Archer, Dillon, Wills, & Wong (2013) undertook a longitudinal study where the development of primary grade students’ of science related aspirations and interests over time were researched. It was found that students’ aspirations and interests mostly related to parents positive attitude to science, attitude to school science, self-concept in science as well as the student’s gender, ethnicity and cultural capital. Dabney, Chakraverty, and Tai (2013) provide evidence on how doctoral students are influenced by family interest and family occupation for these science studies. These studies reflect that parent involvement, parent’s positive attitudes, and parent’s interest all influence children’s science learning or helps to develop children’s attitude to science.

In the section above, the researchers studied three year old children to doctoral age students and highlighted the importance of family interest and influence when developing science concept formation. Here we can see a gap in the literature and pose the questions: What about science concept formation for infants-toddlers in everyday activities, including play? What types of research is frequently undertaken to examine infants-toddlers development through everyday activities and play?

Research on infants-toddlers' everyday activities, play and science learnings:

There are countless empirical studies related to young children's development through play and everyday activities between 1980 and 2014. Here are some examples taken to show the research evidence, such as, Cohen & Tomlinson-Keasey, 1980 ; Field, Stefano, & Koewler,1982 ; Main,1983 ; Howes, Unger, & Seidner,1989; Moyles,1989 ; Rogoff & Morelli,1989; Rogoff, Mosier, Mistry, & Goncu,1989; Werebe and Baudonniere,1991; Tamis-LeMonda & Bornstein,1991; Mayer &Musatti,1992; Goncu,1993a; Goncu ,1993b; Tamis-LeMonda, Damast, & Bornstein,1994; Farver & Wimbarti,1995; Damast, TamisLeMonda, & Bornstein,1996; Caulfield, 1996; Lyytinen, Poikkeus, & Laakso,1997; Pierce,1999; Goncu, Mistry, & Moiser, 2000; Duncan & Tarulli, 2003; Fleer, 2004a; Ugaste, 2005; Larkin, 2006; Alcock, 2007; Lillard, 2007; Sandberg & Vaurinen, 2008,; Gray, 2009; Brooker, 2010; Fleer, 2011a; Fleer 2011b; Chen and Fleer, 2013; and Singer, 2013. These studies have individually focused on infants-toddlers-pre-schoolers various types of development through play or everyday activities such as cognitive development, language development, physical development, general child development, the developmental nature of play, development of inter-subjectivity, development on metacognition, communication development, the effect of relations in development, conceptual development, emotional development, development on learning rules and so on. However, infants-toddlers science learning and development through everyday activities including play are missing in this substantial body of literature. There are very few studies on infants-toddlers science learning. Those found as discussed below.

Forman (2010) conducted research on science experiments in the play events of two and three years old children. He argued that the children acted like scientists in play events in their lives. It was concluded that children could develop their thinking as a scientist through play and there was no need for direct instruction into how to play. However, it has been recommended that children need older and equally curious play partners to make the play event more effective for becoming a scientist. This paper drew on the actual play event and the reflections of the author for interpreting the event. There were limited references to build this argument. It seems the researcher would like to follow the child's interests only and did not consider the child's development in relation to other peoples or material world. Conversely, it is important to consider the child's everyday play or life in relation to his/her social situation, culture, environment, interactions with adults and peers. As Howe (1996) recommends, a child needs to be considered not as a solitary thinker but rather the child must be viewed as being in a social context, where everyday concepts are integrated into a system of relational concepts through interaction, negotiation and sharing.

In another study, Gopnik (2012) studied scientific thinking in young children. The author argued that very young children (from two years) have scientific intelligence this comes from what they have gained from everyday thinking and learning. Children analyse their experiences and revise their representations on the basis of everyday experience, as scientists do. Gopnik (2012) has used Probalistic models and Bayesian inference for deriving children's learning mechanism in relation to science. Probabilistic models create accurate and comprehensive predictions about children's learning. Bayesian methods determine the probability of possibilities. It was found that children's exploratory and pretend play also support very young children's (from two years) demonstrated scientific intelligence along with everyday thinking. Inquiry based science education is based on children's science experience in their early age. This quantitative study provides knowledge only on scientific thinking or intelligence of young children.

It does not illustrate the overall understanding on how scientific concepts formation occurs in everyday life at home for toddlers.

One study that focused on toddlers' science learning was found, it was situated in a formal settings. In this article, Yoon and Onchwari (2006) discuss three key points for teachings science to young children. They identified toddler play environments where science opportunities existed and they noted that learning is maximized if teachers have 1) knowledge of child development and learning, (2) knowledge of individual differences and (3) knowledge of the social cultural context in which children live. In addition, the authors argue that teachers need to involve children in the 5Es Instructional model: Engaging, Exploring, Explaining, Extending and Evaluating. The researcher provided a sample science lesson but did not discuss the details of the case examples in which toddler's science learning could be developed in a family home context.

The early childhood studies reviewed above, strongly recommend a need for considering the importance of children's learning and development of science at an early age. However, very few studies have focussed on infants-toddlers learning science, in particular there is a big gap in understanding the overall context for science learning at the infants-toddlers age. It is argued that framing research within meaningful social contexts, where authentic understandings of young children's thinking in science can be gained, is urgently needed (Fleer, 2009a).

The aim of my study is to understand infants-toddlers in a holistic way in the learning of science in everyday contexts at home. Understanding the child in a holistic way means to reveal the child's thinking from an individual perspective, as well as from a social situation or orientation. As Hedegaard and Fleer (2008) recommends, a child needs to be studied in daily life across different institutional settings and arenas from all three perspectives (individual, institutional and social). In my thesis, infants-toddlers have been studied through their everyday activities including play in individual contexts, family contexts (institutional) and the social context, in order to understand their science learning and development. Scientific concepts are cultural acts (Wells, 2008) and children's scientific thinking within a sociocultural context must be broadened from an individual to the social context in which the individual is situated (Fleer & Robbin, 2003).

In studying children in a holistic way, it is necessary to study the socio-cultural context so as to understand the overall views of a child (see Howe, 1996; Fleer & Robbin, 2003; Ravanis, Koliopoulous, & Hadzigeorgiou, 2004; Martin, Jean-Sigur, & Schimdt, 2005; Robbins, 2003, 2009; Siry & Lang, 2010; Siry, 2013; and Fleer & Pramling, 2015). However, in the past children's science has tended to be dominated by Piagetian theory (Piaget, 1972) and the theory of constructivism (see Driver, Guense, & Tiberghien, 1985; Osborne & Freyberg, 1985; Watters & Diezmann, 1998; and White, 1988) from 1970s to 1990s. According to constructivism, "children's science is resistant to external suggestions, deep within the child's thought, age specific, maintained in children's consciousness over several years, the child's first answer" (Fleer & Pramling, 2015, p. 9). It reflects that the child is understood only from the individual perspective, as Vygotsky argues, children's experience is considered as a "mosaic of mental life developed comprised of separate pieces of experience, a grandiose atomistic picture of the dismembered human mind" (Vygotsky, 1997b, p. 4). The trend of learning science in children's everyday life has been changed from individual learning experiences though to personal interaction with the physical environment towards a collective learning experience where social and cultural influences are key (Driver, 1989). "A cultural-historical reading of science education would position science as a form of cultural knowledge that is historically and collectively formed and understood, rather than as something that is located within the individual" (Fleer & Pramling, 2015, P. 10).

The research design of this project was created to provide ways of revealing and reflecting upon infants-toddlers science concept formation within everyday societal conditions as part of family practices. Therefore, the main research question of the study has been developed on the basis of the general literature reviewed in this chapter which is: What conditions are created in the everyday family life for the development of infants-toddlers' (ten to thirty six months) science concept formation?

Through this research question, this study will try to fill the gap in early years science education in the context of everyday family life, where a holistic perspective on learning and development in science is central.

Conclusion

Throughout this chapter the focus has been on how children's science learning has been explored. This review of the literature provides an understanding of the existing research into children's science learning and development and the gaps that this study seeks to address. As discussed in this chapter, children's science learning is researched mainly in formal contexts from the age of three years and above, few studies focus on informal contexts and family involvement. There was almost no literature located at the infants-toddlers level except for Forman (2010), Gopnik (2012), and Yoon and Onchwari (2006). Thus, it is most significant to explore the family's involvement in the development of infants-toddlers science learning in the family home. The reviewed literature also provides the rationale to study children from the cultural-historical perspective, which leads to the child being studied in a holistic way. Therefore, this study addresses the gaps in the current science literature at an early age by using cultural-historical theory to provide a theorisation of the holistic way of infants-toddlers science learning and development in the family home context. The next chapter will discuss the methodology used to attain this.

Chapter 3: Methodology

"Understanding child development as a dialectical unit of two essentially different orders, it sees the basic problem of research to be a thorough study of the one order and the other and a study of the laws of their merging at each age level"

(Vygotsky, 1997b, p. 22).

Introduction

The purpose of this chapter is to justify why I have selected cultural-historical research methodology in each phase of the project. "A methodology for studying children's development in everyday settings has to use methods, where the methodology focuses on children's motives, projects, intentional actions and interpretation" (Hedegaard & Fleer, 2008, p. 5). This chapter draws connections between the cultural-historical theory and methods and brings new insights to understand the cultural-historical research methodology that animate Vygotsky's philosophy. Veresov (2014a) terms cultural-historical theory a developmental theory where development is a dialectical process of qualitative change. In cultural-historical research methodology, the researcher can observe and analyse children's development at each age in a particular manner (Vygotsky, 1997b). A research methodology based on theory informs us about what we do in practice (Tudge, 2008). The following sections focus on how cultural-historical theory orientates the research methodology of this study.

Cultural-historical research methodology

Dialectical-Interactive research: A wholeness approach.

In cultural-historical research, child development is studied as a whole. The study design of this research project has been shaped by my understanding on the readings of Vygotsky (1987, 1997a, 1997b), Hedegaard and Fleer (2008), Fleer and Ridgway (2014) and Veresov (2014a, 2014b). Applying Vygotsky's (1997a, 1997b) philosophy is to learn about children's development in everyday settings. Through digital technology a contemporary method has been used (Fleer & Ridgway, 2014). This provides a context for explaining the cultural-historical research methodology in a dialectical way (Hedegaard & Fleer, 2008).

Cultural-historical research provides a lens for the researcher to understand child development (Veresov, 2014b) in everyday settings. In the development of the child, the biological and cultural development of behaviour represents a child's mental development and cultural –historical research methodology mainly focuses on the cultural development of the child (Vygotsky, 1997b). Vygotsky (1997b) describes cultural development as follows:

> Culture creates special forms of behaviour, it modifies the activity of mental functions, it constructs new superstructures in the developing system of human behaviour. This is a basic fact confirmed for us by every page of the psychology of primitive man, which studies cultural-psychological development in its pure, isolated form. In the process of historical development, social man changes the methods and devices of his behaviour, transform natural instincts and functions, and develop and create new forms of behaviour-specifically cultural. (p. 18)

According to a cultural-historical methodology, "child development is a dialectical process between the child and their social and material world as a form of cultural development" (Fleer, 2014, p. 19). Veresov (2014b) extends this by saying that child development is a social-cultural process where every higher mental function originated in the social environment. In line with the cultural-historical methodology, my study focuses on child development and in particular, the process of young children's science concept formation. As supported by Veresov (2014a), cultural-historical theory explores child development as a process for qualitative changes.

In the next four chapters, I have answered subsidiary research questions under the main research problem of this project. I have used particular concepts from cultural-historical theory for analysing the data to understand young children's development in science. A theoretical gaze is important to the researcher for understanding each phase of the research design, such as the research problem, the methods, the data collection, and the data analysis (Hedegaard & Fleer, 2008; Fleer & Ridgway, 2014). Cultural-historical theory is a unique system of interconnected instruments for realising the analysis of the process of development in its wholeness and complexity (Veresov, 2014a). In addition, child development can be studied from individual trajectories through to sociocultural contexts (Veresov, 2014b). According to Vygotsky it can be said, the methodology of this research permeates the whole exposition of the child (Vygotsky, 1997b). From the point of the whole exposition of the child, cultural-historical theory refers to the complex process of development of higher mental functions (Veresov, 2014a). "Development is always a very complex and contradictory process but first of all, it is a dialectical process of qualitative change" (Veresov, 2014a, p. 132).

In cultural-historical research methodology, the researcher can investigate how children contribute to their own developmental conditions and at the same time, perspectives of others that illuminate the societal and the institutional conditions that create a child's social situation should also be studied (Hedegaard & Fleer, 2008). Moreover, in cultural-historical research, the researcher is positioned within the activity as a partner with the researched person (Hedegaard & Fleer, 2008, p. 30). Therefore, considering the relations of all these perspectives, this type of research uses a dialectical-interactive view of research. This dynamic methodology for researching children's learning and development provides a way to include the child's perspective in research alongside the cultural-historical practices in which they live and learn (e.g. family practice) and the researcher's motives and goals for the study (Hedegaard & Fleer, 2008). In each phase of my thesis, I have used a dialectical-interactive view of research under the broad umbrella of a cultural-historical research methodology. Hedegaard (2008a) provides differences between traditional experimental research of a child's functioning (a descriptive approach) and a cultural-historical research approach where a dialectical-interactive method is used. This is shown in Table 1.

Table 1

Main differences between a descriptive approach and a dialectical-interactive research approach (Source: Hedegaard, 2008a, p. 35)

Research Method	**Research Principles**	**Knowledge form**	**Knowledge content**
	Descriptive methods		
Laboratory Experiment	Control Groups Blind test 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 practices	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 perspectives

I have used a dialectical-interactive method in each phase of my project. The main research problem of my project is to learn what about the conditions in everyday family life that support the development of infants-toddlers' (ten to thirty six months) science concept formation. Following a dialectical-interactive approach, the central focus is studying the conditions in everyday practice. I have one main research question shadowed by seven subsidiary questions presented in the next four chapters. I have discussed different conditions for the development of infants-toddlers science concept formation in their everyday family life. It is noted here, parents create the conditions for scientific concept formation in their infants-toddlers and artificial conditions were not created. The findings chapters (Chapter 4, 5, 6, and 7) explain details about the conditions in the study design.

Parents' creating new conditions in everyday practice is considered an experiment in a dialectical-interactive approach however this is not a traditional laboratory experiment (Hedegaard, 2008a). For the concrete experimental study in cultural-historical research, two research questions need to be answered: "What to study?" and "How to study?" (Veresov, 2014a, p. 137). 'What' questions cover potentially the exact psychological process of functions in the course of an experiment and which aspect of the processes of development of this psychological function the researcher is going to analyse. ‘How’ questions explain the researcher’s selection of theoretical concepts, this selection is based on ‘what questions’ which reflect the selected aspects of development. Based on the questions in my research, I have investigated the process of science concept development in infants-toddlers everyday life.

In the following four chapters (Chapter 4, 5, 6, and 7), I have discussed relevant concepts from cultural-historical theory in relation to the seven subsidiary research questions. Here I have addressed the research questions based on theory, in addition, the theoretical concepts were used to guide the study with the parents before the data collection process have been discussed. This method is typical of the dialectical-interactive approach emphasized by Hedegaard (2008a). In chapter four, I have tried to find out the possibilities of science concept development of infants-toddlers in their everyday context and new dialectical-theoretical knowledge has been formed. Chapter five explains the interactive role of parents and children in shared everyday activities for developing science concept formation. The dynamic aspects of motives are discussed and related to the development of science concept formation in infants-toddlers play and this is extended further in chapter six. In chapter seven, parent interviews gained through leading and provoking questions are presented. This approach confirms the interview as an experiment in a dialectical-interactive approach for undertaking research (Hedegaard & Fleer, 2008).

Similarly, Hedegaard (2008a) suggests that the dialectical-interactive approach allows for the conditions and the child’s development to be conceptualised as a whole and thereby the research problem becomes connected to how well the researcher in his or her conceptualisation can theorise the different perspectives. A wholeness approach to studying children should encompass daily life across different institutional (e.g. family, school) settings and arenas from all three perspectives, which include societal, institutional and the individual (Hedegaard & Fleer, 2008).

In my research, I have studied the whole picture of family practices. This includes different play and activities (e.g. collaborative play, shared activities), activity settings (e.g. play corner inside home, outside play, cooking space, bed time story) and regular activities (e.g. meal time, sleep time) of the family context. In the overall settings from a cultural-historical background I have tried to find out the qualitative changes for the development of young children's science concept formation. According to the dialectical-interactive method, the research is based on a conceptual model of children's activity settings in relation to practice traditions, where it is possible to follow changes in practices and activity settings over time and identify qualitative changes (Hedegaard & Fleer, 2008). Furthermore, I have tried to see the whole picture of family practice from all three perspectives, which are societal, institutional and the individual so that I can research the infants-toddlers development of science concept formation as a whole, which is the main point of the cultural-historical research. I have derived a diagram (figure 2) from Hedegaard and Fleer (2008) relating to my research design as follows:

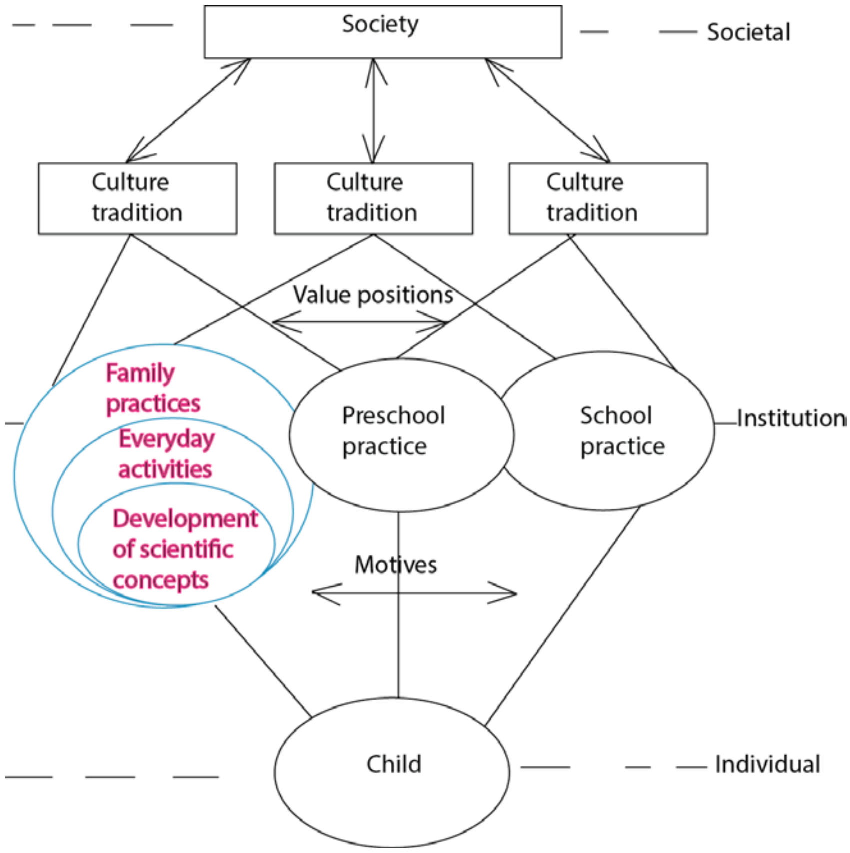

Figure 2. The development of scientific concepts through everyday activities in family practices. (Adapted from Hedegaard & Fleer, 2008)

According to my research design, the family's (as an institution) every day activities lead to the development of scientific concepts because "children's development takes place through participating in societal institutions and a child's development can be thought of as a qualitative change in his or her motive and competences, and development can also be connected to the change in the child's social situation" (Hedegaard & Fleer, 2008, p. 11). In chapter seven, I have discussed details about children's social situation of development in relation to their science concept formation. Vygotsky (1998) emphasizes that a child's social situation of development changes because of several reasons such as the age period, family culture and the societal context. Thus, the child's particular development depends on how the child's social situation is created (Hedegaard & Fleer, 2008). Looking at the three perspectives (individual, institutional, and societal) of the child's social situations provides the opportunity to examine the qualitative changes in children's science concept formation of infants-toddlers. "The cultural-historical methodology provides opportunities to generate processes of development by creating various types of social conditions and social situations of development for children" (Veresov, 2014b, p. 227).

Cultural-historical case study.

"Finding a method is one of the most important tasks of the researcher" (Vygotsky, 1997b, p. 27). For my research, I study three individual children in their everyday settings and how these children's everyday activity leads to the development of scientific concepts. According to a case study method, the case can only be studied or understood in context (Gillham, 2000). I have studied children's regular activities in their everyday context. In addition, the case study approach is appropriate for descriptive questions (e.g. what questions) or explanatory questions (e.g. how questions) (Gay, Mills, & Airasian, 2009). As I have discussed previously in chapter one, my research questions are framed as 'what questions' or 'how questions'. Case study research provides evidence based on qualitative approaches, which include a deep understanding of the research (Gillham, 2000).

Yin and Davis (2007) describe the use of the case study approach as understanding encompassed with important contextual conditions of real life contexts that are presented in depth of the contexts. According to Yin (2009, p. 18), a case study is an empirical enquiry that "investigates a contemporary phenomenon in depth and within its real-life context".

The study focuses on the detailed investigation of three families as a collective case study, in the Bangladeshi-Singapore and the Bangladeshi-Australian cultural group, using the dialectical-interactive framework. Since I am Bangladeshi, I have chosen a Bangladeshi family, as I understand their culture as I have life long experience within this culture. The main research question of this cultural-historical case study is to explore what conditions are created in the everyday family life for the development of infants-toddlers' (ten to thirty six months) science concept formation. The main research question and all other subsidiary research questions are identified regarding regular activities, play activities and social interactions in the family context in relation to the development of science concept formation of infants-toddlers.

In my research, I take a participant observation approach in the context of a case study because in observational studies, investigators are able to discern ongoing behaviour as it occurs and because case study observations take place over an extended period of time, thus allowing the researcher to develop more intimate and informal relationships with those they are observing, generally in natural environments (Bailey, 1994, as cited in Cohen, 2007). With this, according to a cultural-historical approach, "the researcher as a scientist has to conceptualise her own participation (motives, projects and intention) as part of the researched activities" (Hedegaard & Fleer, 2008, p. 202). I am an active participant in my study design in line with cultural-historical theory.

"Sampling is about choosing exactly what sources you will collect data from – what places you will visit, what events you will attend, which people or organizations you will talk to and so on" (Newing, 2010, p.65). I have selected targeted (also known as purposive) sampling for my project as I look for individuals who are most relevant to my study (Newing, 2010). My intention is to study children of Bangladeshi-Australian and Bangladeshi-Singaporean families who are culturally and historically from Bangladesh. Targeting families who align with my own cultural origins from Bangladesh, means it would be easy for me to enter the daily settings of the researched person and understand the culture of family activities.

The aim of the sampling design in qualitative research should be to make sure that "enough data is gathered to give an accurate understanding of the issue under investigation and the different perspectives that are present in the study population" (Newing, 2010, p. 75). Considering the aim of the sampling design, I think three children from three Bangladeshi-Australian and Bangladeshi-Singaporean families is enough for gathering data to get an accurate understanding for solving my research questions. I have conceptualised a diagram (Figure 3) from the institutional perspective below, showing my understanding of the case study approach from the theoretical perspective of cultural-historical research:

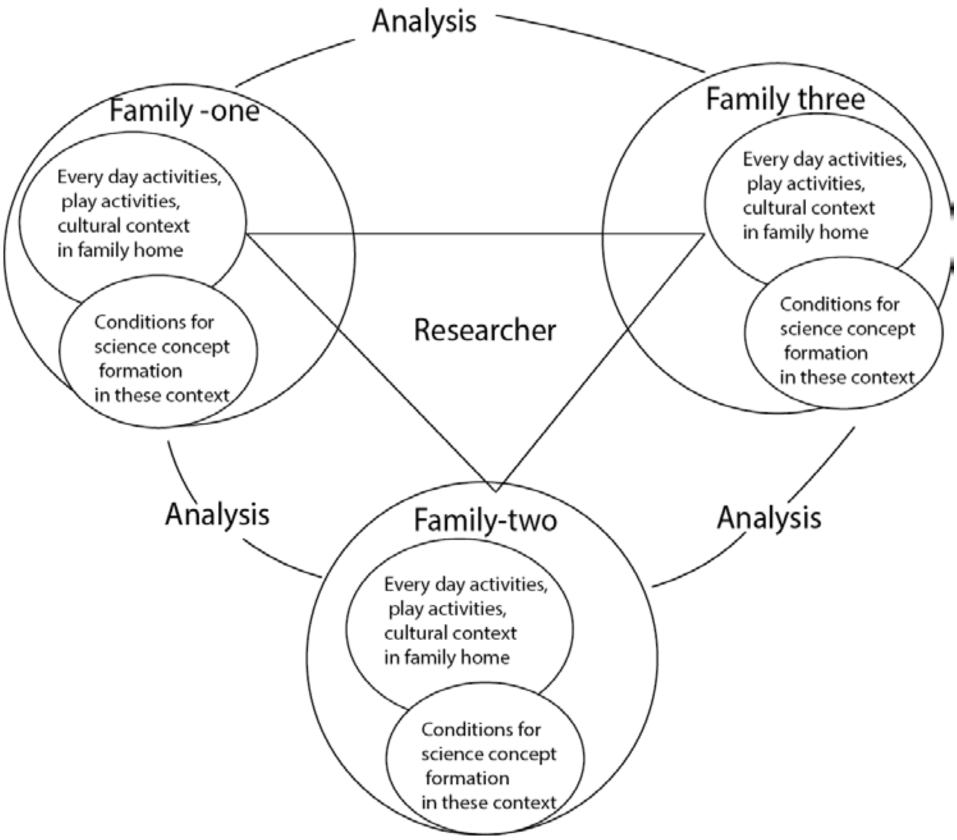

Figure 3. Cultural-historical research: The case study approach. (Adapted from Hedegaard & Fleer, 2008)

According to Figure three, the researcher as an active participant observer focuses on three families' everyday contexts in relation to everyday activities, play activities and cultural context and analyses how these contexts create conditions for infants-toddlers science concept formation from an individual trajectory within the institution of the family. In the next section, I will discuss in detail the researcher's position in cultural-historical research methodology.

Role of the researcher.

In qualitative studies, some scholars (Atkinson & Hammersley, 1994; Flick, 2006; Silverman, 2006) designate the researcher's position as participant observer whereas other researchers (Erickson, 1996; Johnstone, 2007) label the word as observant participant. Both terms provide the idea that the researcher takes part in research activities as an inside observer. In cultural-historical research, the researcher is positioned within the activity as a partner with the researched person and the researcher always has to keep the aim of the research in mind when entering the research settings (Hedegaard & Fleer, 2008). Hedegaard & Fleer (2008) describes the researcher's position as a double role as:

> The double-ness of the researcher in the research situation-both as a researcher and as having a personal relationship to children and adults in the setting-can also be viewed in the same way when making interpretation of the protocols, where the researcher seeks meaning in relation to both roles. (p. 205)

In my study, I have explained my position as involving multiple roles. When collecting data from the family contexts, I have participated as a secondary participant in these contexts. As a secondary participant, I built good relationships with the families and in particular with the children in order to have a strong understanding of their everyday context. In some cases I played with children as an active participant according to the cultural obligations and demands of being in a Bangladeshi home. In this situation, I created the conditions for the research by acting in the expected cultural manner, whilst also acting as a researcher gathering data in the home context. I was a primary participant in this context. The roles I took were made clear in both the data collection phase and during the analysis phase where I indicated when I was acting in a lead role with the children or when a secondary participant observer. In each context, the research aim was kept in mind when participating as a primary or secondary participant and as a research professional while analysing data. In addition, I have analysed data at my research desk as a professional researcher. So I have multiple positions in my project, which is visualized in the following diagram:

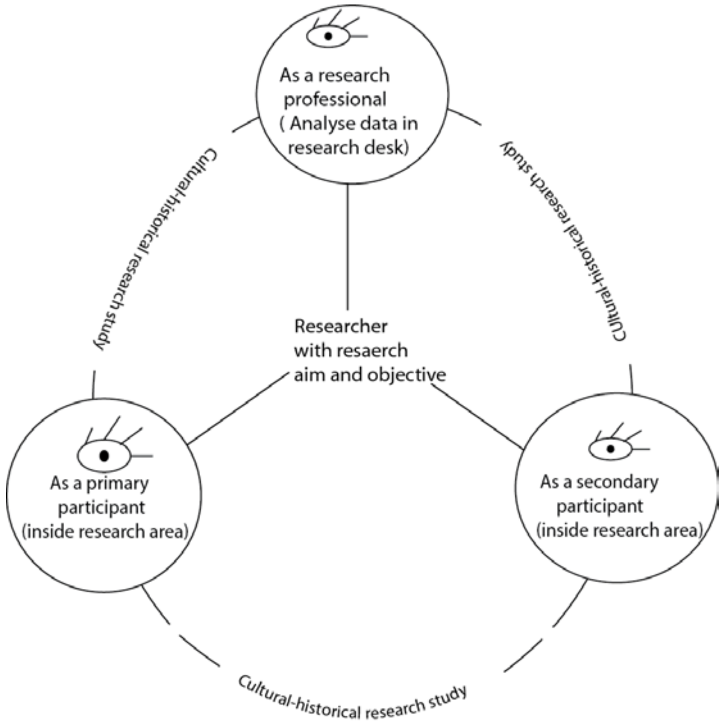

Figure 4. Multiple role of the researcher. (Adapted from Hedegaard & Fleer, 2008)

In a cultural-historical research framework, the researcher always considers the participants' perspectives, especially while collecting data in the context of the family home, where it is necessary to consider minimising the power position held between the researcher and the participants.

The next section will outline the digital methods I have used in this study in order to carry out research consistent with the cultural-historical research methodology described above.

Digital tools in Cultural-historical research.

Fleer (2008b) states,

> Research using digital video and computer technologies provides a useful framework for a dialectical-interactive research approach and as the aim of the cultural-historical research is to study children in everyday settings in their social situation, it is important to examine the different perspectives of the participants being observed. (p. 104)

Flicks (2006) extends that visual data provides important input in the collection of qualitative research. Fleer (2014) argues that using digital tools are worthless without theoretical understanding. Being a researcher in a cultural-historical study, I have used digital tools, which include a video camera, a still camera and an audio recorder in my project. In particular, "visual methodology within cultural-historical framework creates the conditions for the researcher to be an insider of the research setting in order to investigate young children's activities and engage in the social practices of everyday life" (Veresov, 2014b, p. 225). As I have already discussed the researcher's role in my study and using visual methodology as a researcher, provides the opportunity to understand the research context in-depth as an insider of the research setting.

The uniqueness of using digital visual tools within cultural-historical framework is that it exposes and uncovers the process of development (Veresov, 2014b). Fleer (2014, p. 20) contends that "digital video observations provide detailed accounts of how, in everyday life, cultural development is shaped by and shapes the social situations that the child find themselves in". In my study, I have used digital video tools for collecting the details of activities that focus on children's everyday life such as sleep time, shower time, story time, wake up time, meal time, play activities and transition periods. Digital video tools provide opportunities to explore the process of child development, but also analyse the process of child development in its dynamic and complex state (Veresov, 2014a). The specific methodological discussion regarding using digital tools (e.g. video camera for collecting children's everyday activities, audio recorder for parents' interview) has been continued in next four chapters (Chapter 4, 5, 6, and 7) as part of the publications included in this thesis.

Moreover, Fleer (2008b) discusses that digital video observations make it possible to look at different perspectives (individual, institutional, and societal) visually through video clips and to discuss these observations with participants either informally or more formally with interview questions. Regarding this view in my mind, I have interviewed the parents to find out the things that the researchers were unable to observe themselves (Stake, 2010). In a cultural-historical research study, the interview process is not like asking questions and answers but rather shared knowledge construction and deconstruction between two persons while dialoguing (Hviid, 2008). I have discussed with the parents in this study their thinking and their intentions when interacting with their children in particular activities when collecting video data. The following table 2 shows the details of the research participants and the quantity of data I have collected in my project.

Table 2

Details of sample and data gathering

Participants	Age Period	Location	Data Gathering tools	Times of visit	Hours of video data	Interview of Parents
Family one-Jhumki	23 months to 28 months	Singapore	Video camera, still camera	15 times	6 hours	One final interview after viewing the data (field notes). Parent was interviewed about

	= 6 months					the activity during each visit (field notes).
Family two-Barnan	10 months to 13 months = 4 months	Australia	Video camera, still camera, voice recorder	11 times	12hours 12min 19sec	One final interview after viewing the data (video camera). Parent was interviewed about the activity during each visit (voice recorder or field notes).
Family three - Joy	30 months to 36 months =7 months	Australia	Video camera, still camera, voice recorder	10 times	11hours 42 sec	One final interview after viewing the data (video camera). Parent was interviewed about the activity during each visit (voice recorder or field notes).

					Total video data= 29 hours 13 min	Three final interviews and several small interviews in relation to activities.

The whole data gathering process was completed over a one-year period. Two cameras were used for video observations where one was in a stationary position and the other one was used for taking close observations, often in the hand of the researcher who followed the children during activities undertaken. One volunteer research assistant was involved with supporting the researcher in gathering the video data. Occasionally the parents also collected video data, such as during sleep time or over weekends. A total of 30 hours of video data were collected from three children's everyday life. Parent participants collected a total of five hours of video data and the researchers gathered the rest of the data. One hour forty-four minutes of videos and one hour twelve minutes of audio interviews with parents and necessary field notes have been gathered over one year. The interview questions were developed from a cultural-historical perspective of child development, specifically focussing on scientific concept development in their everyday life.

Data Analysis.

I have collected qualitative data in my research, and qualitative data are essentially meaningful but diverse (Gibbs, 2007). Vygotsky's analysis of children's learning and development, while not a complete explication of these phenomena, provides some methodological insight (Holzman, 2009). As I have discussed, I am looking at the process of infants-toddlers development in science concept formation, the process of development has two forms, which are lower forms and higher forms. Vygotsky (1997b) describes:

> To understand the process of development of higher mental forms we have to learn the nature of movement of lower or simpler forms and no higher form of behaviour is possible without lower forms, but the presence of lower or secondary forms does not exhaust the essence of the main form. (Paraphrase from p. 82)

Following Vygotsky's philosophy, I have analysed the data from the lower forms of behaviour of infants-toddlers to higher forms of behaviour for understanding the development of higher mental function in science concept formation. In particular, chapter five explains infants-toddlers development of higher mental function from real forms to ideal forms and chapter six describes the mental progression over time in science concept formation.

In a cultural-historical theorisation of researching with young children, Quinones and Fleer (2011) create the methodological tool of Visual Vivencias for studying children aged three years and younger which conceptualises both the theory and the tool of capturing young children's everyday settings. Visual Vivencias is "an analytical tool to further understand visually the child's emotional experience of the event" (Quinones & Fleer, 2011, p. 123). Visual Vivencias supports the researcher in the following way (Quinones & Fleer, 2011):

- Dynamically visually documenting the "alive" experiences of the child and the social environment such as the relationships the child is living in those moments of time.
- Dynamically showing the young child's united thinking and emotion through his social interactions towards others.

- The child's making meaning and sense of events through subjective components, configurations and productions.
- Researcher's subjective sense and interpretation of the events (scenarios, social life of the child). (pp. 114-115)

Since I am completing research on children aged 10 to 36 months, Visual Vivencias is an appropriate tool for interpreting the data. Through analysing data, I have tried to make relations between my theoretical understanding and the actual practices to achieve the aim of my research. In addition, I have visited and revisited children's emotional expressions, activities and interactions with adults repeating the process to understand the data and to answer my research questions. Visual Vivencias provides me with insight into understanding the research context from the child's perspective. As supported by Li (2014), visual analysis supports the researcher to understand the data dialectically from the simple to the complex, where the researcher can interpret the data from different perspectives.

I have also used Hedegaard's (2008b) holistic approach to interpret my data. Hedegaard (2008b) outlines three ways of interpreting data, which are 1) common sense interpretation, 2) situated practice interpretation and 3) interpretation on a thematic level. First, the researcher interprets the visual data using his/her common sense in relation to research aims. Then the researcher analyses the video data with a theoretical understanding, which is situated practice interpretation. Finally, the researcher bridges the theory and the practice in video data for answering the research questions. I have used visual Vivencias for developing a data table (see Appendix A: Table 5) and three levels of interpretations for analysing data. In addition, Sikder and Fleer (2015a) form four categories of small science concepts, which conceptualise both the theory and the tool for studying infants-toddlers everyday science moments (see Chapter 5 for analysing the table as an analytical framework). The analytical framework that was used to determine the science moments in this study (Chapter five) is shown in Table 3 below.

Table 3

Analytical framework for identifying small science categories in infants-toddlers life (Sikder and Fleer, 2015a)

Categories of *Small science*	Activity Settings	Every day concepts	Scientific concepts
Multiple possibilities for *small science*	Preparation of snacks	1. Mixing ingredients 2. Follow the instructions 4. Cooking 5. Concept of shapes	1.Force (push hard, press, roll) 2.Correlation 3.Properties 4.Change of state of matter 5.Heating and Cooling continuum
Discreet Science Concepts	Mirror play	Identification of body parts	Human body
Embedded Science	1. Day time	Everyday experience of day,	1. Light and Dark 2. Air

	2. Night time (switch on-off) 3. Breathing	night and breathing	3. Breathing process
Counter Intuitive Science	1. Sunrise and sun set 2. Moon follows me	Historical development of knowledge	3. Solar system (Earth is moving The position of earth in the universe)

In the four chapters that follow, I have provided details of the data analysis using Visual Vivencias, three levels of interpretations and the analytical framework (Table 3) for identifying small science categories in infants-toddlers life (Sikder and Fleer, 2015a).

Ethical Issues

A basic concept in qualitative research is trust (Boeije, 2010). Boeije (2010, p. 44) adds, “Researchers have to consider the moral accuracy of their research activities in relation to the people they meet along the way, such as participants, hosts, funders, colleagues and parties who are likely to encounter the implications of the research". Since I have studied children and their family context, it is mandatory for me to give attention to ethical issues where voluntary participation, privacy and confidentiality are important. Therefore, I gained ethical approval (see Appendix B) from Monash University Human Research Ethics Committee before my data collection. In addition, I have visited four to five times the participant’s family home before starting data collection as I wanted to build trustworthy and friendly relationship with the children.

Thus, children may not feel any stranger anxiety during data collection process. For example, when I have visited the participants' home I played with children for 10 to 15 minutes. I have also showed them my cameras (video and still) and how the cameras can be operated as children are very curious about digital technology. For studying young children, developing trustworthy and friendly relationship with children is essential to undertake before starting to collect data.

The approved consent forms were signed by participants for involvement in the research assuring voluntary participation and confidentiality. Moreover, for privacy, I have used pseudonyms and removed any identifying information that may guide others to recognize the participants. Furthermore, in interview sessions, if any participants did not wish to answer or wanted to avoid any questions, I respected their wishes at all times. As suggested by Mayne and Howitt (2014), the ethical documents (e.g. informed consent, institutional ethics approval) does not protect a vulnerable participant, rather the key to ethical reporting is to present researcher and participant while they engage in a sensitive and ongoing dialogue during participation. Finally, during video observations if any child felt any discomfort or any other issue arising from the situation, I stopped video observations at that moment. Although the ethics report is a small part of a study, it enacts genuine ethical principles at the heart of the project (Mayne & Howitt, 2014). In each paper (Chapter 4, 5, 6, & 7), ethical principles have been reflected on consistently.

Conclusion

Following the dialectical-interactive research framework provided me with deeper understanding of a cultural-historical research methodology as a whole. In a cultural-historical research study, the researcher always needs to consider the child's perspective either during data collection time or data interpretation at the desk. The theoretical gaze of the researcher creates the conditions for the research settings. Digital video tools have an exclusive role for data collection and data interpretation for understanding the specific development of young children. A cultural-historical research methodology informs my new understandings of the institutional practice (family) of the development of infants-toddlers science concept formation. The next four chapters present detailed findings and discussions of data along with extensive literature reviews and theoretical framework, which have framed the four publications in this thesis.

Part II: Thesis Including Published Works

Chapter 4: Small Science in Everyday Life

"The word is almost always ready when the concept is ready".

(Tolstoy, ibid, as cited in Vygotsky 1987, p. 241)

Overview of thesis including published works

The PhD thesis (including publications), invites the candidate to create a systematic plan of how to present the findings across a set of published papers. When I started to plan for the writing of articles, as part of thesis including publications, I had to consider a number of things. First, how many papers I would need to develop during the PhD candidature period? What would be the specific outcomes of the research to be reported in each paper? Which journal is most relevant for publishing my research project? Considering these questions, I have re-organized the sequence of subsidiary research questions and categorized the questions to tell the story of the writing process of four papers, which are all in line with the central research question of my study. Next, I have linked the data and the subsidiary research questions in relation to the development of each particular paper or book chapter. The sequence of the papers needed to be placed in the thesis in such a way that each paper/ book chapter would tell an episode chronologically of the analysis of the data, so that when all the papers are taken together the whole story is told.

Since my project aimed to understand the holistic view of infants-toddlers science concept formation, I had to set the four papers/ book chapter in such a way that all four papers/ book chapter could cover the complete view of my project on infants-toddlers science learning. Vygotsky's theory of (1987) everyday and scientific concepts was the central construct for this project, and I have used this concept in each paper/

book chapter. In addition, play is one of the leading activities of young children, thus I have also used Vygotsky’s (1966) conception of play in most papers.

The first paper provides knowledge on the possibilities of infants-toddlers science learning in an everyday context. In the second paper, the parent’s role has been discussed for developing science in infants-toddlers age. The third paper (book chapter) describes how science learning is fostered when a motive in a play context is developed through the dynamic relations between parents and children as they explore science concepts together. The fourth paper unpacks parent’s perception in relation to science concept formation in their children’s everyday life. Through these four papers, I have attempted to reflect the whole story of science concept formation during the infants-toddlers age period.

Background of the first paper

In my first paper (Chapter 4), I wanted to reveal the possibilities of science concept formation during infants-toddlers life through everyday activities and play. Therefore, I have looked at all the data (30 hours of video data) and developed a data table (see Appendix A: Table 5) of the science possibilities in everyday life. In the table 5, I have highlighted some subjects, which include the activity settings, parents-child’s position in the context, possible everyday concepts, and possible science concepts. This table provides an overall map of my PhD data.

In the first paper, Vygotsky’s (1987) theory of everyday and scientific concept formation has been used for explaining the theoretical framework that supports the analysis of the data, drawing primarily upon Hedegaard’s (2008b) three levels of interpretation. In addition, play is one of the leading activities in young children, thus the theoretical concept of play (Vygotsky, 1966) was also applied in understanding and unpacking the data. Findings are derived from the empirical data gathered and analysed.

Small science has been developed as a new term for describing science during the infants-toddlers period. Small science represents the scientific moments that occur in the everyday lives of toddlers and infants. In addition, small science has been categorized in four ways. I also present the dialectical relations between small science and everyday cultural contexts in this first paper.

I developed my first paper and presented it at the European Early Childhood Education Research Association conference in 2013. I received valuable feedback from the conference participants and improved my paper based on this feedback. I submitted my first paper to the Journal of *Research in Science Education* (RISE) as was planned.

> *Research in Science Education* (RISE) is an ‘A’ ranked journal. The journal with a Scopus SNIP (Source Normalized Impact per Paper) of .500 or more, and that ranked A from the 2010 ERA Ranked Journal List. Scopus SNIP (2011) provides information that RISE achieves score 1.293. *Research in Science Education* is an international journal publishing and promoting scholarly science education research of interest to a wide group of people. The journal examines early childhood, primary, secondary, tertiary, workplace, and informal learning as they relate to science education. (Source: RISE website).

My study focuses on science in early childhood education. Therefore, I chose RISE for publishing my first paper. My supervisor co-authored the paper with me. I am the principal author and my supervisor is the second author. I have contributed 80% for writing this paper and my supervisor contributed 20% of the writing and overall guideline to develop the paper for an “A” ranked journal.

During the publication process, I received blind peer reviewed comments, which suggested some minor revisions. I am providing two examples of what the reviewers suggested and how we responded to the comment as shown:

Reviewer #1: This paper reports on a small study examining infant and toddler development of scientific concepts. This is an under-researched area and the paper does add new knowledge. The theoretical framing is appropriate to the main argument in the paper - the explication of Vygotsky's ideas about scientific and everyday concepts is very clear and the dialectical relationship between these is carefully articulated. This pays off later in the presentation of the model for a dialectical conceptualisation of infant and toddler science learning. The paper would benefit from some thorough editing to tighten up the expression and to reduce the over citation of references throughout.

Response: The study gives new insights into infant-toddler science and learning, and through this gives new understandings about this age period. We have kept seminal references and reduced some of the multiple citations in order to make the reading of the literature smoother.

Reviewer #2: The study seeks to investigate the scientific development of infants-toddlers in families. This is a very important topic for research in the field of science education. It is a well written manuscript with a clear introduction and well-elaborated theoretical frame-work. The research-design as well as the main results are clearly accounted for. I look forward to seeing this study in print. There are some minor issues that need to be attended to:

- To me, it does not become self-evident to use the concept 'small science'. The concept may connote to the scientific concepts emerging in the everyday activities of the toddlers as somehow 'childish' in a negative sense. I recommend the authors to consider if there might be alternative options for labelling the scientific concepts (e.g. emergent science).

Response: We believe the concept of *small science* does capture the early forms of scientific concepts that such young children experience early in life. The concepts are not fully formed science concepts. Naming them as small science is one way to capture this. We have field tested the term, to see if this term does give an ‘immature’ thought to young children’s learning, as discussed by the reviewer. The advice received is that it was overwhelmingly positively received.

During the review period, I presented this first paper to the Australasian Science Education Research Association (ASERA) Conference 2014 and I received positive feedback from the scientific community. The paper was revised on the basis of conference responses and reviewers’ feedbacks and sent back to the journal. I am awaiting acceptance of the final version of my paper.

Through the first paper (Chapter 4), small science introduces new knowledge to the field of early childhood science education.

***Small science*: Infants and toddlers experiencing science in everyday family life**

(Submitted to Research in Science Education)

Shukla Sikder and Marilyn Fleer

Abstract

Vygotsky (1987) stated that the restructured form of everyday concepts learned at home and in the community interact with scientific concepts introduced in formal school settings, leading to a higher level of scientific thinking for school aged children. But what does this mean for the scientific learning of infants and toddlers? What kinds of science learning are afforded at home during this early period of life? The study reported in this paper sought to investigate the scientific development of toddler (10 months to 36 months) growing up Bangladeshi families living in Australia and Singapore. Three families were studied over one year. Digital video observations were made of everyday family life and analysed using Vygotsky's theoretical framework of everyday concepts and scientific concepts (30 hours of digital observations). While there are many possibilities for developing scientific concepts in toddlers' everyday life, our study found 4 categories of what we have called *small science*: multiple possibilities for science; discrete science; embedded science and counter intuitive science. The findings of this study contribute to the almost non-existent literature into infant and toddler scientific development and advance new understandings of early childhood science education.

Keywords Cultural-historical; science; early childhood; infants- toddlers; play; family

Introduction

There is now a growing pool of research into science for early childhood education with a steady set of findings amassing over the last two decades (Archer et al. 2012; Evangelou et al. 2010; C.Rule 2007; Fleer 1991, 1997, 1999; Fleer and Robbins 2003; Hadzigeorgiou 2010; Martin et al. 2005; Robbins 2005; Shaw et al. 1992). This is because it is now understood that activities related to science can provide rich possibilities for supporting young children's learning and development (Hadzigeorgiou 2010). Consequently, researchers from all over the world, such as, Greece, Kenya, USA, Turkey, Korea, UK, Australia, and Brazil, have been engaged in conducting studies into science learning in early childhood period (Bayraktar 2011; Fleer 2009; Goulart et al 2010; Kim and Lim 2007; Ravanis and Bagakis 1998; Sackes et al. 2011; Shaji and Indoshi 2008; Traianou 2006). However, much of this research has focused on the science learning of preschool aged children. There is very little known about how families influence very young children's learning in everyday life (Johansson 2011) particularly scientific learning.

Children aged up to three years mostly depend on adults, especially parents or other adults in the family. Our interest in researching this age period centres mostly on knowing how family practices during this age support scientific learning, because we know that young children generally engage in play activities where they develop concepts about everyday life. How everyday concepts are transformed into scientific concepts during this age period is not well known. Additionally, it can be argued if children learn scientific concepts from an early age through everyday practices, they might develop more positive attitudes towards the study of science in their life (Hadzigeorgiou 2010). This paper presents the findings of a study which examined a range of everyday practices at home, and determined what kinds of daily activities lead very young children to develop scientific concepts. Our research seeks to fill a gap in understandings about how toddler's everyday life and playful activity at home helps shape scientific concept formation.

We begin this paper with an overview of a cultural-historical conception of play, followed by a theoretical discussion of play and everyday and scientific concept formation. We then give an overview of the literature that features early childhood science education research, noting those studies which have focused on toddler and infant development in science learning. We conclude the paper with the study design, the findings and their implications for early childhood science education.

Theoretical Understandings

Vygotsky (1987) used the term *scientific concepts* to name academic or discipline concepts. In line with this thinking, we discuss the development of scientific concepts for toddlers as *small scientific concepts* because we recognise and wish to make visible and to name the rudimentary form of concepts that could be presented to toddlers in everyday play situations. Vygotsky (1987, p. 167) noted that "Scientific concepts are not learned in final form-they too develop", and as such, we *seek to examine the process of scientific development of toddlers in everyday family life.* We draw upon cultural-historical theory to discuss these concepts further.

A cultural-conception of play: Vygotsky (1966) suggested that play is a prototype of everyday activity in a child's life. Children's play reflects the context in which it occurs, and in many ways play acts as a mirror for what is important in a culture (Dockett and Fleer 1999). In this situation, culture is not static; it is formed from the efforts of people working together, using and adapting material and symbolic tools provided by predecessors, and new ones that are in the process of being created (Rogoff 2003).

Everyday and scientific concept formation: One of the central defining features of Vygotsky's writing on play is his view that play provides a space for the conscious realization of concepts (Fleer 2008a). That is, "A cultural-historical view of concept formation, in young children, foregrounds the importance of context, in conjunction with the dynamic and evolving nature of concept formation" (Fleer 2009, p. 282). According to Vygotsky (1987), the concept is not a simple mental practice, but a difficult and proper act of thinking which cannot be mastered through simple memorization. There are two dimensions of concept development - everyday concepts and scientific concepts- which are related (1987). Vygotsky explained *concept formation* in the following way:

> The concepts are not simply a collection of associative connections learned with the aid of memory. The child's concepts can be improved to a higher level through consciousness. So concepts develop. At any stage of its development, the concept is an act of generalization which is Elementary Generalization and higher forms of generalization. Direct instruction in concepts is impossible. Then child does not learn the concept; only imitate the word through memory rather than thought (Vygotsky 1987 pp. 169-170).

As extended by Fleer (2009, p. 283), "at the everyday level, concepts are learned as a result of interacting directly with the world-developing intuitive understandings of how to do things". Since play is an everyday part of early childhood (Vygotsky 1966), it is expected that everyday play activities would support the development of concepts at a given age. For example, a toddler who rides a scooter over grass or a concrete path is engaged in an everyday play activity. A child who blows hot soup in order to cool it is engaged in a real life event, that is not play. However, these divisions are not always possible because blowing hot soup can be turned into a game, and a game can be turned into an everyday task. Similarly, the concepts learning through play and everyday life are also interrelated between everyday and scientific concepts. For instance, there are some spontaneous concepts that are inherent in the everyday play activity of riding a scooter, such as, setting the handles for direction, balancing the body to drive the scooter, using one leg to push (force) the ground so that the scooter will move forward according to the directions of the handlebars, or not when at rest on the scooter (equal forces acting). Concepts about push and pull to move the objects, to operate the handles to give direction, and to balance the body, are all developed during everyday play activities in a child's life. There are scientific concepts behind these everyday play activities, such as force and motion. However, children may not be consciously aware of the scientific concepts, such as the concept of force when riding a scooter. Vygotsky (1987) argued that spontaneous/everyday concepts help to progress the development of scientific concepts. However, scientific concepts are not automatically developed through everyday practices and their associated everyday concepts. There are some processes that are needed for developing everyday concepts into scientific concepts. Vygotsky (1987) explained:

> A system that emerges in the sphere of scientific concepts- -transferred structurally to the domain of everyday concepts, restructuring the everyday concept and changing its internal nature from above. The dependence of scientific concept on spontaneous concepts and their influence on them stems from the unique relationship that exists between the scientific concept and its objects. This relationship is characterized by the fact that it is mediated through other concepts. Consequently, in its relationship to the object, the scientific concept includes a relationship to another concept, that is, it includes the most basic element of a concept system (p. 192).

Therefore, when children learn the scientific concept in its final form, it is actually the combination of a set of concepts. For example, force as a scientific concept, can be understood through a set of concepts such as push, pull, motion, friction, and pressure. Every single concept cannot be developed at once, because each concept is learned through different everyday activities. Vygotsky (1987) argued that it is impossible for a child to learn scientific concepts in a final form, rather the child needs to go through the process of understanding, learning each concept as it occurs through the adult's assistance and participation. Additionally, scientific concepts are the potential outcome of everyday concepts through the process of instruction (Vygotsky 1987).

When this theorisation of the relations between everyday practices and scientific concepts are considered, it is possible to see the significance of the dialectical relation between everyday concepts and scientific concepts. Vygotsky (1987) clearly described the dialectical nature of concept formation in this way:

> Child's spontaneous concepts develop from below to above, from more elementary and lower characteristics to the higher, while his scientific concepts develop from above to below, from the more complex and higher characteristics to the more elementary (Vygotsky 1987, p. 219).

Fleer (2009) extended the process of concept formation in her research by stating that it is essential to find out how everyday concepts and scientific concepts can be connected within play based circumstances, so that it becomes possible to determine how pedagogical approaches in early childhood education build concepts during play. But how do everyday concepts in the everyday life of toddlers become a foundation for scientific concept formation? We now examine the literature in order to better understand infant and toddler learning of science concepts.

Literature Review

The focus of the study reported in this paper is on the scientific play of infants-toddlers. While there are many research studies on children's science learning in early childhood education settings, there are very few studies of infants-toddlers engaged in play that builds scientific understandings in family settings. In the section the research into children's learning in science is briefly reviewed in relation to those studies which are focused on infants-toddlers science experiences or learning in early childhood settings, such as family, childcare, preschool or kindergarten environment. As will be shown, there is a gap in the literature into infant and toddler learning science at home in playful contexts.

There are a number of studies reported in the literature on children's science and technology development between the period of 2001 and 2013. Some studies focus on technological media only, such as, Hall and Schaverien (2001), Keengwe and Onchwari (2009), and Bers (2010) and how children aged from three years develop their learning through technology. However, all of those studies concentrate upon children aged three years or older. There are some studies which examine how science is promoted through the reading of story books or in relation to educators using science journals as a source of support for science learning of young children. These studies (Pringle and Lamme 2005; Mantzicopoulos and Patrick 2011; Brenneman and Louro 2008) reveal how children can learn science through storybooks, texts or even through referring to pictures and information from journals, but they do not give insights into how these books are used in everyday life to support scientific learning at home.

Some researchers (Metz 2011; Siry and Kremer 2011) have found that children's engagement in science learning is central for developing science curricula. Many researchers (Baldwin et al. 2009; Bayraktar 2011; Brenneman 2011; Chang 2012; Hadzigeorgiou 2010; Kearney 2009; Martin et al. 2005; Nadelson et al. 2009; Sackes et al. 2009; Smolleck and Hersberger 2011; Tu 2006; Yoon and Onchwari 2006; Zembylas 2004) have investigated the teacher's role, teacher's ability, teacher's awareness, and teacher's understanding of science to develop children's science learning in kindergarten or pre-school settings. These studies show the importance of the role of adults in supporting learning, but these studies were all undertaken in formal educational settings, and therefore we do not know if these outcomes are relevant to family practices for supporting scientific learning.

We found very few science studies that explicitly concentrated on science learning of infants-toddlers in family settings. What we know is, that Forman (2010) did research about science experiments in the play events of two and three years old children. Forman (2010) presented data from play events and developed an argument that children acted like scientists during their play. Forman (2010) concluded that children could develop their thinking as a scientist through play and Forman (2010) noted that there was no need for direct instruction in science. It seems the researcher followed the child's interests only, and did not consider the social context surrounding learning through play, that is, we know very little about the family practices that surrounded the children's play. In a cultural-historical reading of science and play, it is important to consider child's everyday play or life in relation to his/her social situation, culture, environment, interactions with adults and peers. Fleer (1991, p. 97) argued, "Science learning in early childhood is better placed within a paradigm in which learning is viewed as being socially constructed" rather than as something that children somehow do by themselves. In an another study by Gopnik (2012) on scientific thinking of young children, s/he found that very young children (from age 2) demonstrated scientific intelligence gained from everyday thinking and learning. Gopnik (2012) used Probalistic models and Bayesian inference. This is a kind of quantitative measure which reflects certain type of results related to the certain situation. It does not represent the overall understanding of the development of scientific concepts, but rather focused only on children's scientific thinking or intelligence.

Taken together, it was noted that in the few studies that were related to toddlers and younger, researchers have not examined how everyday life may or may not afford science learning. In addition, these studies have drawn primarily upon a constructivist perspective in designed and implementing their studies, allowing for insights into what children can do or how they think in science. But they do not fully explore the social and environmental conditions naturally surrounding the child, as would be expected in a study of infant and toddler learning of science in everyday life. In our research we have used cultural-historical theory because this theory seeks to put centre stage how everyday concepts learned in everyday life are dialectically related to scientific concepts. What we do know of those studies which draw upon cultural-historical theory is that they are limited in number, that preschool aged children do learn really complex science concepts (Fleer 1991, 1992, 1996, 1997, 2009; Fleer and Beasley 1991; Siry et al. 2012; Tytler 1998; Tytler and Peterson 2000) in educational settings, such as kindergartens. While cultural-historical informed studies of science in the early childhood period have examined the scientific concepts of children aged from three to five or pre-schoolers and primary school aged children, we could not find any cultural-historical studies that focused on infants and toddlers learning science. Only one cultural-historical study was found that examined family context of young children's science learning (Robbins and Jane 2006). However, this study was focused only on the occasional interactions between pre-schoolers or early years of schooling aged children and grandparents and did not examine the everyday activities of children's regular life.

The literature reviewed has clearly shown that most of the studies undertaken are focused on children age 3 years and older in education settings. Only some of these studies have focused on family settings. Although two studies have been found about family settings on infants–toddlers' science learning, there is still a gap in this area of research. What has consistently emerged is that we know very little about how infants and toddlers experience science learning at home. This study seeks to fill this gap. In the next section we describe the research design, where we examine how toddler learning in science is shaped through everyday family activities in different family contexts.

Research Design

In our cultural-historical study, children's learning and development is conceptualised in relation to the child's perspective as they participate in everyday family practices (cultural-historical practices) where the circumstances in which they live and learn is considered as part of the study context (Hedegaard and Fleer 2008). Hedegaard (2008) puts forward a dialectical-interactive approach whereby the conditions and the child's development are conceptualised as a whole. A wholeness approach to studying children should encompass daily life across different institutional (e.g. family and school) settings, these are gained through the study of children from the perspectives of society (learning science is important), institution (family) and the individual (specific focus child) (Hedegaard and Fleer 2008).

This holistic approach allows the researcher to gain a picture of the everyday family practices, the activity settings that families create (e.g. meal times), and the play activities of the family. Thus, from the dialectical-interactive view, the research based upon this conceptual model "conceptualises children's activity settings in relation to practice traditions, where it is possible to follow changes in practices and activity settings over time and identify qualitative changes" (Hedegaard and Fleer 2008, p. 11).

Research Questions: This study sought to investigate the nature of the scientific interactions that took place in the everyday life of toddlers (10 months to 36 months) in different play contexts at home and in the community over a period of one year. The research questions driving the study were:

1. What are the everyday concepts that families developed during everyday interactions and activities with infants and toddlers that are foundational for later science learning?
2. What are the possibilities for scientific development in everyday family practices at home for infants and toddlers?

Sample

Sampling is a key aspect of the research design for any research project (Newing 2010) and in this study we have used targeted (also known as purposive) sampling: "Targeted sampling involves intentionally selecting those cases -usually people who are most relevant to study" (Newing 2010, p. 73). The study researched children of Bangladeshi families who live abroad. The first named author is from Bangladesh. To gain authentic data it was deemed relevant for one of the researchers to speak Bengali and to understand the context of the families participating in the study. This allowed for easy entry into the daily settings of the researched persons and to understand the context of family play in depth.

Three Bangladeshi families participated in the study. Three children (one boy and two girls) and their families temporarily living in different countries (Singapore and Australia) agreed to be involved in the research. The age range of the children was 10 months to 36 months. One boy namely Barnan (pseudonym) was observed from the age of 10 months to 13 months in Australia. Jhumki (pseudonym) was observed from the age of 23 months to 28 months in Singapore and Joy (pseudonym) was observed from the age of 30 months to 36 months in Australia. Therefore, the age range of the participant children covers the whole infant-toddler period.

The aim of the sampling design in qualitative research should be to make sure that "enough data is gathered to give an accurate understanding of the issue under investigation and the different perspectives that are present in the study population" (Newing 2010, p. 75). Considering the aim of a sampling design, three children from three Bangladeshi families gives enough data for gaining insights into such an under researched area. It is beyond the scope of this study to generalise findings to a particular population. The study only seeks to gain insights into the science-learning possibilities of the three families. Further studies across contexts would allow for a deeper understanding of the target population.

Data Gathering Method

Video camera, still camera and voice recorder were used for collecting data. These tools have a long tradition in educational research, as noted by Flick (2006), who suggests that they help to collect qualitative data. Particularly, children can be observed and studied in their daily settings by digital observations and researcher can revisit the data which allows for later discussions with participants (Fleer 2008b). In addition, visual data can be viewed from the perspective of the child (their intentions) and the perspective of a family member (their intentions and reactions), data can also be analysed in a dialectical-interactive way (Hedegaard and Fleer 2008). This gives the possibility for a duality of interpretation – what is the adult's motives and intentions for the child, alongside of how the child responds and shows agency in the everyday family situations. To achieve this, the researcher used one camera to follow the focus child and their parents (mostly mother) as they interacted in everyday situations at home and in the community. Observation sessions usually lasted forty five minutes to one hour and took place mostly during the period the family nominated as the play time or suitable family time for their infant or toddler. Video observations afford a rich and complex data set for gaining insights into science opportunities in everyday interactions and play in family settings not easily achieved through simply using field notes. The video observations and interview data that were gathered for this study are shown in table 1.

Table 1 Details of sample and data gathering

Partici pants	Age Period	Location	Data Gathering tool	Times of visit	Hours of video data	Interview of Parents
Jhumki	23 months to 28 months= 6 months	Singapore	Video camera, still camera	15 times	6 hours	One final interview after viewing the data (field notes). Every time has been interviewed about the activity in each visit (field notes).

Barnan	10 months to 13 months=4 months	Australia	Video camera, still camera, voice recorder	11 times	12hours 12min19 sec	One final interview after viewing the data (video camera). Every time has been interviewed about the activity in each visit (voice recorder or field notes).
Joy	30 months to 36 months=7 months	Australia	Video camera, still camera, voice recorder	10 times	11hours 42 sec	One final interview after viewing the data (video camera). Every time has been interviewed about the activity in each visit (voice recorder or field notes).
					Total video data= 29 hours 13 min 1 sec	Three final interviews and several small interviews in relation to activities.

A total of 30 hours of video data were collected. As part of the study design, the parents had the opportunity to see all the video data relevant to their family for the final interview. Additionally, interviews took place in situ during each data collection visit, and were captured as field notes or audio recording. The overall data were gathered over one year, thus giving the possibility for more in depth data analysis for the full infant to toddler period for one child.

The role of the researcher: In this study the researcher has a dual position - as a researcher, and as a research participant. This is conceptualised as a double move because the researcher needs to gather data, but also she must engage with participants as human being in the research site (Hedegaard and Fleer 2008). It is not possible for a researcher to stay out of the data gathering context when studying infants and toddlers.

Analysis

In a cultural-historical theorisation of researching with young children, Quinones and Fleer (2011) created the methodological tool of Visual Vivencias for studying children aged three years and younger which conceptualises both the theory and the tool of capturing young children's everyday settings. Visual Vivencias is "an analytical tool to further understand visually the child's emotional experience of the event" (Quinones and Fleer 2011, p. 123). Since the study focuses on children aged one to three years, Visual Vivencias is an appropriate tool for identifying emotionally charged situations in the data because the concept of Visual Vivencias draws attention to the levels of engagement by children and/or family members interacting at that moment of a scientific learning possibility. We used this concept to identify meaningful data for analysis across a range of ordinary everyday interactions that were occurring between infants/toddlers and their parents going about their life. That is, we looked for *moments of science learning* in everyday life where a high level of infants-toddlers engagement in everyday concepts was evident (e.g. intense eye contact; extensive handling and studying of materials, exclamations, copying of actions with energy and attention).

Hedegaard (2008) outlines three ways of interpreting data, which are 1) common sense interpretation, 2) situated practice interpretation, and 3) interpretation on a thematic level. In a common sense interpretation, the researcher interpreted a single video clip in an activity setting (e.g. potential moments of scientific exploration or engagement, e.g. burning a tongue on hot food or closely observing an adult blowing hot food). A series of video clip across several activities settings has been inferred by the researcher through situated practice interpretation (e.g. many examples of the same everyday concept, such as blowing air over hot food). Finally, theoretical concepts are used to find the answer related to research question on a thematic level (e.g. attention on scientific concept, heating-cooling continuum).

Since toddler speech is not matured enough to express verbally their understandings, the researchers tried to make the linkage between children's everyday activities and the scientific concepts central for the analysis in order to determine the intentions of the toddler (Hedegaard and Fleer 2008). The central construct for analysis has been done according to Vygotsky's (1987) dialectical relation between scientific concept formation and everyday concept in everyday context where the intentionality of the infant-toddler and the adult were examined closely. Data were analysed using everyday and scientific concepts through the three levels of interpretation outlined by Hedegaard (2008).

Findings

There were two main findings of this study. The first finding related to identifying small moments of everyday activity that were occurring for all the infant-toddlers in this study. We have termed this first finding as *small science*. An example of one distinct moment in science learning is shown below: (1) *small science*—press hard, push, roll and change of state of matter under force (academic concept). This is followed by a summary of all the *small science* identified through this study. Here, an example of *small science* experiences is illustrated. This example was analysed, illuminating the second finding of the study, where four categories of *small science* were identified: multiple possibilities for science, discrete science, embedded science and counter intuitive science. Table 3 summarises these categories.

We now turn to a detailed example of *small science* found as a result of the study. The vignette gives insights into how an infant/toddler and his parents foreground *small science* moments in everyday life. The example shows how the *small science*s are promoted in this particular play situation, but this example is also illustrative of how *small science* can or does occur generally for infants and toddlers, thus giving important insight into pedagogy for science education for children below the age of 3.

The Vignette

Activity settings: Preparing different shapes with playdough through a playful context

Date: 17 September 2012, Location-Singapore,

Participants: Jhuma (Jhumki's mother), Jhumki (23 months), Jhumki's teddy bears. Total video length: 50 mins and field notes on the day

Small science—press hard, push, roll, and change of state of matter (dough becomes elephant, finger, doll, duck, cake) - Force

Jhuma has one paper and two play dough containers on the floor. Jhumki looks at the containers, sits on the floor, and tries to open the containers. Jhuma is busy with something. R1 sits beside Jhumki and opens the lid of the containers. Jhuma brings some different shapes, different coloured dough, and one pressing toy. Jhuma takes some play dough and starts to do rolling and says to Jhuma, "Please follow me".

Jhuma: Jhumki, roll by turning around your hand and make a dough ball.

Jhumki follows her mother and rolls out the dough. Jhuma takes the pressing toy and presses the dough to make it flat.

Jhuma: Jhumki, look what I am doing (2/3 times)? I am pressing the dough.

Jhuma: Press, press, press.

Jhumki goes to R1 and observes her mother's activity through the video camera. Jhuma makes different shapes by using shapes such as an Elephant.

Jhuma: Elephant, wow! very nice.

Jhumki goes back to the play context after some time. Jhumki brings all of her teddy bears to play with her. Jhuma helps her to set the bears in the play context.

Jhuma: Press you doll shape (2/3 times) on the dough and make a doll. Jhuma holds Jhumki's hand and helps her to press hard.

Jhuma: Jhumki, press/push a duck biscuit cutter (3/4 times) on the dough. Jhumki pushes the duck shape biscuit cutter then Jhuma helps her to push hard and take out the duck shape from the cutter. Jhuma makes sounds like quack quack. Jhumki also says, "quack, quack".

Jhuma again takes the dough and makes Jhumki's finger shape by pressing her finger into dough. R1 helps her to do so.

Then Jhuma starts to make a birthday cake with the dough as Jhumki's birthday is coming soon.

Jhuma makes two layers of the cake and starts to sing "Happy birthday song". Jhuma prepares candles and puts them on the cake and Jhumki does the same thing. Jhumki wants one birthday hat and her mum makes one with dough. Then she pretends to cut the cake with the plastic toy knife by pressing the knife and her mum sings the song. Jhumki also sings the song.

They are making another shape. Jhuma holds Jhumki's hand and supports Jhuma to press correctly into the dough. Jhumki does it by herself.

Jhuma: Good, well done.

They make another cake and Jhumki helps her mum to cut the cake. Jhuma also mentions the dough's colour such as red, yellow and green throughout the play moment. Jhumki repeats the colour name.

Then Jhumki takes the dough and presses with the one finger cutter and presses by herself and make a finger shape. Jhuma and R1 clap hands and encourage her to do the same.

Jhuma tells her the name of the shapes. Jhumki touches all the shapes and tries to follow Jhuma by saying the names. Jhuma repeats the whole process three/four times (roll, press hard, push the cutter, turn the dough into a shape) and explains the process every time to the child. Jhumki follows the steps at all the times, doing exactly what her mother's does. R1 also participates as a passive play partner as required.

Interpretation of the Vignette

The play event is derived from Jhumki's regular play activities in the home. She appeared motivated to engage in the play moment. Jhumki was familiar with the materials and the process/steps of the event. Play is integrated into everyday family practices (Elkonin 2005) as they celebrate a birthday in the play context. The context was the combination of everyday activities (birthday moment) and using play materials to make different shapes, such as a cake, elephant and doll. Elkonin (2005) has argued that children want to act like adults. This was evident when Jhumki acted like her mother, pressing out the dough in exactly the same way as she did. Under the age of three, play is serious business for children (Vygotsky 1966). Jhumki took the play activity very seriously and concentrated on the preparation of the different shapes.

Jhumki learned *small science* concepts such as to press hard, to push, to roll and to turn the play dough into shapes (e.g. as a doll or duck through her mother's simple scientific narration to accompany these movements and moments). Jhumki's play motive in this event, and her interest to make different shapes, had a serious purpose (Vygotsky 1966). The language of push, press hard, and roll, as symbolic of actions of force, represent moments of *small science* that occur during positive and engaged playful interaction at home. At this stage, we can say the academic concept of force will not be learned completely. However, it will become incrementally understood through the learning of *small science* concepts such as push, press hard, and roll in everyday life. As Vygotsky (1987) stated, it is impossible for a child to immediately learn scientific concepts in a final form; rather, the child needs to experience the processes of the concept in everyday situations before conceptual development is fully established. The concept of *small science* helps name this incremental process that is so relevant for infants and toddlers experiencing science concepts in everyday life. Jhumki's everyday play activities through this event helped her to experience these science concepts as small science moments.

Also, Jhumki understands how dough changes shape through the process of pushing, pressing, and rolling. This one example of everyday science play illustrates how everyday situations are not only filled with small science moments but that families give these moments scientific meaning through how they narrate these events. In the case of Jhuma and Jhumki (see also Table 2 below), it is evident that *small science* moments were being narrated regularly in everyday playful situations.

This is also represented in Figure 1 below, where the relation between everyday life events, and *small science* moments across one event, yielded two different science concepts to be experienced. Jhumki learning from these experiences would not constitute completed scientific concepts, but rather it is the beginning of the process. It is unlikely that this two year old girl, Jhumki, will know the completed scientific concepts, such as what is Force. However, the process of understanding the concepts can start from early age, as the vignette shows. Jhumki understands the experience of the *small science* concepts, such as, roll or press firmly. As noted by Vygotsky (1987) "Like the formation of spontaneous concepts, the formation of scientific concepts is not completed but only begun at the moment when the child learns the first meanings and terms that function as their carriers" (Vygotsky 1987, p. 179).

Vygotsky (1987) argued that scientific concepts develop in educational settings through adult assistance and participation, and here the scientific concepts means concrete academic concept. According to this theory, it is understood that children under age three cannot learn the concrete academic concept. However, *small science* can be learned through everyday activities or everyday playful contexts, as was shown in the example above. Experiencing *small science* helps explain the process of how a series of *small science* experiences can in time lay the foundation for learning the concrete scientific concept in future. However, *small science* concepts need to be noticed by children, and if they can apply their understanding in similar or different contexts, then we can say children have learned the *small science* concepts. That is, children use scientific concepts in a voluntary manner, and this constitutes the nature of knowing a scientific concept (Vygotsky 1987).

The idea of *small science* captures the simple scientific narration that we see accompanying the everyday scientific moments that infants and toddlers experience at home with their families. However, *small science* also includes the infant and toddler engagement in these moments. That is, both the narration of the adult in that moment, and the engagement of the infant/toddler in that moment, constitutes what we have termed *small science*. This dialectically relation is also shown in Figure 1.That is, everyday concepts help to progress the development of "scientific concepts and scientific concepts blaze the trail for the everyday concepts" (Vygotsky 1987, p. 169). *Small science* constitutes this progressive zone or trail identified by Vygotsky (1987). As such the concept of *small science* helps explain the small incremental moments of learning science that can and does occur all of the time. The concept of *small science* makes visible what infants and toddlers experience, but which until now, has not identified in the literature.

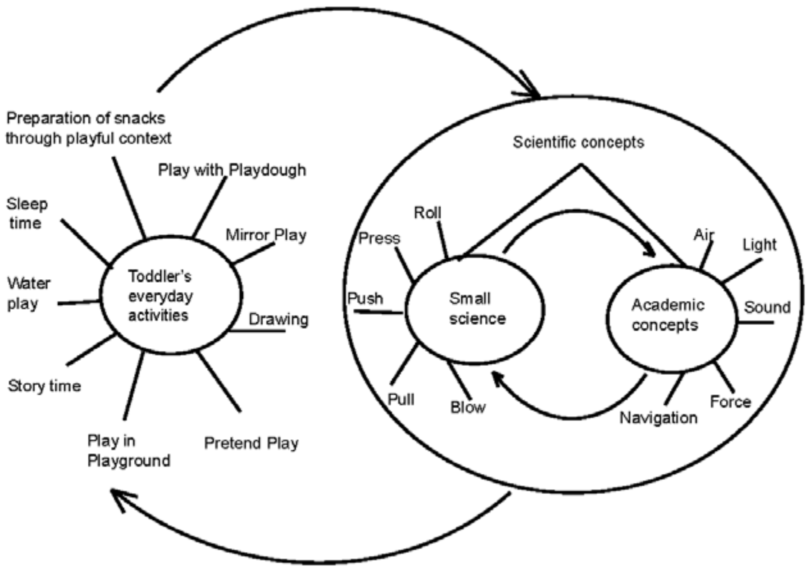

Figure 1 Dialectical Relations between everyday concepts through everyday activities and scientific concepts (academic and *small science*)

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The development of everyday concepts through everyday activities will foreground those elements that have been identified in the cultural-historical literature on play, such as, logical order, rules in games, interpreting a consequence, application of materials, object meaning and meaning object (Vygotsky 1966) and also those derived from our general knowledge such as, mixing ingredients, making different shapes with dough, learning to ride a tricycle follow the instructions, and playing with a range of toys that make a sound. In Figure 1 above we can see this relationship. Here scientific concepts are divided in two ways, one is academic concepts and another is *small science* concepts as representing the trail of multiple *small science* moments. Academic concepts represent the abstract concept (Vygotsky 1987) such as Force, air, light, sound which require a verbal definition and understanding. While small scientific concepts, such as push, pull, blow, pressure, floating and sinking, are the simple scientific narrations that accompany the everyday possible scientific moments. These *small science* concepts are the runway for developing concrete academic concepts in a completed form that would be expected to be fully understood in the future. The *small science* concepts are determined only in the narration in the moment and only under the condition of the child's active engagement in that same moment.

A range of small science possibilities

Many examples of *small science* moments were noted in this study. It is evident that a broad range and number of *small sciences*, such as push, pull (force), colour (light), pressing buttons (sound), and insulation were being promoted in the everyday activity settings across the families studied. Data from all three participants in the different context were examined in order to determine the essence of the scientific concepts that were being promoted in various everyday settings. We have divided scientific concepts in two ways; one is academic concepts as outlined by Vygotsky (1987) and the second is in relation to the *small science* noted across families as a major finding of this study. Table 2 shows the range of *small science* that emerged from the data.

Table 2 Range of *small science* possibilities in everyday settings at home

Activity setting	Everyday Concept	Scientific concepts	
		Small science being promoted in everyday settings	Academic Concepts
Trying to swim in the swimming pool (everyday activity), Playing with water in the pool (Playful event)	1.In the process of learning to swim in the pool experiencing force in the water; inflated objects for water play 2. Rules of swimming	1. Floating 2. Sinking 3. Pushing 4. Pulling 5. Spinning	1. Force
Play with play dough (playful context)	1.Making different shapes with dough 2. Application of materials	1. Rolling 2. Pressing 3. Pushing 5. Spinning 6. Colour	1.Force 2. Materials and how they behave
Preparation of real snacks through playful context	1.Cooking chapatti (snacks) 2.application of materials 3. Concepts of shapes 4. Follow the instructions 5. Mixing ingredients	1. Push, 2. Pressing hard, 3. Rolling 4. Blowing air over heated objects 5. Increasing or decreasing fire to create more or less heat 6. Change of state of matter	1. Heating and cooling continuum 2. Change in the materials as a result of heating 3. Force
Discover a treasure box (playful context)	1.Playing with a range of toys that make a sound 2.Application of materials	1. Making sound - tiger roar, flute sound, box sounds 2. Colour (orange and black) 3. Hard, soft (texture) 4. Pressing buttons 5. Blowing a flute	1. Sound 2. Light 3. Materials 4. Force
Pretend Play (Develop a zoo and a playground with blocks, do picnic in the park with all the animals, use playdough)	1. Know the different animals and where they live, and how they live 2. Rules in games 3. object meaning and meaning object 4.logical order	1. Saying animal names, matching animals to food 2. Loud roars. Talking about the sounds animals make 3. Colour of the animals – shades of colour 4. Constructing a playground with	1. Animal habitat (Food habitat, movement habit) 2. Differentiate sounds (Sound made by animals 3. Light 4. Force 5. Heating and cooling continuum

		block e.g. sliding, seesaw 5. Blowing food to cool it	
Riding tricycle in home (playful context)	1.Learning to ride a tricycle 2. Rules of riding tricycle	1. Push and pull 2. Resistance of surfaces riding over 3. Press horn	1. Force 2. Sound (horn)
Mirror Play	Identification of body parts	1. Seeing self (reflection)	1. Human Body
Sleep time (everyday context)	Emotion – being in the dark	1. Switch light on/off 2. Shadows	1. Light
Eating Ice cream from IKEA Shop and operate the machine to get the ice cream (everyday context)	1.Experiencing the ice-cream melting 2. Application of materials 3. Logical order	1. Melting	2. Change of state of matter
Travel by metro train (everyday context)	1. Operation the top up machine (using touch screen) 2. Application of materials 3. Logical order	1. Pressing button, 2. Tap card on card reader for opening the gate	1.Force

According to the full data set summarised in Table 2 and analysed further and presented in Table 3, the activity setting shows evidence about context and about what are the everyday concepts that can be learned through these activity settings. It was found that *small science* concepts were actively promoted through these everyday activities. It was noted that playful contexts afforded the richest possibilities for collectively experiencing *small science.* All these *small science* concepts together form the basic experientially based everyday concepts that develop infant-toddler understanding about academic concepts in future. As stated by Vygotsky (1987), a system of concepts is supporting to develop the scientific concept. As was shown in the vignette above, we know that one experience does not just promote one concept. There are other science concepts evident in this one example, such as colour, identification, sounds, and so on.

Categories of *small science*

In examining all the data (summarised in Table 3), we noted a clustering of *small science* moments. Four categories of *small science* were found across all the activity settings analysed. They were:

1. Multiple possibilities for science;
2. Discrete science;
3. Embedded science and
4. Counter intuitive science

They are shown in Table 3 below.

Table 3 Types of *small science* in everyday activity settings

Categories of *Small science*	Activity Settings	Every day concepts	Scientific concepts
Multiple possibilities for *small science*	Preparation of snacks	1. Mixing Ingredients 2. Follow the instructions 4. Cooking 5. Concept of shapes	1.Force (push hardly, press, roll) 2.Correlation 3.Properties 4.Change of state of matter 5.Heating and Cooling continuum
Discreet Science Concepts	Mirror play	Identification of body parts	Human body
Embedded Science	1. Day time 2. Night time (switch on-off) 3. Breathing	Emotion	1. Light and Dark 2. Air 3. Breathing process
Counter Intuitive Science	1. Sunrise and sun set 2. Moon follows me	Historical development of knowledge	3. solar system (Earth is moving The position of earth in the universe)

This table shows understanding about the variation of *small science.*

Multiple possibilities: There are multiple possibilities for *small science* through one activity. Multiple possibilities for *small science* can be created through one event. For example, preparation of different shapes contains multiple possibilities for *small science* as discussed in the vignette above.

Discrete: Another *small science* noted in this study was discrete science concept. Discrete science concepts shows one activity that generally would not go in multiple direction, but rather only allows for one science learning to occur at a time. For example, when children play in front of a mirror, they may identify their body parts, which is an everyday concept most relevant to infant-toddlers. .

Embedded: There is another kind of *small science* that we may never notice though we experience it regularly in our everyday life. For instance, children experience day and night everyday through their emotion. If we are conscious about this experience then toddler's can learn easily about the scientific concepts of light and dark. Conceptual work around this giving children scientific lens through children's every day experience. Adults become narrator for the child such as in noticing and naming day and night, in discussing darkness as the absence of light when turning off lights at night, or commenting upon the air when breathing.

Counter intuitive: We classified *small science* in another way, which is counter intuitive science. This *small science* is exactly opposite of everyday experience. We have learned many concepts through longstanding historical development of knowledge, as noted in our understandings of the solar system. Historically, a geocentric view dominated thinking in the science community. Thinking differently about the solar system, such as the Earth not being the centre of the solar system, is counter intuitive to what children see each day. For example, children always mention that the moon follows them. This is a very regular everyday incident. A scientific understanding of the solar system can only be learned in relations with someone who has this knowledge. It cannot be learned by simple observation.

Conclusion

There is a big gap in what we know about how scientific concepts can be promoted at infant and toddler age. The study reported in this paper fills this gap by introducing the concept of *small science*.

The findings of the study have shown that everyday activities, either in a playful context or through regular family practices, such as playing with play dough, mealtimes and sleep time (learning about day and night), create opportunities for developing *small sciences* concepts in toddlers' everyday life. However, we know that infants–toddlers experience these types of everyday activities in relation with others. Then why did Vygotsky suggest that scientific concepts are not developed from an early age? "… regardless of when an everyday concept is formed, everyday concepts are central, not alternative, for developing a scientific concept" (Fleer and Pramling 2015, p. 31). What are the requirements for developing scientific concepts in everyday contexts?

In the vignette described above, Jhumki was fully attentive during the play episode. She was fully motivated by the event as it was part of her regular play practices. Kravtsova and Kravtsov (2011) state that a child's motives are central for making conscious and purposeful actions, concepts and events surrounding young children. The playful event of working the play dough was purposeful for both (mum and child) for different reasons. The adult was trying to promote the *small science* concepts through the event. Conversely, the child's goal was trying to make the shapes like an adult, since the child always likes to be like an adult. As we know, young children are more object or action oriented, rather than focused on meaning or abstract concepts at this young age (Vygotsky 1966). As Vygotsky (1987) argued:

"Perception is the dominating function of activity in early age (before preschool age)… Nonverbal and non-meaningful perception transferred to meaningful and verbal object perception during the transition from infancy to early childhood. However, meaningful perception is generalized or abstracted perception… The foundation of conscious awareness is the generalization or abstraction of the mental process, which leads to their mastery… Conscious awareness enters through the gate opened up by the scientific concept" (pp. 189-191).

Although young children are more involved with objects or actions at an early age, the process of scientific concept formation can start at any age. It is evident that scientific concepts have a unique relationship to the object and, as has been theorised previously, this relationship is mediated through other concepts. For example, force can change the shape of something. The child does not understand the abstract concept of "force" at first. The child needs to relate force with other rudimentary concepts, such as press, roll or push, pull, and then finally, it becomes meaningful to him/her. What we can say is that if we want to know about a child's development in science, then, we need to know the process of scientific development experienced by the child. It has been understood that concepts never exist on their own, but rather, they are always part of a system of concepts that are related.

We have shown through this study that the development of scientific concepts in the infant–toddler period is more than simply a dialectical relation between everyday and scientific concepts, but rather, there are four ways in which this relation occurs (multiple possibilities, discrete, embedded and counter intuitive), and that the idea of *small science* helps to explain the process of learning science within this very early age period.

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Chapter 5: Social Interactions in Small Science Moments

"Man [sic] is a social creature, that without social interaction he [sic] can never develop in himself any of the attributes and characteristics which have developed as a result of the historical evolution of all humankind".

(Vygotsky, 1994, p. 348)

Background of the second paper

Having established in my first paper the concept of small science to capture and name the science learning possible during the infants-toddlers age period, then it was obvious to me that I needed to know how the science concepts were developed. The second paper (Chapter 5) seeks to answer how small science is possible and under what social context. I reviewed the data table (see appendix A: Table 5), which provided me with an overall understanding about the data. In particular, I looked at the column where I recorded child and parent's position in each context. It is impossible to show all the contexts from the data set (almost 30 hours of video data) for discussing the parent's role and social context in one paper. Therefore, I have used table 3 (see chapter 4, paper 1) as an analytical framework for analysing the data.

Table 3 describes four categories of small science and each category provides examples of one activity setting along with everyday concepts and scientific concepts developed in that setting. Consequently, I have chosen four activity settings from the data set in relation to four categories of small science. Since the data shows that the parents' role is very important to develop small science in young children, then I selected the cultural-historical concept of the relations between the "Ideal and Real form" from Vygotsky's (1994) writing on "the problem of the environment". I also used a system of concepts for the analysis, which include the social situation of development

(Vygotsky, 1998), and the development of higher mental functions (Vygotsky, 1997b). These systems of concepts supported me to understand the parent's role and the role of the environment for framing young children's science concept formation during the infant-toddler period. In the paper, I have described the details of four contexts (four vignettes) using four categories and show how parents and children collaboratively act in each context. The paper provides the details of the empirical evidence of *how* infants-toddlers can learn small science concepts in their everyday context with the support of parents.

I presented the paper at a symposium at the International Society for Cultural and Activity Research (ISCAR) Congress in 2014. I received some valuable suggestions from the Congress delegates and incorporated the suggestions into my paper to improve it further. Finally I submitted the paper to the Journal of Cultural Studies of Science Education. This is because I have used cultural-historical theory and studied science education in a variety of contexts. The aims and scope of Cultural Studies of Science Education is as below:

> Cultural Studies of Science Education aims to provide an interactive platform for researchers working in the multidisciplinary fields of cultural studies and science education. By taking a cultural approach and paying attention to theories from cultural studies, this new journal reflects the current diversity in the study of science education in a variety of contexts, including schools, museums, zoos, laboratories, parks and gardens, aquariums and community development, maintenance and restoration (Source: CSSE website).

According to 2010 ERA journal lists, Cultural Studies of Science Education (CSSE) is a "B" ranking journal. The SNIP (Source Normalized Impact per Paper) for CSSE is .531.

My supervisor co-authored this with me. I am the principal author and my supervisor is the second author. I have contributed 90% for writing this paper and my supervisor contributed 10% by writing and providing overall guidance to develop the paper.

During the publication process, peer review comments were forwarded and minor revisions were requested. I have provided two examples from two reviewers' suggestions and the way I responded to the comments as shown below:

Reviewer #1: This is a well-written paper which provides several examples to support the theories relating to the impact of parent-child relationships on a child's learning in science. Given the extent of the data collection, the authors presumably have many other examples, which would support their conclusions. Whilst there is not an expectation that other examples are provided here, a summary statement about the rest of the research, which highlights that these four vignettes are not isolated examples would have been valuable.

Response: We have tried to explain that the vignettes are not isolated and they represent the whole data set (see page 13, 15, 18, 25)

Reviewer #2: This paper is on an important research topic where as the author remarks there are few publications. It is written within the framework of Vygotsky and this both makes interesting reading and also raises questions about the influence of other research frameworks. In particular it focuses on parent- toddler learning in science at home.

The introduction of the term "small science" ..."as simple narration of everyday moments" needs more explanation.

Response: We understand that we should explain more about small science. Thus we have expanded the concept along with example (see page 7)

We have revised the paper based on the reviewers' feedback and sent the paper back to the journal. In addition, the Chief Editor provided some more feedback and we have edited the paper according to the Editor's suggestions. Next, another editor advised more revisions and we adhered to these suggestions. Finally, our paper was accepted, it took around five months for this process. The paper is not yet published but we have an acceptance letter.

The second paper provides an in-depth understanding of parent-child collaboration for developing small science concepts in regular everyday contexts. Each individual vignette reflects the idea of the categories of small science development found within the study of each family home context.

The relations between ideal and real forms of *small science*: conscious collaboration among parents and infants-toddlers (Cultural Studies of Science Education)

Shukla Sikder[1] and Marilyn Fleer[2]

Executive summary

Vygotsky (1987) stated that academic or scientific concepts require a level of conscious awareness on the part of the child within everyday situations. Academic concepts can be any kind of concept, such as science concepts, mathematics concepts, language concepts and so on. Vygotsky theorised how these academic concepts could be developed by school aged children, but he said less about the prior to school period. Scientific concepts do not instantly develop in their final form but rather follow a process of conceptual development guided through adult-child interaction. It is understood that not any kind of social interactions can be considered developmental, but rather it is interaction which is purposeful and which is viewed as useful for a child's development. Any kind of conceptual development requires the interaction with the ideal form as presented through adult interaction in social contexts. In any stage of development, ideal forms need to be present in the real context. Ideal in the sense that it acts as a model for that which should be achieved at the end of the developmental period; and in contrast, the real form represents the beginning point of child development (Vygotsky, 1994).

Many studies have documented the interactions between adults and children for developing scientific concepts in formal settings but little is understood about what happens in family homes for

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the prior to school age period. We do not know how scientific concepts develop during infants-toddlers everyday life at home. What kinds of social interactions in everyday family life support infants and toddlers to develop early forms of science concepts?

This paper presents the findings of a study of infant and toddler learning of science at home. A total of around 30 hours of video data were collected from three Bangladeshi families in Australia and Singapore. Three children aged from ten months to thirty-six months were filmed over one year in their everyday context. Informed by cultural-historical theory, the findings indicate that a form of conscious collaboration between parents and infants-toddlers is the key for developing *small science* concepts from rudimentary to final form. Small science has been defined as simple scientific narration of the everyday moments that infants and toddlers experience at home with their families. It was found that it was the families who filled the gap in understanding, through actively supporting the development of their infant-toddler's higher mental function. Here the relations between infant-toddler real forms of development were carefully considered by the parents in relation to the ideal form that they created through collective dialogue of small science moments in the environment. If infants-toddlers learn these small concepts in their everyday settings, it is probable that they could link these early forms of understandings to learning abstract concepts later in school. This study contributes to understanding the nature of social interaction patterns for developing small science concepts in the everyday context of family life. This paper also provides pedagogical suggestions for early childhood science education.

Key Words

Ideal and Real form · Cultural-Historical · Infants-Toddlers · Small science · Early Childhood Science Education ·

There are a huge number of studies examining the role of adults or parents on various types of development through everyday experiences or play in infants-toddlers life. Mothers' interactions with infants-toddlers create multiple possibilities for development, such as the effects of mothers on toddlers creative play (Cohen and Tomlinson-Keasey 1980), the effect of mother-infant attachment on exploratory behaviour, social behaviour, cognitive development, and language development (Main 1983), and how mothers influence toddlers' play as a play partner (Tamis-LeMonda and Bornstein 1991). In addition, this research shows how development is promoted through mothers' intention to play with toddlers (Damast, Tamis-LeMonda and Bornstein 1996), mothers' management skills in helping infants-toddlers developmental nature of play (Pierce 1999), and the relationship of infant-mother for developing infants' temperament (Crockenberg and Smith 2002). Further, mothers' multiple roles in developing toddlers' curiosity and exploration in positive or negative ways (Shin, Elicker and Nope 2004) have been noted and mothers' understanding and verbal stimulation for supporting social-emotional and cognitive development of infants has been presented (Page, Wilhelm, Gamble and Card 2010).

There is also some research into the father's role on infants-toddlers, for example, fathers extend toddler's present level of expertise through collaboration in pretend play (Farver and Wimbarti 1995); and father's interactive role as a support for toddlers development (Appl, Brown and Stone 2008).

We also found literature on the relation between adults and toddlers during play, where communication skills were developed (Mayer and Musatti 1992), where mathematical knowledge was enhanced (Lee 2012), and where toddlers solved problems with the help of their teachers (Gloeckler and Cassell 2012). It can be argued that parent or adult-infants-toddlers relationship has a significant role to play in children's development (Maas, Vreeswijka and Bakela 2013). What can be observed is that these empirical studies focus on cognitive development, language development, physical development, general child development, developmental nature of play, communicational development, the effect of relations in development, and curriculum development, such as mathematics. However, the literature does not empirically address how scientific concepts develop from birth.

We do not know whether or how scientific concepts develop in the infant and toddler age period. Only two studies were found on science related development in this age period. Alison Gopnik (2012) investigated children as scientific learners from two to four years old. She applied Probalistic models and Bayesian learning methods for deriving children's learning mechanism in relation to science. Gopnik (2012) found that very young children do learn spontaneously from their everyday experience. She argues that children's exploratory play is a kind of experiment for learning science, but she suggests that this approach is not ideal for learning science in institutional contexts. Gopnik (2012) also argues that children experience science intuitively in their early age and this understanding is foundational for inquiry based science education. She proposes that "science itself could help turn young children's natural curiosity and brilliance into better science teaching and learning" (Gopnik 2012, p. 1627).

In another study undertaken by George E. Forman (2010), who used a constructive approach for investigating two to three years old children's science understanding, it was noted how children learn science intuitively. The researcher collected video data from children's play context and analysed the data from the perspective of children's cause-and-effect thinking. Forman (2010) found that children do not need instruction to learn scientific concepts. Rather, Forman (2010) argues that they just need an advanced partner with them for developing scientific understandings of everyday life. These two studies show how children act as active science learners or scientific thinkers. However, even when mentioning the adults' role, they do not discuss how adults help children to develop science at such a young age.

Consequently, we need to know more about how infants and toddlers develop scientific thinking in everyday life. In particular, we need to determine the adults' role in the development of their scientific thinking at home and in the community. The study reported in this paper seeks to fill this gap by examining social interactions in everyday family life that supports the development of scientific concepts for infants and toddlers.

What do we know about the adults' role in the development of scientific concepts?

The general literature on the development of science concepts beyond the toddler period shows the importance of the adult's role, particularly the teacher's role for the acquisition of science concepts in formal settings. David Jerner Martin, Raynice Jean-Sigur, and Emily Schmidt (2005) claimed the significant role of the teacher in science learning for children from birth to eight years old. Jared Keengwe and Grace Onchwari (2009) investigated teacher's technological understanding for developing children's science learning. In their study, 12 early childhood educators were trained by an institute, whereby teachers learned how to integrate technology into their classroom over an 8-week period. The authors concluded that the institution expected teachers could comfortably use appropriate technology tools in their teaching for the development of young children's technological skills and science knowledge. In another study by Louis Nadelson, Rex Culp, Suzan Bunn, Ryan Burkhart, Robert Shetlar, Kellen Nixon, and James Waldron (2009) into teachers' perceptions of teaching the concept of evolution, researchers sought to examine how teachers engaged in the *science learning that was provided by the researchers.* The researchers provided science lessons that were aligned with the curriculum standards and teachers from two elementary local schools piloted the lessons. They found that young learners were capable and eager to learn evolutionary science. Mesut Sackes, Kathy Cabe Trundle, and Lucia M. Flevares (2009) found the efficacy of teacher's knowledge in effectively selecting supporting literature for the teaching of science concepts in early years of childhood.

Teachers' emotional engagement and teachers' support have been studied as part of improving children's science learning by Michalinos Zembylas (2004). Teachers' beliefs and positive attitude towards science in pre service primary school training can help to develop science teaching in school settings (Bayraktar 2011). It has been argued that teachers could create the opportunities for developing science concepts in children's life by practicing science concepts in classroom settings (Smolleck and Hersberger 2011). Science concepts can be developed in five year olds through drawing (e.g. pictures) with the guidance of teachers in kindergarten (Chang 2012). In reviewing these studies it is noted that although the teacher's role has been discussed as central for the development of science learning, parents' role has been ignored.

As might be expected, many researchers who draw upon cultural-historical theory to frame their research have explored how science concepts can be developed at an early age through scaffolding adult-child interactions. Marilyn Fleer and Warren Beasley (1991) claimed that focused interactions in the engagement of science tasks can enhance children's science learning in preschool. Back in 1991, Fleer conducted research into children's understandings of electricity where three to five year olds investigated batteries and bulbs when exploring torches. It was found that a socially constructed approach to teaching and learning was needed to contextualise children's exploration of electricity. Adult-child interactions were carefully focused to support discussions of circuits for successfully making torches, and also for developing understandings of an electrical current. It was found that an interactive approach to teaching science in preschools can change children's conceptual thinking, but it requires an active role for the adult in supporting conceptual development (Fleer 1992). Fleer (1996) also investigated how children's everyday experiences about science concepts at home can be extended to the teaching situation of childcare settings. She found parents' engagement in experiencing science concepts at home in children's daily life is essential for building scientific learning in the childcare setting because in the home the children ask scientific questions, whilst they did not in the childcare setting. She argued that the teacher can extend children's experience in childcare settings for learning science concepts when families and teachers work together to understand children's scientific curiosities.

Jill Robbins and Beverley Jane (2006) have also shown the importance of family in supporting scientific learning of young children. They have argued that science learning can occur through grandparents who can support young children's learning (one to twelve years old). These authors have found everyday concepts could emerge with science and technological concepts through authentic intergenerational interaction between grandparents and children. Children can develop knowledge of science concepts in real life meaningful experiences, such as gardening, cooking, mending, cleaning, playing in the sandpit, riding, and being with their grandparents.

Adult-child interactions have also been shown to be important when children are playing. For instance, Fleer (2009) found that scientific concepts can be learned in playful learning contexts where teachers act as mediators of science learning in preschool. As mediators, teachers need to pay special attention to consciously considering the scientific concepts in children's playful context through purposeful interactions. Further, Maria Ineˆs Mafra Goulart and Wolff-Michael Roth (2010) claimed that the kindergarten science curriculum can be conceptualised as a collaboration between children and teachers. Another study by Christina Siry, Gudrun Ziegler, and Charles Max (2012), who explored a kindergarten's everyday circumstances of water, found that children's science learning process was supported when science learning was developed through jointly investigating the scientific query in a collaborative way.

It has been evident from the review of these cultural-historical research studies that scientific concepts, science learning, even science curriculum can be developed through the collaboration between adults or teachers and children. However, most of the studies were done in formal settings with children aged from three to six years. Only one study discussed the parent's role (Fleer 1996), but the average age of the children in the study was from two years eight months to four years ten months. Another study (Robbins and Jane 2006) showed family involvement for developing science study in young children's lives. However, the focus was on the grandparent's role, whereas the parent's role was neglected.

What we have learned from the review of the literature is that we need to know more about parent's role to support infants-toddlers science learning in everyday family life. As such, we need to know more about how parents contribute to infants-toddlers' conceptualisation of early forms of science concepts. Consequently, this paper seeks to fill this gap by researching the different everyday contexts of infants-toddlers' life with a view to theorising possible pedagogical practices for supporting scientific development in this early age period.

In the next section the theoretical concepts informing the study design and findings are introduced.

Cultural-historical conceptualisation of ideal and real forms of small science

Lev Semenovich Vygotsky (1987) introduced the construct of scientific concepts or academic concepts, which required a level of conscious awareness in order to be transformative of everyday practice. Scientific concepts could be any kind of academic concepts, such as mathematics, language, science, and so on. Vygotsky theorised how these academic concepts could be developed during schooling for school aged children, but he said less about the prior to school period.

Scientific concepts do not instantly develop in their final form, but rather follow a process of conceptual development guided through adult-child interaction (Vygotsky 1987). Scientific concepts are not simply acquired or memorized by the child and assimilated by his or her memory, but arise and are formed through an extraordinary effort of the child's own thought (paraphrased from Vygotsky 1987, p. 176). An example of Force, is taken from real life and introduced here to explain the process of scientific concept development. "Force" is an abstract or science concept studied by school aged children. However, this concept does not develop at once. Push and pull are the basic ideas for understanding force (Gamble 1989). Therefore children need to learn push and pull concepts prior to learning the scientific concept of "Force" at school age. Many opportunities arise during children's everyday life to learn push and pull concepts during their infants-toddlers age through everyday contexts, such as riding a bike, playing with play dough, brushing teeth, and so on. At an early age, and not at the age referenced by Vygotsky (1987), these moments can be conceptualised together as opportunities for the development of small concepts. For instance, adults could take a conscious role in developing over time and with repetition the *small concepts* of pushing a bike/pulling dough. These moments are termed by Shukla Sikder and Marilyn Fleer (2015) as *small science concepts* (e.g. push/pull) and they need to be present to support children's understanding of everyday life prior to the time they learn the final abstract (Force) concept. As Vygotsky (1987) pointed out, formal or abstract concepts do not become active unless the concept relates to a child's personal daily life. Thus If infants-toddlers learn these *small concepts* in their everyday settings, it is probable that they could link these early forms of understandings to learning abstract concepts later in school. In this study, we examine how these small science concepts become ideal forms from real forms in everyday life during the infant-toddler age period.

Small science pedagogy can be thought of as simple scientific narration of the everyday moments that infants and toddlers experience at home with their families. It has been shown that small science, as a part of scientific concepts can be developed in the infant-toddler age (Sikder and Fleer 2015). It is argued that for the development of scientific concepts, the foundation of lower and elementary forms of everyday concepts must be generalised (Vygotsky 1987) in the form of many small science moments (Sikder and Fleer 2015). Sikder and Fleer (2015) present an example that helps to understand small science concepts in relation to academic or scientific concepts:

> Jhumki(around two years) learned small science concepts such as as to press hard, to push, to roll and to turn the play dough into shapes (e.g. as a doll or duck through her mother's simple scientific narration to accompany these movements and moments). The language of push, press hard, and roll, as symbolic of actions of Force, represent moments of small science that occur during positive and engaged playful interaction at home. At this stage, we can say the academic concept of Force will not be learned completely now. However it will become incrementally understood through the learning of small science concepts such as push, press hard, roll in everyday life. The concept of small science helps name this incremental process that is so relevant for infants and toddlers experiencing science concepts in everyday life. Jhumki's everyday

play activities through this everyday event helped her to experience these science concepts as small science moments (p. 13).

As Vygotsky (1987, p. 167) argued "scientific concepts are not learned in final form, they too develop". Similarly small science also develop gradually (Sikder and Fleer 2015), but how they develop from the real form to the ideal or final form in the home context is not well understood.

The relations between ideal and real form was introduced by Vygotsky (1987) to explain children's development. "Ideal in the sense that it acts as a model for that which should be achieved at the end of the developmental period; and final in the sense that it represents what the child is supposed to attain at the end of his development" (Vygotsky 1994, p. 346). In contrast, the real form represents the beginning point of child development (Vygotsky, 1994). For instance, a young child starts to babble at the starting point of his/her speech development which is the real form of the child's language development. The child gradually develops language skills by interacting and observing role models. Adults or parents represent the ideal form in this context. When the child is skilled enough to express their understanding through language, it could be considered to be the final form of language development. Since we are focusing on conceptual development of the child in relation to science, we have searched for conceptual examples. Vygotsky (1994, p. 348) hypothesizes one example to explain children's conceptual development of number:

> Imagine a child who will develop his [sic] concept of numbers, his arithmetical thinking, only among other children, who will be left to his own devices in an environment where no developed form of arithmetical thinking exists, rather than in school or in kindergarten, i.e. without any interaction with the ideal form of adults. What do you think, will these children get far in developing their arithmetical thinking? None of them will, not even the mathematically gifted ones among them. Their development will remain extremely limited and very narrow in scope.

This example explains the necessity of the ideal form of adult's interaction for developing a child's concept of number. Similarly, any kind of conceptual development requires the interaction with the ideal form as presented through adult interaction in social contexts. In order to understand the child's development of small science concepts, we look at another example. A toddler learns to *push* when s/he learns to ride a scooter. At the beginning, the child is unaware of the concept "push" as a part of scientific concept of "Force", but rather simply works with the concept in an everyday way. Then the adult shows the child how to push the scooter or they use the word "push" in many everyday situations, such as when riding a bike, or when on a swing. In these different everyday situations the adult's expression or action or verbalisation represents the ideal form (Vygotsky 1997).

What are the relations between the ideal and real forms in this example? The child consciously attempts to apply the everyday concept of push when riding a scooter after observing the adult's actions in this everyday situation. That means that the starting point of the child's unconscious *push* is the real form. However, when the child begins to act consciously, 'applying a push' as observed by the adult, we note a microgenetic movement towards the scientific concept. The purposeful action gives evidence of this movement in thinking and consciousness. However, everyday action and understanding is not necessarily a conscious act. Nor does the action show all the characteristics of the ideal form of understanding of the scientific concept of Force. But purposeful action is nevertheless representative of what has been observed by infants and toddlers in everyday family situations. As discussed above, we have captured this purposeful action through the concept of *small science* (Sikder and Fleer 2015). We argue that the concept in action or in words would need to be present in the child's everyday social and material environment if the ideal or final form of the concept is to be understood and used, as would be evident when infants-toddlers learn the small science concept *push* and consciously apply it on their own. Therefore in any stage of development, ideal forms need to be present in the real context. As Vygotsky (1994, p. 347) emphasizes, "child development will be very slow and proceed in an unusual manner if the suitable ideal form is absent in the environment".

Then what is the process to develop ideal forms of small science? Vygotsky (1998, p. 203) stated, "the social environment is the source for the appearance of all specific human properties of the personality gradually acquired by the child or the source of social development of the child which is concluded in the process of actual interaction of ideal and present forms". Vygotsky (1997) considers every higher mental function as social. Consequently small science as part of the development of higher mental function (scientific concept development) could be considered as part of the social development of the child. Lidiia Il'inichna Bozhovich (2009) interprets child development as qualitative transformation from one structure to another. Thus, the social environment is the source of qualitative changes in the child's life through the social interaction from one form to another form (Vygotsky 1994, 1997, 1998) which is also supported by Bozhovich (2009).

The child's experience in the environment, the child's engagement with objects, the conscious awareness of concepts, and the child's cooperation with adults, represent the basic characteristics of social interactions for the development of one form to another form (Vygotsky 1987, 1994, 1997, 1998). Thus, it is understood that not any kind of social interactions can be considered developmental, but rather interaction which is purposeful and which is viewed as useful for a child's development. In Figure 1 below is a diagram which shows our conceptualisation of the development of higher mental functions from real form to ideal form that informed our study.

Figure 1: The development of higher mental function from real form to ideal form in child's life through purposeful social interaction (Adapted from Vygotsky 1994, 1997, 1998)

As shown in Figure 1, the dashed line represents the real form and the plane line represents the ideal form. In each context, we see both forms influencing each other. Central here is the purposeful interaction between the adult and the infant-toddler for realising scientific development (Vygotsky, 1987). Purposeful interactions have also been noted by Gordon Wells (2008). He has established that scientific concepts, as cultural resources, are developed and used collaboratively in everyday life. Different forms of collaboration are documented in the literature, for instance guided participation (Rogoff, Moiser, Mistry, and Goncu 1989), socially constructed learning by Fleer (1991), embedded science thinking in sociocultural contexts by Robbins (2005), and collective cultural interactions by Fleer and Pramling (2015). There is evidence that science oriented collaborations are part of children's everyday social interactions.

In this study, we examine the social interactions, particularly the main interaction patterns found between parents and children as they are developing *small science concepts together, where development is conceptualised as a relation between the* real and ideal form in infants-toddlers everyday life. We ask: Can parents present the ideal form of science in their interactions in everyday contexts? What kinds of social interactions occur to support the development of science learning? What are the relations between the ideal and real form of scientific concepts in everyday life which support differing levels of conscious awareness of science in family homes?

Overview of the study

The human child is a social creature; the attributes and characteristics of the child can be developed only through social interaction (Vygotsky 1994). Similarly every higher mental function requires social interactions for developing from external means to internal means of mental functioning (Vygotsky 1997). Infants-toddlers experience various types of activities in their everyday life such as meal time, sleep time, bath time, play time. We already know at this age, that children develop *small* *science* concepts through these everyday activities in their daily life (Sikder and Fleer 2015). However, we do not know yet about the kinds of social interactions that are needed for growing *small science* in infants-toddlers life. Moreover, how these real life contexts create the ideal form of small science concept requires more study for this age period. In this study, we particularly examine the following questions:

1. How do parents in everyday family life support infants-toddlers to develop their small science concepts?
2. What kind of social interactions support the development of small science concepts in infants-toddlers life?
3. What are the social relations between real forms and ideal forms of science for the development of small science concepts of infants-toddlers?

Who participated in the study?

Three Bangladeshi families (Singapore and Australia) were involved in this study. This included one boy and two girls aged between ten months to thirty six months. Ethics approval was granted for conducting this study by an authorized Human Research Ethics Committee. The children were observed as shown in Table 1 below:

Table 1: Participants at a glance

Participants	**Age Period**	**Duration of data collection**	**Location**
Barnan	Ten months to thirteen months	Four months	Australia
Jhumki	Twenty three months to twenty eight months	Six months	Singapore
Joy	Thirty months to thirty six months	seven months	Australia

Pseudonyms of participants have been used. In drawing upon cultural-historical theory, this study focuses on the process of science concept development. Therefore, the researchers have tried to collect data over four months/ six months/ seven months in one child's everyday life so that the child's progression of learning science could be better understood.

How we collected the data

The data have been collected through video camera, still camera, voice recorder, and field notes by two researchers (the first named author and one research assistant) and the families. For gathering qualitative data, these instruments have a long tradition (Flick 2006). Video observations (n=30 h) of three families engaged in everyday activities, including meal time, sleep time, outdoor times, play times, bath times, story time were undertaken. A total of 36 visits were made either at home or during outdoor family activities (e.g. going to the park). Each session lasted about forty five minutes to 1 hour according to family routine or as nominated by the family.

A still camera was used to document images that were relevant to the focus of the study. Researchers, parents and even children captured images that were used as data in this study. A still camera was given to the family for taking the relevant pictures. Parents took some pictures and children also captured images by themselves during the everyday context. In addition, sometimes parents used the video camera for collecting data when the researchers were absent such as night time or weekend. Five hours video data were collected by parents and twenty five hours video data were gathered by the researchers.

Digitally observing children in their regular contexts allows researchers to re-visit data sets and to discuss relevant issues about the study with participants at a later time (Fleer 2008). The researchers set interview questions after observing the visual data and returned to families to ask questions in relation to the visual data. Three final interviews were conducted with parents (three mothers). These interviews were also video recorded except for one mother's interview where field notes were recorded. Interviews were completed after each observation session, where the video camera, voice recorder or field notes were used primarily as the main sources of data collection. Field notes were written after each visit to the participants' homes.

The position of the researcher

In line with cultural-historical theory, Mariane Hedegaard (2008a) has argued that the researcher must be integrated into the study site. Researcher positioning was determined in two ways in this study. The first focuses on the researcher collecting data from the family home in relation to the children's everyday life using the instrument of the video camera. In the second position, the researcher acts as a participant by asking questions to parents or children and or responding to questions or conversation while gathering data. These dual positions allowed the researcher to gain more meaningful data.

Analysis

Sikder and Fleer (2015) formed four categories of small science concepts which conceptualise both the theory and the tool for studying infants-toddlers everyday science moments. This analytical framework was used to determine the science moments in this study. It is shown in Table 2 below. The categorisation in Table 2 is the same as that in Sikder and Fleer (2015).

Table 2: Analytical framework (Sikder and Fleer 2015)

Categories of *Small science*	Activity Settings	Every day concepts	Scientific concepts
Multiple possibilities for *small science*	Preparation of snacks	1. Mixing Ingredients 2. Follow the instructions 4. Cooking 5. Concept of shapes	1.Force (push hardly, press, roll) 2.Correlation 3.Properties 4.Change of state of matter 5.Heating and Cooling continuum
Discreet Science Concepts	Mirror play	Identification of body parts	Human body
Embedded Science	1. Day time 2. Night time (switch on-off) 3. Breathing	Everyday experience of day, night, and breathing	1. Light and Dark 2. Air 3. Breathing process
Counter Intuitive	1. Sunrise and	Historical	3. solar system (Earth is

Science	sun set 2. Moon follows me	development of knowledge	moving The position of earth in the universe)

First, we organised the whole data set based on evidence of small science in each of the categories in Table 2. Our investigations provided several contexts in relation to small science moments in each category. We have chosen one example only in each category for explaining small science in detail in this paper.

In the second step, we examined the *relations* between the established understandings of science concepts and small science from the infants-toddlers. This was completed in order to answer the research questions. As such, the concept of *ideal and real* form as applied to science concepts and small science moments was used to understand the data. That is, the whole set of video data (30 hours) were analysed using the ideal form of science in relation to present forms of small science of the infants-toddlers. The analysis involved investigating social interactions through the whole data set that were related to the relations between the ideal and real forms of science in everyday life.

Finally, the data set was interpreted in three layers following Hedegaard's (2008b) holistic approach to analysis. The primary layer looked at the activity settings in the video clips for locating the possibilities of social interactions. This analysis focused on the infant-toddler's small science experiences, infant-toddler's engagement with objects in relation to small science concepts, and infant-toddler's conscious awareness of the concepts when in collaboration between infant-toddlers and adults in these small science moments. In particular, the researchers use their common sense understanding in relation to the study focus at this level.

The secondary layer examined multiple video clips for confirming the interaction pattern for developing small science concepts. Finally, the third layer bridged theory and practice to answer the research questions. For example, how parents collaborate in real life with children for developing science concepts (empirical) and if the theoretical lens supports conceptualizing the idea (theory).

Outcomes and Considerations

The findings derive from the whole data set and were classified according to four categories following the general concept of the relations between the ideal and real form of small science (Table 2). The data reflects that infant-toddler's regular interactions are mostly with mothers in every type of activity, there was evidence of some interactions with fathers in everyday contexts or play situations, and a few interactions with peer group or senior play mates in a playful context.

The data provides evidence of the importance of parent-child collaborations, the child's motivation in the science context, the child's engagement in the science moments, and parent-child consciousness about the development of an ideal form of small science. These categories (Table 2) have informed the basis for answering the research questions that were posed earlier, and have shaped the subsequent findings that are discussed in the next section.

We are now going to discuss four detailed examples under the four categories of small science (multiple possibilities, discrete, embedded, and counter Intuitive science). Vignettes give insights into how social interactions support the development of small science concepts in infants-toddlers everyday life. Although most categories are clearly evident in the data set, counter-intuitive science is less obvious across the data set. In our previous research we have defined this as moments in the everyday life of children where they observe events which are counter-intuitive to a Western scientific explanation, such as the Earth revolving around the Sun.

Multiple possibilities and contexts for small science

Infants-toddlers can develop multiple small science concepts through one event (Sikder and Fleer 2015). For example, in a swimming pool children can develop multiple small science concepts such as floating, sinking, pushing, pulling, and spinning.

The data showed infants–toddlers have experienced regular occasions of multiple possibilities for small science moments in their everyday life. For instance, discovering a toy box, bath time, story time, brushing teeth, riding a bicycle, playing football, playing with playdough, cooking play, play in playground, meal time, drawing time, pretend play, are examples of different everyday contexts for potentially developing multiple small science concepts in the data set. The small science concepts could be multiple in these contexts such as rolling, pressing, pushing, pulling, spinning, floating, sinking, heating and cooling continuum, hard and soft (texture), sound, identification of materials or animals, discovery of new substances, change of state of matter. One of the contexts taken from the data set, which is illustrative of the social interaction for growing multiple possibilities for small science concepts, is shown below as Vignette 1. We have illustrated dialogues (:) and actions (normal sentence structure) in the vignette regarding small science concepts and social interaction from the video clip.

The Vignette 1. Pretend Play (Doctor-patient), participants- Joy (two years ten months), Joy's mother Sima, the first author is referred to as Researcher 1 - R1.
Joy is going to her toy corner. She finds a bag. R1 starts to chat with her.
R1: What is this bag?

Joy: Doctor's bag.

R1: Where is your patient? Are you the doctor?

Joy does not answer.

Sima: Are you the doctor Joy?

Joy: Yes.

Joy opens the bag and takes out the stethoscope.

R1: Where is your patient?

Sima: I am feeling sick. Do you want to check my heartbeat? Please come and check my heart beat.

Joy goes to her mother with the stethoscope.

Sima helps Joy put the stethoscope into her ears. Joy checks her mother's heartbeat.

Sima: Am I all right?

Joy: Yes.

Sima: Have you heard my heartbeat?

Joy: Yes.

Sima reported that she was sick one day when Joy brought the stethoscope and checked her mother's heartbeat. Sima also mentioned that Joy referred to her father as a Dr. Jhantu and to herself as Dr. Joy.

Joy goes to her doctor's bag, finds the injection and tries to inject her mother's ear. Then Sima shows her that it should be on hand.

Sima: This is needle. Push the injection to hold the tool like this (showing how to inject).

Joy pushes the injection into her mother's hand and smiles.

Sima: Now please check my pressure.

Joy goes to doctor's bag and takes out the ear torch. She checks her own ear.

Sima: You cannot see your ears by yourself.

Joy: No, there is no dirt in my ears.

Joy looks into the doctor bag and takes out one bandage.

Joy: Mother, you need bandage?

Sima: Oh, yes. I am cut and hurt here (shows her hand).

Joy sets the bandage on Sima's hand.

Sima: Ok?

Joy: Yes.

Sima: Please check my pressure now.

Joy finds and takes out the blood pressure measuring machine from the bag. She sets the machine onto her mother's hand and Sima helps her to set it. Joy is pumping the small balloon for measuring the pressure.

Sima: How much pressure?

Joy: It does not work.

Sima: Pump hard, pump hard. Look how do I pump?

Sima shows with her hand by pumping the balloon. Joy pumps hard and then it works.

Sima: You can do it.

Joy: Done.

Sima: Am I ok?

Joy: Yes.

Sima: Have you done your job?

Joy: Yes.

Sima: Then pack you bag.

Joy: Do not take out you bandage because you have still pain.

Sima: Ok.

The following is taken from a post observation video interview with Sima.

R1: Why did you buy the doctor's bag?

Sima: I buy this doctor bag because she was little bit afraid to see the doctor. I think she will be familiar with doctor's tools if I buy this toy. Once we were watching a cartoon programme related doctor-patient in TV. Then Joy asked me many questions about doctors. Then I buy this toy for her.

R1: Did you describe the tools of this bag to Joy?

Sima: Joy recognises some tools by herself like thermometer; bandage as she experiences them at home. I explain about the stethoscope, injection tool, and the pressure measure machine. Joy is very interested to play with this doctor bag and now she does not feel scared to visit doctor.

Interpretation of vignette 1. In this vignette we illustrate how Joy experienced some small science concepts associated with push, pump hard, identification and application of doctor's instruments through this pretend play. Joy experienced the small science concepts through the collective experience (imagination) with her mother. She started to play then her mother joined the event. The doctor-patient game is social as her mother explains that Joy experienced it by visiting their doctor and also through watching a TV programme. Vygotsky (1966) says, play is socially or culturally constructed. As supported by Elkonin (2005, p.46), "play is social in its content precisely because it is social in its nature and in its origin, that is it arises out of the conditions of the child's life in society". Therefore it is not surprising to find one theme of Joy's play is associated with doctor play.

Joy wanted to be Dr. Joy, as her mother noted. Kravtsova and Kravtsov (2011), argue it is important to examine the child's motives when determining purposeful action. It was evident that Joy was conscious of doing her duty as a doctor and purposeful in her actions for satisfying this role in play. Vygotsky stated, satisfying a need is the main motive for children's play (1966). Joy took the ideal role "Dr" from the society. Although children have strong motives for participating in the important life events of their society (doctor role), due their perceived capacity or for safety reasons, they are not always able to participate (perform being a doctor), so they do so through play (Fleer 2011).

Although Joy started to play this game by thinking about the role of doctor in society, her mother's role as an ideal patient or an ideal doctor discussing specific technological problems and the need to pump, was the ideal form in this context for developing small science concepts. For example, as a starting point, Joy could not push or pump properly, this represents the rudimentary form of the practice, but her mother showed her how to do it. Sima provided the ideal form by performing the pushing or pumping action for Joy to see. As Vygotsky (1994, p. 348) discussed in the example of mathematics, the adult's interaction is necessary for presenting the ideal form for developing a child's concept of number. Afterwards Joy consciously tried to apply the actions of push or pump and succeeded in doing so.

Moreover, Joy's mother was extending the game through asking and answering questions for Joy. Joy's mother explained each action in this event so Joy understood and she repeated the same thing two or more times. Joy's mother's explanation for understanding the small science concepts (push/pump) could be defined as a scientific narration. As extended by Fleer and Pramling (2015), "scientific narrative" has been used during interactions between adults and children when solving scientific and technological problems. Joy's mother consciously creates a scientific interaction in the environment, and through this Joy has the possibility to learn some small science concepts such as push, or to pump hard. It is well established that students' prior conceptions (Gilbert, Watts and Osborne 1982) or students' existing ideas (Bell 2005) need to be considered in the teaching of science. Small science concepts as discussed here, support building understandings of abstract science concept in the future.

Vygotsky (1994, p. 338) argued that the environment can play an important role in children's development if one can use it as a relative yardstick. Joy's mother extended her talking in a very relative way and Joy could follow the communication at the same way. For instance, when Joy was starting to play with the doctor bag, Sima extended their conversation in relation to doctor-patient tasks. The activities were extended through relevant communication and collaboration between a child and an adult. In this play, Joy and her mother were both conscious about their roles. Her mother was conscious of the concepts that Joy could learn, therefore she engaged Joy consciously in the actions, naming these, in what we have termed small science concepts. As Vygotsky (1987) stated, "conscious awareness of concepts exists in the atmosphere of social thought that surrounds the child" (p. 187).

Furthermore, Joy was consciously aware of applying her new learning concepts (Vygotsky 1987) such as pushing the injection and pumping hard. Joy was spontaneously involved with the objects (the doctor's tools) and as Vygotsky (1966) says, objects and how they introduced the tools for mediating concepts. In this play, Joy's intention was to play the doctor's role (ideal form from the society) and Joy's mother consciously collaborated in each step of this play by helping Joy to learn small science concepts (showing the relations between the real form and the ideal form). At the same time Joy also collaborated in a similar way to the play context. Multiple possibilities for small science concepts can be developed through social interactions particularly when there is a conscious collaboration with the child from real form to ideal form, such as when discussing health conditions and drawing attention to body parts and actions (eg. Heart beat). Through the entire play, Joy learned more than one small science concept (e.g. Push, pump, identification and application of doctor's instruments), which reflected the multiple possibilities of small science concepts.

Discrete Science Concepts

The discrete science concepts category shows that one activity does not generally go in multiple directions but rather only allows for one science learning (one idea/concept) to occur at a time (Sikder and Fleer 2015). As shown in examples from our data set, a child can learn the small science concept of *melting* through eating an ice cream, or a child can learn about body parts through engaging in mirror play. In the following vignette of the mirror play, relevant dialogues (:) and actions (normal sentence structure) have been illustrated from the video clip:

Vignette 2. Mirror Play, Participants- Barnan (one year, one month), Barnan's mother Nita, and Filmed by first named author R1.

Nita: Barnan, please look at the mirror, R1 will see what you can do.

Nita: Can you do Hi5 in mirror (Nita does a Hi 5 with her fingers in the mirror -twice).

Barnan does a Hi 5 with his fingers in the mirror (twice) and observes himself in the mirror.

Nita: Hi 5.

Nita: Barnan see, mother is doing AHAHAH sound with mouth and looks at mirror.

Nita is trying to attract Barnan making the sound again and again.

Nita: Barnan see, mother plays with her eyes (Nita opens and closes her eyes looking in the mirror). Barnan follows his mother opening and closing his eyes two times as he observes himself in the mirror.

Nita: Well done, very good Barnan.

Barnan smiles.

Nita: Where is your nose Barnan?

Nita makes a sneezing sound with her nose. Barnan loses his concentration and looks down. Nita makes a knock knock sound with her finger on the mirror and also says knock knock.

Nita: Do knock knock Barnan.

Barnan does knock knock with his fingers on the mirror. Then Barnan makes an Ahh sound with his mouth in mirror as Nita has shown it before.

Nita: Barnan again do Ahh.

Barnan does it again.

Nita: Where is your belly button, Barnan?

Nita removes his clothes from his stomach

Nita: Oho! We cannot see your belly button with this cloth because you wear a singlet.

Barnan looks at his covered belly.

Nita: Can you show your daddy finger in the mirror?

Barnan shows his daddy finger in mirror.

Nita: Oma! you have shown your daddy finger in mirror, very good.

Nita: Can you see your hair in mirror?

Barnan shows his hair and observes it in the mirror. Barnan also shows his mother's hair.

Nita: Good you can also show your mother's hair.

Nita: Can you show "No more monkeys jumping on the bed"?

Barnan points his right finger by showing no more in the mirror and tries to jump (also observing this action in the mirror).

Nita: Oh, you also jump and we can see that in mirror.

Nita: Can you show "Scold" in mirror?

Barnan: Bob, bob (Nita reports to R1 that bob bob means scolding language).

Then both of them are doing the Ahah sound to the mirror repeatedly.

Barnan's mother shares that they play the mirror game very often and Barnan is learning his body parts through different types of body movements.

Interpretation of vignette 2. This event was derived from Barnan's everyday experience as his mother does this activity regularly with him at home. At this age, teaching about body parts is an obvious everyday concept for parents to focus on. It is argued that children's (from age four) understanding about their body through identifying body parts is the beginning of understanding foundational concepts in biology (Jaakkola and Slaughter 2002). Young children (four to seven years) already have concepts about the inside of their body, understandings gained from everyday empirical experiences (Garcia-Barros, Martínez-Losada and Garrido 2011). Therefore, identification of body parts could be the first step to understanding the scientific knowledge of body function in the early years of childhood.

In this vignette, a collective experience of Barnan's daily life is shared. In this example, the mother took a central role in their interactions, and Barnan mainly imitates his mother. A child can investigate the rules of everyday life through experience and by imitation of social events in everyday life (Fleer 2011). In this case, the social environment has the ideal form (Vygotsky 1994) that the child could imitate and investigate. Cultural development can occur through imitation (Vygotsky 1997). In the mirror play, Barnan's mother with her expressions of body parts through the mirror play represented the ideal form to him. Barnan was motivated in this social environment, firstly observing his mother's activity, and then participating in it (Fleer 2011). Nita's body movements and the sounds she created attracted Barnan's attention. Nita consciously introduced one body part after another, through mirror play.

At Barnan's age (one year one month), it is very difficult to concentrate for a long time. Nita was very conscious of that. She was doing "knock knock" or making "ahah" sounds when Barnan lost attention. Nita set the environment in the context of thinking about Barnan's age, thus we can see how the social environment becomes a source of a child's development of small science. Moreover, Nita was very conscious and careful in her narration and this helped Barnan to understand the topic of body parts as introduced by the mother (e.g. Fleer and Pramling 2015).

Nita's main purpose in this mirror play activity was to identify and teach Barnan the names of body parts through reflection of an image in a mirror. The process of teaching depends on the child's cooperation with adults and interaction between ideal and real form (Vygotsky 1998). Here Barnan was cooperative and he imitated the ideal form as reflected in his mother's actions in the mirror. Nita collaborated with Barnan to teach the body parts and Barnan cooperated with his mother. Nita's instruction about body parts was very clear to Barnan and thus Barnan could follow her instruction. It is argued, instruction moves ahead of development (Vygotsky 1987). "Development based on collaboration and imitation is the source of all specially human characteristics of consciousness that develop in the child" (Vygotsky 1987, p. 210).

Barnan could identify his body parts - eyes, finger, hair, mouth, belly and nose in collaboration with his mother. The mother took the central role for creating the science learning environment so that Barnan could learn these concepts through the reflection of an image in the mirror, and this one experience represented the learning of just one discrete science concept (rather than multiple science concepts as introduced previously). Barnan experienced the process and started to learn the scientific concept collectively in his everyday situation. As noted by Fleer and Pramling (2015) science acts as a form of cultural knowledge which is formed collectively.

Embedded Science

Embedded small science refers to the science ideas and actions/ activities we may never notice, though we experience them regularly in our everyday life (Sikder and Fleer 2015). For example, we are breathing at every moment, but we may never notice our breathing process. However, it is very easy to realize this process if our attention is drawn to it and made conscious. In the following vignette of embedded small science, taken from our data set (field note), we discuss how this embedded science can be made visible and developed through everyday social interactions. In the vignette, relevant dialogues (:) and actions (normal sentence structure) have been represented.

Vignette 3. Story time and sleep time; Participants: Jhumki (two years two months), Jhumki's mother Jhuma, and Jhumki's young brother Raj (7 months). First named author R1 took field notes about light and dark issues. R1 discussed with Jhuma. Jhuma discussed that they used to do this event as part of their regular sleep time as below:

Jhuma: I take Jhumki and Raj to bed at 8 pm everynight. I recite very common Bengali Rhymes such as *"ai ai chand mama tip die ja/ chander kapale chand tip die ja"* (translated version: Moon, please come and kiss to my child's forhead) or *"ghum parani masi-pisi moder bari esho/ khat nei palon nei chok pete boso"* (translated version: Sleeping aunties, please come to my home, sit on our eyes and make us fall in sleep). Raj tends to sleep very quick. We need to switch off the central light.

Jhumki: No, story.

Jhuma: We switch off the central light. Because the room need to be dark as Raj falls in sleep. We will do story time and you can switch on the bed side lamp while we read story.

Jhuma switches off the central light but Jhumki wants to switch off the light. Jhumki always wishes to switch on-off the light. Then Jhumki again switches on then switches off the central light with support of Jhuma. In particular, the central light's switch is beyond Jhumki's reach and Jhuma supports her to switch on and off the central light.

Jhumki switches on the bed side lamp.

Jhuma: Jhumki, the bed side lamp has shadow which reduces high volume of light and Raj can sleep comfortably.

Jhumki: Yes, mum. Jhumki switches on and off the bed side light two/three times.

Jhuma: If you switch off the light we can not read the story as we need light to read the story.

(Jhuma tells to R1 that Jhumki likes to do experiment by switch on and off.)

Jhumki switchs on the bed side light.

Jhuma picks up picture story book and engages Jhumki to read the story.

When Jhumki feels sleepy, Jhuma asks her to switch off the bed side lamp.

Jhumki: No, I want more story.

Jhuma: No, dear. You nearly falls in sleep so you have to switch off the light. Now sleep time.

Jhumki: Now sleep time. Jhumki switches off the bed side lamp.

Jhumki: Good night, sleep tight. Finally they go to bed for sleep in dark.

Interpretation of Vignette 3. In this vignette, story time was the regular transition event that took place prior to sleep time where the lights are turned on and off in preparation for and for ending this event. Thus the light being turned on-off is not a particular event that occurs separately from routine daily life in this family. It is an everyday situation that we participate in. At night if the room is dark, we need to switch on the light as necessary and switch off the light when we go to sleep. In this vignette, Jhumki experiences this situation. When Jhumki and her mother started their preparation for story time, they switched on the bed side lamp as was their routine. In addition, Jhumki's mother asked to switch off the central light because Raj falls in sleep and Jhuma explained that the room need to be dark for Raj's comfortable sleep. For story time the bed side light was needed and sleep time required all the lights to be off. Vygotsky argued that the "environment is not the only condition of child development, but we need to approach the relationship that exists between the child and its environment at a given stage of his development" (1994, p. 338). In this case, Jhumki's mother asked to switch on the bed side light while they were preparing for story time and also her mother suggested that the bed side light had to be switched off at sleep time. Jhumki's mother was approaching the necessary steps for changing the environment so that Jhumki could understand the significance of the light being on or off. Lights being on and off were being made conscious to this infant-toddler.

Jhumki liked to switch on and off the bed sidelight as she wanted to act as an adult. In addition she was experimenting by switching on and off the light. Therefore, Jhumki's involvement with the objects showed a motive for play. Moreover she was conscious of the concept of light (and dark as the absence of light) because the family examined light in two similar situations within one evening. For learning any kind of scientific concept, a child needs to continually rework them (Vygotsky 1987). "Conscious awareness of similarity requires the formation of a concept or generalization which represents the objects between which the relationship exists" (Vygotsky 1987, p. 184).

Jhumki's mother was narrating the light's condition, such as how light decreased, and she repeated the sentence: "switch off the light at sleep time". This type of conversation was purposeful to inform Jhumki about the ideal situation of the environment (ideal forms-sleep time requires dark, story time requires light). Additionally, Jhuma allows her to switch on-off the light in different situations. Jhumki was satisfied with this as every child wishes to act like an adult (Elkonin 1978). In this situation, Jhumki wanted to act in the ideal form as her mother asked which was to switch on the light for story time and switch off the light for sleep time. It was noted in previous observations, that in the very beginning when Jhumki tried to switch off the central light, she was unable to do so by herself (real form).

The whole environment for bedtime story telling was a collective experience and very natural. As Bozhovich (2009) has pointed out, the development of abstract thinking (i.e. light/dark) should be natural according to a child's age related features. In this example we show the beginnings of this abstraction through social relations between Jhumki and her family. Light is a science concept under physics, which is embedded in our everyday life. Longstanding research has shown that students can develop long-lasting understandings of physics if they are able to connect physics knowledge with everyday experiences (Solomon 1983). Although the scientific concept of light is complex, according to the child's age, the context and the child's experiences can create the foundations for understanding light. This type of scientific thinking can be developed through the socio-cultural context of interpersonal relations (Robbins 2005). In this context, it is evident that the parents and child focused their conversation on light through regular practice, which means the science concept is socially and culturally constructed. Additionally, the conversation was a scientific narration (Fleer and Pramling 2015) about a collective experience. These narratives form through collective experiences, conscious awareness of the small science concept, and with the child's active involvement, together represent the conditions for the child's understanding of light.

Counter Intuitive Science

Counter intuitive science is exactly the opposite of an everyday experience. We have learned many concepts through longstanding historical development of knowledge (Sikder and Fleer 2015). For example, once upon a time we had an understanding about the solar system where the sun moves around the earth as an accepted heliocentric view by scientists. However, we have learned otherwise. In presenting the area of counter intuitive science, it is not always possible to determine how infants and toddlers understand these experiences. However, as an analytical concept, it gives the possibility for considering how some forms of science that are in children's everyday environment may be potentially more difficult to understand or even to discuss with parents. As such, it is difficult to determine how an infant might come to understand the concept of day and night, and the solar system, as presented in everyday life.

In our research we found examples of small science concepts that were counter intuitive. In Vignette 4, an example is given of an everyday situation and how this is conceptualised by the parent. This example is consistent with the literature on alternative views held about night and day.

Vignette 4. Field Notes- First named author R1 took field notes about sunrise and sunset issues. R1 discussed with Joy's mother.
R1: Do you think joy understands about sunrise and sun set or moon rise?
Sima: Yes, Joy understands about sunrise and sunset from two years of age. According to Joy, sun rises at daytime and sun sets at night time. Moon-star rises at night time. When we wake up the sun rises and when we go to sleep the moon-star rises.
R1: How did she learn it?
Sima: I and her father always greet her at morning or evening by saying "Good morning" or "Good evening". If the sun is shiny then we told her that it was lovely sunny day. At evening, we showed moon to her and rhyme together one Bengali nonsense rhyme " Ai ai chand mama tip diye ja..". That means we talked about the presence of sun or moon at daytime or night time. So these types of regular conversation help her to understand about sunrise or moon rise. Joy then responds to us about greetings according to the time of day or say, "Wow! It is a lovely sunny day".
R1: Do you think, Joy understands about why sun rises at day time or sun sets at night time or do you ever discuss with her about it.
Sima: No, Joy does not know about the solar system and I never explain it to her.

Interpretation of Vignette 4. In this vignette, we could not see the interaction pattern between the infant-toddler and an adult directly. However, we understand from the interview conversation that Joy experiences the idea regarding the presence of the sun or the moon through regular conversations and practical experience in her daily life. In this situation the ideal form is Joy's parents' conversation with her and she gains it through the collective experience. We could say this is collective socially constructed learning (Fleer 1991). The parents use their conversation to build

Joy's consciousness about the ideal concept of day or night. As argued by Vygotsky (1994, p. 349) "the child's higher psychological function, his [sic] higher attributes which are specific to humans, originally manifest themselves as forms of the child's collective behaviour, as a form of co-operation with other people". In addition, "conscious awareness of concepts exists in the atmosphere of social thought that surrounds the child" (Vygotsky 1987, p. 187).

According to the vignette, it is clear that the child has developed the concept of sun or moon through collaboration with her parents particularly by scientific narration (Fleer and Pramling In press) in the social environment. This experience is also embedded in daily life, but if we do not notice it, it could be ignored. In this sense, Joy's parents are successful in teaching her this embedded small science concept of day and night. However, Joy's parents did not extend their conversation about why we see the sun during the day and why we do not see it at night. If her parents continued their conversation using simple narration about the solar system, then there is a possibility to learn about this, not at once, but gradually over time. Counter intuitive science needs a great deal of exploration with interrelated concepts, because children cannot experience it directly (Fleer 1997). Adults can help children to develop counter intuitive concepts (such as the shape of the moon), which are formed culturally within everyday life. Parents can reconcile possible presuppositions or alternative views through how they narrate or point out to their infants and toddlers, (Vosniadou and Brewer 1992). It is argued that children's knowledge is fragmented if they do not acquire the scientific knowledge of the Earth (Panagiotaki, Nobes and Potton 2009) or day/night.

In this case, Joy's parents through their interactions represented the ideal form of scientific thinking in relation to day and night (but not in relation to the moon only being visible at night). Since the ideal form (conversation about solar system) was absent then there was little possibility for Joy to learn about this concept. Vygotsky (1994) says, the ideal form needs to be present in the environment otherwise the development will be very slow or in an unusual manner. Therefore, Joy at this stage could not learn the counter intuitive small science concept at a young age in the context of the family.

Final Comments

In our research we have found many social interactions in everyday family life that have a significant effect on infant and toddler learning. Firstly we have seen, infants-toddlers have many experiences related to small science moments in their everyday family life. The vignettes represent four categories of small science and are only part of the data set. The vignettes are not isolated examples; rather they highlight the essence of interaction patterns during the everyday context for developing the four categories of small science concepts. It is evident here, that all science moments in the everyday life of young children are socially (Robbins 2005) or culturally (Wells 2004) constructed through collective experience (Fleer and Pramling 2015) as also noted for older children (Fleer 1991).

In each context presented in this paper, we have shown how the parents create the environment, and it is the family (social/ cultural) environment that becomes the source of the infant-toddler development (Vygotsky 1994). The environment contains two forms – the real form of the children's development, for instance, what they were starting to do in the family context; and the ideal form as presented to them through the parents. The data gave evidence of the ideal forms, such as when the mother shows how to operate the doctor's tools in Joy's doctor play, when the mother gestures to and names body parts in mirror play, and when the mother engages in conversation about the ideal situation of dark/light.

In each context, when the child starts to engage in the task, their concept was initially unformed and there was a gap in the infants-toddlers' development. It was the families who filled the gap in understanding, through actively supporting the development of their infant-toddler's higher mental function. Here the relations between infant-toddler real forms of development were carefully considered by the parents in relation to the ideal form that they created through collective dialogue of small science moments in the environment. In each example, parents take the central role of mediating the concepts and or consciously teaching the concepts. Their social interactions are the main mediators to fill the gap from the real form to the ideal form (Vygotsky 1994). Parent narratives related to small science moments that give a level of scientific consciousness to infant-toddlers' everyday world.

The infants-toddlers were spontaneously involved in the environment, actively engaged with objects, and consciously becoming aware of the small science explanations given by their parents. As said by Vygotsky (1994, p. 349) the child as "a human being is a creature who is social by his [sic] very nature, whose development consists of, among other things, mastering certain forms of activity and consciousness which have been perfected by humanity during the process of historical development, this fact is essentially what provides the foundation for this interaction between the ideal and rudimentary form".

This study has shown that small science concepts can be developed through a special form of narrative collaboration, where parents and infant-toddlers both consciously consider the environment from a scientific perspective. The outcome of this study gives evidence of how small science concepts can be developed in infants-toddlers lives through social interactions as a relation between the real and ideal forms but specifically through parents-infants-toddlers consciousness where narrative and collaboration are central.

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Chapter 6: Dynamic Aspects of Motives in Science Concept Formation

"A genuine diagnosis of development must be able to catch not only concluded cycles of development, not only the fruits, but also those processes that are in the period of maturation." (Vygotsky, 1998, p. 200)

Background of the third paper (Book chapter)

The first paper and second paper provide the theoretical knowledge of small science and empirical details of the development process of small science concepts in infants-toddlers life. However, we still do not know the dynamic aspects of motives for developing small science concepts in everyday play of an infant-toddler. The third paper/book chapter (Chapter 6) will discuss the dynamic relationships of an infant-toddler with the social environment which motivate the child for playing and learning small science concepts in the regular play context. Therefore I reviewed one child's particular play moment in which I considered the relationship between the child and the social environment for trying to understand the motivational factors in the play moment. In the data set, there are a series of video clips of the child's playful activities in relation to small science moments. I selected a representative video clip at infant-toddler age that showed how the dynamic aspects of motives creates the conditions and potential for developing small science concepts in play contexts at the infant-toddler age.

The child has been studied as a whole in the play context. For example, I studied how the child became motivated by the activities of the family members who interacted with the child in the play situation. Similarly, I was curious about the culture of play and how the motivations to particular objects and actions in the collective play in the child's home were fostered. I wanted to know how does the family create the motivational environment for the child? I also wanted to know if the child was motivated by their biological needs, as well as what was afforded for them by the family in their everyday environment. Finally, I considered all the infant-toddler interactions in the family home in relation to the societal motives that are featured in the play moment? In the third paper/book chapter, Cultural-historical theorisation of motives in play, learning and development has been used to understand the dynamic aspects of motives in infant-toddler play. In the vignette, I have discussed the influence of each motive in the child's play moment and how play motives create scientific learning motives in the regular play context. In this paper/ book chapter, there is a new understanding about the dynamic aspects of motives which have a significant influence on infant-toddler's play. It was found that the successful dynamic of the play motives as a whole, enhanced infant-toddler's development of science concept formation within everyday family practice.

I presented the paper at the Symposium during the Pacific Early Childhood Education Research Association (PECERA) Conference in 2015. I received valuable feedback from the participants and improved my paper according to their suggestions. Finally I submitted the paper as a book chapter to the editing book of Springer baby book named "Studying Babies and Toddlers: Cultural Worlds and Transitory Relationships", which will be published by Dordrecht Springer. The Faculty of Education (Monash University) provides staff and students with a list of book publishers, where Springer is described as having a world-wide reputation. This book combines the chapters from the scholars who are doing research on babies and toddlers and the book is edited by the well-known scholars in early childhood education. Since my project is about infants-toddlers science learning in the family context, I decided it was an appropriate place to publish my third paper.

I submitted the paper/book chapter to the editors two months ago and received a letter of acceptance for the paper/book chapter with minor suggested changes. My paper/book chapter was finally accepted after being reviewing twice. However, I would like to provide two examples of reviewer's comments regarding the book chapter as follows.

Reviewer: 1

Comments to the Author

What do you mean by dynamic aspects of play motives? It needs your explanation. Also, how do these links to children's emotional experience? You may need to make it more explicit in your chapter.

Response to reviewer 1: Thank you. The comment is thoughtful. I have added one paragraph on page 3 as follows:

For understanding children's motives in cultural-historical theory, we have to study the dynamic aspects of child's relation to the world (Hedegaard, 2012) in the particular context. Explaining the relationship of dynamic aspects of motives, Hedegaard (2012) showed how the particular family culture has been influenced by multiple relations of the moment. Hedegaard (2012) discussed children's relation as relevant to a societal motive, institutional motive, the motive of the situation, person activities as a motive, and human's self-driven motive in the family culture.

Reviewer: 2

Comments to the Author

What does this vignette mean in each part to the reader. Please put initial interpretation for reader.

Response to reviewer 2:

Thank you for your thoughtful comment. I have added one paragraph, "The mother creates a collective play moment which is very common culture in Barnan's family home. Barnan was very curious to the tiger toy and tried to explore the "roar" sound.

However, Branan was not successful in this play moment which will be discussed details later in the discussion” on page 7.

The third paper (book chapter) provides a detailed account of one child’s particular play context, insights and knowledge of understandings the dynamic aspects of motives in infant-toddler’s play for learning small science concepts.

Chapter 13 (Accepted book chapter as Chapter 13 of Studying Babies and Toddlers: Cultural Worlds and Transitory Relationships. Dordrecht Springer)
Chapter Title: Relationship of Dynamic Aspects of Motives in Infant-Toddler's Play: Enhancing the Development of *Small Science* Concept Formation

Shukla Sikder

Abstract
Motives as a psychological concept is vital for understanding play and how a play motive influences children's learning and development (Fleer 2010). Play provides space for the conscious realization of everyday concepts (Fleer 2008). The process of concept formation begins at a very young age (Vygotsky 1987). It is evident that science concept formation in infants-toddlers life, named as *small science*, can occur through play and everyday activities (Sikder & Fleer 2015a). It is established that play motives enhance children's learning and development in concept formation (Fleer 2012). However, we need to know more about how the dynamic aspects of motives create the conditions and potential for developing *small science* concepts in play contexts at the infant-toddler age. The qualitative case study reported in this chapter investigates the dynamic aspects of motives that provide the possibility for scientific concept development for young children in their everyday cultural life at home. Digital video methodology has been utilized for data collection from the child's everyday family context. In this chapter, an analysis of 12 hours of video data gathered over four months from one child's everyday family life is presented. Hedegaard's (2012) planes of analysis were used to analyse the data. The findings indicate that the dynamic aspects of motives have a significant influence on infant-toddler's play. Successful dynamic play motives as a whole, enhance infant-toddlers' development of science concept formation as part of everyday family practice. This research impacts on an under-researched area of infant-toddlers' science concept formation.

Key Words: Infant-toddler, dynamic aspects of motives, play, *small science* concept, learning and development

13.1 Introduction

There is an extensive body of literature that provides understanding of various types of development through play or everyday activities. The literature shows that play enhances children's specific development in particular contexts, such as children's development in preschool period (Duncan and Tarulli 2003), the effect of relations in development (Lillard 2007), conceptual development (Fleer 2011), emotional development (Chen and Fleer 2013), development on learning roles and rules (Ugaste 2005) and so on in infant-toddler-preschoolers age. However, these studies identify individual aspects of children's learning and development and do not include how the relationship of dynamic aspects of play culture creates a motive for them.

The literature has noted the influence of children's motives for play, learning and development (Fleer 2010; Fleer 2012). However, these studies generally focus on a single entity, such as a societal motive for children's play and ignore the dynamic aspects of motives in play in a particular cultural context. Additionally, the literature mostly looked at children over three years of age. Throughout this chapter, the researcher will examine a young child's (10 to 13 months) play motives from the perspective of the dynamic aspects in everyday family culture and how play motives, enhance the child's scientific learning and development. Why would the researcher like to examine infant-toddler's scientific learning and development?

In early childhood education all over the world, more attention has been directed to research in science education over the past decades. It is evident that science activities can provide rich possibilities for supporting children's learning and development (Bayraktar 2011; Fleer and Pramling 2015). However, infant-toddler's science learning and development through everyday activities, including play in family culture, is missing from this considerable body of literature.

There are very few studies (Forman 2010; Gopnik 2012; Sikder and Fleer 2015 a & b) on infant-toddler's science learning. The literature provides knowledge on children's science concept formation at a young age based on self-interest, inquiry-based science education, parent's engagement in science learning, and everyday context for science learning. However, none of these reveal how the relationship of dynamic aspects of a play motive enhances infant-toddler's science learning and development in their everyday life. In addition, these studies do not explain play motives in their cultural context. In this chapter, the researcher will try to fill this gap by examining how the dynamic aspects of motives influence infant-toddler's play, and how play motives as a whole, contribute to infant-toddler's science learning and development in an everyday cultural context.

The next section will discuss the theoretical aspects of motives and the meaning of dynamic aspects of motives for this play context.

13.2 Cultural-Historical Theorisation of Motives in Play, Learning and Development

Unlike other concepts in cultural-historical theory, there is no single standard definition of motives. Chaiklin (2012, p. 223) says, "Motives should be defined and limited more rigorously in relation to societal needs". Further, Fleer (2012) suggests that "Motive defined in this way- as something generated through observing or participating in an activity- rather than as something that comes solely from within is a powerful concept for understanding play" (p. 91). From a cultural-historical point of view, motive is tightly connected with a person's will and motives influence a person's action (Kravtsova and Kravtsov 2012). In order to understand motives, Hedegaard (2012, p, 24) mentions, "we have to follow the child in his or her activities as intentional actions and interactions with others in activity settings". Therefore, according to the cultural-historical point of view, motives do not develop only from a person's own internal tendencies but also from a person's relationship with others and their environment in a social-cultural context.

The concept of motive is central in cultural-historical theory (Chaiklin 2012), and Fleer (2012) argues motives are a central concept in play. In play, the child learns to act in a cognitive realm which depends on internal tendencies and motives, and play provides a background for changes in need and consciousness of a much wider nature (Vygotsky 1966). Elkonin (2005) contends that play is not driven by internal instincts or motives, but rather it is through the child's engagement with their social work environment and their relationship to others and the material world, that motives for play develop. Fleer (2010) emphasizes that motives work as a psychological concept for children's development in play.

For understanding children's motives in cultural-historical theory, we have to study the dynamic aspects of the child's relation to the world in the particular context (Hedegaard 2012). In a "homework" example, Hedegaard (2012) investigates dynamic aspects of children's relation in the particular context and showed how each aspect of motives contributes to children's learning and development in the situation. Explaining the relationship of dynamic aspects of motives, Hedegaard (2012) shows how the particular family culture has been influenced by multiple relations of the moment. Hedegaard (2012) discusses children's relation as relevant to a societal motive, institutional motive, the motive of the situation, person activities as a motive, and human's self-driven motive in the family culture. Hedegaard (2012) suggests that the concept of social situation is the key to understanding this dynamic and "the social situation of development is nothing other than a system of relations between the child of a given age and social reality" (Vygotsky 1998, p. 199).

In Hedegaard's (2012) research, the children were studied through using a wholeness approach. Vygotsky (1998, p. 188) argued that "child development is such a complex process that it cannot be determined at all completely according to one trait alone at any stage". It is not meaningful then if we investigate only a single motive to understand children's development in the particular context.

It is well established that a play motive can contribute to children's learning motive and development if teachers connect teaching practices with children's experience or interest in a play context (Fleer 2012). However, it is still unknown how this dynamic aspect of motives in play contributes to children's learning and development at a young age. Using a cultural-historical point of view, children's motives in play should be studied as a system of relations between the child of a given age and social reality as part of the social situation of development, then we can understand the dynamic aspects of motives in play.

Thus, a play moment of a young child (around 12 months) will be investigated where the mother sets a collective play situation for exploring sound concepts in everyday culture of their family home.

Since the mother sets some toys for exploring sound concepts, the study investigated how the child was able to understand the sound concepts in this play culture. It is established in previous research (Sikder and Fleer 2015a) that infant-toddlers can develop *small science* concepts through everyday activities, including play as part of family practices, where *small science* is defined as simple scientific narration of the everyday cultural contexts that infants and toddlers experience at home with their families. Here is an example taken (Sikder and Fleer 2015a) for understanding *small science* concepts in an infant-toddler's life:

> A child (around two years) learned *small science* concepts such as as to press hard, to push, to roll and to turn the play dough into shapes (e.g. as a doll or duck through her mother's simple scientific narration to accompany these movements and moments). The language of push, press hard, and roll, as symbolic of actions of Force, represent moments of *small science* that occur during positive and engaged playful interaction at home. At this stage, we can say the academic concept of Force will not be learned completely now. However it will become incrementally understood through the learning of *small science* concepts such as push, press hard, roll in everyday life. The concept of *small science* helps name this incremental process that is so relevant for infants and toddlers experiencing science concepts in everyday life. The child's everyday play activities through this everyday event helped him/her to experience these science concepts as *small science* moments (p. 13).

The above discussion explains the theoretical understanding of the dynamic aspects of motives and the meaning of *small science* concepts in an infant-toddler's life. In this chapter I now examine how the relationship of play motives enhance children's scientific learning and development from the cultural-historical point of view.

13.3 Study Design

Data Collection

The data have been collected from three Bangladeshi children (10–36 months) who lived in Australia and Singapore during the period of 2012-2013. In this study, children used everyday family contexts (e.g. use family mirror for learning body parts) and toys (e.g. cooking toys) available to them in their family culture. The particular cultural context of one child's (Barnan- pseudonym) everyday life was taken for understanding the dynamic aspects of motives in child's play and scientific learning and development. The researcher has chosen one example where Barnan aged 11 months 18 days plays with musical toys in his family home,

The researcher (Bangladeshi origin) captured video data in infant-toddler's everyday cultural contexts such as meal time, play time, bath time, and story time. A total of almost 30 hours of video data were gathered. In Barnan's family, approximately 12 hours of video data were gathered in regular cultural practices at home over a period of four months.

Data Analysis

For analysing the specific science moment, the researcher used the methodological tool of Visual Vivencias (Quinones and Fleer 2011). Visual Vivencias is "an analytical tool to further understand visually the child's emotional experience of the event" (Quinones and Fleer 2011, p. 123). In this chapter, the child has been studied in relation to the dynamic aspects of the social relations in his home culture, as well as how the child was motivated by the dynamic aspects of the play context. To achieve this, it is essential to study the child's emotional experience (e.g. intense eye contact, happy and sad face, level of engagement, actions with energy and attention, interest in the object) in relation to the dynamic aspects of the play moments in which the child's science learning is taking place. As Hedegaard (2012) recommended, one must study the person's engagement as one of the aspects of motives in child's learning and development.

For analysing the dynamic relationships of motives in play, the researcher chose Hedegaard's (2012, p. 19) planes of analysis in which the dynamic relations in children's learning and development are foregrounded (see Table 13.1 below). Hedegaard (2012, p.18) states, "each plane presented in Table 1 depicts the relation between entity, process and dynamic. These planes are interrelated: society creates the conditions for institutions with its activity settings and persons do so with their specific biological conditions".

Table 13.1. Planes of analysis to capture the dynamic relations in children's learning and development

Entity	Process	Dynamic
Society	Tradition	Societal needs/conditions
Institution	Practice	Value motive/ objectives
Activity settings	Situation	Motivations/demands
Person	Activity	Motive/Intentions
Human's biology	Neurophysiological Processes	Primary needs/drive

The researcher analysed the data from the point of view of each plane and how each plane is related to the child's play culture, as an entity, process and dynamic, as will be discussed in detail in the findings section.

13.4 Findings

The findings discussed below are influenced by the theoretical underpinning which framed the research questions, and which are central for this chapter.

Background of the Play Settings

Nita (Mother) discussed with the researcher that Barnan is scared of unfamiliar sounds. Therefore, she wants to introduce some toys to Barnan (according to his age) which create different types of soft sounds. Nita is the main carer of Barnan and as a mother she always takes part in his play. Srabanti is his regular senior playmate as she is the closest neighbour of Barnan. Nita introduced a box of musical toys in a collective play moment in their family home.

The following vignette (part one and two) is transcribed from a 37 minute video clip where the child explores a musical toy box. Two parts of the vignette show the similarity and contrast to the play culture and how the relationships of dynamic aspects influence the play culture for developing small science concepts in infant-toddler life.

The Vignette: Explore Sound Concepts Through Multiple Toys

Part One: Explore Tiger's Roar Sound

Nita: Wow! What is it (look at the toy box)? Barnan looks at the box, and touches the box

Srabanti: Toy box

Nita: Yes, now we can open the box.

Srabanti picks up a tiger toy from the box and investigates how it works, and tries to attract Barnan by showing the toy to him.

Nita: Srabanti, tell the name of the toy to Barnan.

Srabanti: Tiger. Srabanti presses the tail of the tiger, and it makes sound "roar".

Nita: Oma! Tiger makes roar sound. Nita presses hard on tiger's tail and it makes a roar sound 2/3 times, and she keeps the tiger in the box. The roaring sound attracts Barnan.

Barnan picks up the tiger and investigates the toy with deep observation and tries to press the tail button but fails.

Nita shows him the white tail and shows him how to press the button (the tail) for making a roar sound.

Barnan again tries to press the tail for making a roar sound but fails and loses interest in it.

Interpretation of Part One:

The mother creates a collective play moment which is a very common culture in Barnan's family home. Barnan was very curious about the tiger toy and tried to explore the "roar" sound. However, Barnan *was not successful in this play moment which will be discussed details later in the discussion.*

Part Two: Explore Flute's Sound, Rattle's Sound, and Drum's Sound

Barnan picks up the flute (with long tail) from the toys and looks closely at the flute.

Nita: Wow! It is a flute. Can you blow the flute, Barnan?

Nita takes the flute and blows it lightly 2/3 times, the flute tail becomes long. Barnan is curious about the flute.

Nita: Barnan, blow the flute. Nita encourages Barnan by saying it two/three times. Barnan blows it, but the flute does not work. Nita continuously encourages Barnan to blow the flute.

Then Srabanti blows two/three times on the flute, makes a sound and tail of the flute extends. However, Srabanti blows the flute very hard, and it makes a high volume of sound and Barnan becomes scared and moves to her mother's lap.

Nita: Srabanti, please do not make the high volume as it scares Barnan. Afterwards, Srabanti blows the flute lightly which makes a low sound.

Barnan picks up the flute and successfully blows the flute, as the flute's tail becomes long (2/3 times), but he could not make any sound.

Nita: Barnan, blow hard (2/3 times) then you can make sound. Nita shows how the flute can be blown hard with her physical actions. Barnan tries to blow hard, and blows it happily many times although it does not make sound, only the tail becomes long.

Barnan also successfully makes jigjig sound by shaking a rattle and drums sound by tapping the box with full engagement and support from Nita and Srabanti in this collective play.

Interpretation of Part Two:

Barnan was very happy in this play moment. In this part, Barnan successfully explored various sound concepts such as flutes sound, jifjig sound, drums sound and understands different volumes of sound such as high and low. Why Barnan was successful in part two will be discussed next in detail.

13. 5 Discussions

Cultural Relationships: Dynamic Aspects of Motives in Play -
The collective play situation as an activity setting – development of play motives

The collective play moment is a regular cultural event in this family. The mother takes the initiative to create the activity setting that all the participants join. During this age, the primary caregiver sets joint object-centred actions based on the child's need which becomes the motive of object-centred activity of the child (Karpov 2005). In the vignette the mother as a primary caregiver, sets the collective play situation with the toys by thinking of Barnan's need to learn sound concepts and not to be frightened.

Fig. 13.1 Collective play moment

In this collective play, the attention of adult (mother) and senior play mate Srabanti are important for creating the attractive play situation for Barnan. This collective play culture as an activity setting, motivates Barnan to take part (Hedegaard 2012).

Family as an institution creates the relationships to motivate the child
The demands for the play activity of exploring toys for making sound are created by the family (as an institution) as part of regular play practices and the demand has become a motive for Barnan. The family play event is very familiar, and a regular practice for any child who belongs to the family. Hedegaard (2012, p. 12) relates, "the relations between institutional practice and its objective and the person's motivated activity within his/her social situation of development can be seen as the core in conceptualisation of the developmental process

as self-movement". As we see, Barnan takes part in the play event spontaneously which is the demand of family play.

Fig. 13.2 Spontaneous participation in known family play event

Hedegaard (2012) states, the demands become a motive through repeated actions, and as we see in both parts of the vignette, Barnan repeats intentionally, by making roar sounds or flutes sounds in play moments over multiple observations. The family as an institution creates the relationships between the child and play context that in turn motivates the child to be in this cultural context.

Culture of family play as a societal demand

Hedegaard (2012, p. 18) says society creates the conditions for an institution with its activity setting. Family is one of the institutions in society where children develop their basic learning as part of their social situation of development. Family as an institution is developed historically and sets primary conditions for children's social situation of development as part of societal demands (Hedegaard 2012).

Bozhovich (2009, p. 78) describes child's social situation of development in everyday practice as follows: "Children's positions are determined by two conditions: first, by the demands of the social environment that have developed historically and are placed on children of a particular age (from this perspective we can talk about the position of the pre-schooler, the schoolchild, the working adolescent, the dependent, etc.); second, by the demands that people around them place on children based on the individual developmental features of a particular child on the specific circumstances of the family."

In this vignette, it is clear that Nita (mother) sets the play activity for exploring sound concepts as Barnan is scared of the high volume of sound or different types of sound. Nita considers his age and chooses the toys for learning sound concepts which must be considered as part of the child's social situation of development at the given age (Bozhovich 2009). Play is the leading activity at this age and young children like Barnan learn from play activities (Vygotsky 1966). Since family is the first institution for children's primary learning in the society (Hedegaard and Fleer 2008), the family carries the play tradition historically, Barnan can learn the preliminary sound concepts from the family play as part of the demands of the social environment (Bozhovich 2009) which will help him to fit the societal context in future life.

Figs. 13.3a Exploring various sound concepts through play as part of societal demand at this age

Figs. 13.3b Exploring various sound concepts through play as part of societal demand at this age

Figs. 13.3c Exploring various sound concepts through play as part of societal demand at this age

Figs. 13.3d Exploring various sound concepts through play as part of societal demand at this age

Through the vignette, it is evident that Barnan is motivated to explore various types of sound toys in relation to societal needs as Chaiklin (2012, p. 223) explains: “motive is limited more rigorously in relation to societal needs”.

Human biology as primary motives

Hedegaard (2012) states that each institution has the activity settings which are set by society and the persons do the activities based on specific biological needs, such as eating, etc. In the vignette example, the family created a play environment which the child regularly participated in and where the primary motives of the child were evident in the activity.

Fig. 13.4 Sad Face

Fig 13. 5. Happy Face

Hedegaard (2012) also discussed the behavioural and cognitive traditions that societies support, such as eating etiquette, or attending school, suggesting that they too are part of the concept of motivation. She notes that persons are primarily motivated based on success and failure in these activities, which is driven from both a biological need and also from the environment. We can see, Barnan tries twice to press the tiger's tail for making the roar sound in part one, but fails and therefore loses his primary motivation to play with the toy again. In contrast, Barnan plays many times with the flute as he is successful and achieves his goal which motives him to play more. Thus, the child is motivated because of success which primarily comes from within the child's biological needs as well as from the environment.

Relationships between persons motivates the child

In the play example, the family participates in the activity setting, and each contributes to it from their specific social situation of development, where they act according to their experience (Hedegaard 2012). Nita as a mother tries to engage Barnan in the sound exploration activity which might help Barnan to reduce his fear of varieties of unknown sound. Nita's experience as a mother motivates her to set the play activity for Barnan and Barnan is motivated by the surrounding people (Bozhovich 2009) who encourage him in many ways.

Figs. 13. 6a Activity of mother and Srabanti motivates Barnan to play

Figs. 13. 6b Activity of mother and Srabanti motivates Barnan to play

As Karpov (2005, p. 84) said, “the child develops a motive at this age (within one year), that is, the motive of emotional interactions with caregivers”. Barnan mostly depends on his mother (Nita). Barnan has intensive interactions with her, as we see in the vignette where he is motivated to participate in the actively. Also, Barnan imitates Nita’s activity, to press the tail of the tiger or blow the flute. It is argued by Karpov (2005) that a child starts to imitate caregiver’s actions with objects and toys in accordance with their social meaning. Srabanti as a senior playmate is experienced with all the activities and shows Barnan how he can play with toys for making sounds. Srabanti as a playmate creates an encouraging environment for Barnan which motivates Barnan to do the activities. All the participants’ intentions, experience, and engagement in the activity, motivates Barnan to play, and as Bozhovich (2009) argued, participants emotional experiences in the activity settings are closely linked to the child’s social situation of development. The child meets the social demands when they are encouraged and through this a play motive is fostered.

In both parts of the vignette, Barnan was motivated by the participants' intentions in play and what experience participants bring to the play moments. However, in part one of the vignette, Barnan could not make the sound by pressing the tiger's tail because of the participants' (Nita) low level of engagement in the play moment. If Nita had provided more support to Barnan for pressing the tail button, then perhaps Barnan might have understood the action of pressing to make the roaring sound. Since Barnan is a very young child (around12 months) and has limited or no experience of this "press" concept (precursor to understanding force), he could not imitate the role and function demonstrated by Nita and Srabanti (Fleer 2012).

Figs. **13. 7a** A low level of engagement for pressing the tail

Figs. 13. 7b A low level of engagement for pressing the tail

In this case, Barnan was not motivated to do the activities again because of the low level of engagement of persons in the activity.

Figs. 13.8a A high level of engagement for blowing the flute

Figs. 13.8b A high level of engagement for blowing the flute

Figs. 13.8c A high level of engagement for blowing the flute

Figs. 13.8d A high level of engagement for blowing the flute

In the second part of the vignette, Barnan was fully motivated by the person's activities where their intentions, experience and engagement were appropriate for the given age in the child's social situation of development (Bozhovich 2009). Thus, Barnan potentially understands the concepts of blow, shake, and tap and makes different sounds by doing the activities as understood from his engagement and actions in the context. In addition, Barnan potentially understands the different pitch and levels of sound as high and low in this play context.

Learning and developing small science concepts through dynamic aspects of play motives

In the vignette, it is clearly evident that the mother sets up the play moments for children's learning and development of sound concepts. Here, exploring the concept of sound in play is considered as a *small* *science* moment that encourages the child to investigate sound concepts through familiar toys in cultural play activity (Sikder and Fleer 2015a). We will see how the relationship of dynamic aspects of a play motive enhances the development of the child's scientific learning motives.

Nita creates the play environment for Barnan to explore sound concepts. Barnan is curious about the toy box and toys as seen in the vignette. In part one, Nita shows the pressing button of the tiger's tail to Barnan and how it works for creating the "roar" sound. In part two, Nita blows the flute lightly as she is conscious that Barnan is scared of loud and unusual sounds. Srabanti blows the flute hard and makes the flute's tail long and with a high volume of sound. Through the vignette, the object-centred play activity (pressing tiger's tail or blowing the flute and creating sounds) attracts Barnan, and the adult's work acts as a mediator of the activity which also motivates Barnan (Karpov 2005). Barnan potentially learns *small science concepts such as pitch and high volume and low volume of sound* through the cultural play contexts.

Through part one of the vignette, the child tries to make a sound (roar) by pressing the button twice. His deep observation of the toys, his curious eyes, and intentional actions provides a message that he was motivated to explore sound concept (roar) and understand the concept of pressing as part of *small science* concepts. However, Barnan could not learn *Small Science* concepts in this case as he cannot successfully apply his understanding (pressing the button to make roar sound) in a voluntary manner. It is argued (Sikder & Fleer 2015a) that *small science* concepts can be learned if the child can consciously apply his/her learning in a voluntary manner.

Barnan was unsuccessful in learning the *small science* concepts (pressing button to make a roar sound and exploring sound concept) potentially for two reasons, firstly the level of engagement between the adult and the child and the child's previous experience of this task. At Barnan's age, it is a relatively new experience for him to press the button for making a sound. Barnan tries to press the button for making a sound but fails because of inexperience. Fleer (2012) says that the child cannot imitate the task and functions of the adults if s/he has limited experience of the task. If Nita holds his fingers and presses the button along with his fingers, it is likely that Barnan could possibly understand the pressing concept and do the activity by himself later.

It is also understood from the vignette, that the materials and the mum/senior play mate's modelling provide a way for the child to act in relation to their play motive or contribute to developing a motive for learning (Fleer 2012, p. 92), but it might be unsuccessful because of the level of engagement between them. Elkonin (2005) suggests that play is not driven by internal instincts or motives only, but rather it is through the child's engagement with their social work environment and their relationship to others and the material world, that form motives for play to develop. The moment Barnan fails to do the activity (press the button to make sound, twice) he loses his play motives for the object (the tiger toy) which reduces the possibilities to develop a learning motive of *small science* concepts. Therefore, it is evident here, that successful play motives depend on the dynamic aspects, such as the level of engagement, and the scope of experience of a child's relationship in the play moment.

On the other hand, in part two of the vignette, Barnan potentially learns *small science* concepts by blowing the flute, shaking the rattle, and tapping the box. The adult's conscious engagement in the task is important to develop *small science* concepts (Sikder and Fleer 2015b) and it was seen that Nita was consciously engaged in teaching Barnan how to blow the flute (shake the rattle or tap the box). Nita and Srabanti repeated the task on how to blow the flute, and Barnan tried several times to do it too. Although Barnan had limited experience in blowing the flute, he is finally successful because of the level of adult engagement in the task. Barnan consciously applied his learning of blowing the flute independently, and making the tail longer, as it can be said that the child learns *small science* concepts when s/he consciously applies his/her understanding independently (Sikder and Fleer 2015a).

Throughout the vignette, Barnan potentially learns *small science* concepts which are blowing, shaking, and tapping, as part of science concept of Force. Additionally, Barnan explores various sounds such as the flute's sound, jigjig sound, and drum sound, as part of exploring vibrations and pitch building understanding towards the concept of Sound.

13.6 Conclusion

The relationships of dynamic aspects of motives are integrated in the activity setting (Hedegaard 2012). However, each aspect of motives has been explained individually in this chapter to provide the idea of its importance in children's culture of play. Motives reflect the child's social situation of development from the child's perspectives (Hedegaard 2012). For example, Barna was motivated when he could blow the flute. Consequently, the child intends to do the activities because of his/her satisfaction in play and repeats the actions which enhance his/her learning through a play motive which is part of the child's social situation of development.

Play is a serious game to children under three years of age (Vygotsky 1966), and children are serious in their play activities as Barnan does. Play has been seen as a societal demand at this age in this family environment where the play activities are developed based on child's need. The mother sets a collective play culture as a special form of activity settings in which the engagement of play parteners contribute to the focus child's learning and development.

The argument here is that any single aspect of motives in a child's play cannot be ignored because play is central for a child's social situation of development and new demands afford new developmental possibilities. In this study the child was unsuccessful to do the activities because of a low level of engagement of persons in the play moment which is one of the reasons for demotivating the child in play. Also, when the child failed to press the button by himself twice, he was also demotivated because of self-biological demand. In this play context, it would be incomplete if we study the child only from the point of relationship with people around him/her. If the play activities are set in an unknown environment of the child, the child may act in a different way, or if the child plays individually (not collectively), it would be a different experience for the child. Therefore, we have to consider all the relationships of dynamic aspects of motives in a child's play and learning and consider the child's relationship with people and the environment at his/her given age as part of the social situation of development (Bozhovich 2009).

It is evident from the vignette, that the child's play motives are important for their learning and development. In part one of the vignette, the moment the child loses his play motives the possibilities of learning motives stopped in the play moment. It is evident that the child does not learn the *small science* concept of press because of a lack of motivation in the play moment. In part two of the vignette, the child intends to do the activities many times as s/he is motivated by the dynamic aspects. Through the play activities, the child potentially learns *small science* concepts of blow, shake, and tap as part of scientific concept of Force and also possibly understands the sound concept of flute, rattle, and box. The play motives enhance the child's scientific learning motives when all the aspects of motives fulfil the child's demand at that moment. Therefore, for achieving a successful outcome of the play moment, one might consider the dynamic aspects of a play motive, and the successful play motives that create the rich possibilities for infant-toddler's development of science concept formation in their everyday culture.

This chapter provides theoretical understandings of the relationships of dynamic aspects of play motives in children's play, including an adult's engagement in the moment. It is in the evidence of empirical research that the dynamic aspects of a play motive for enhancing infant-toddler's scientific learning motive in *small science* moments at an early age are better understood. This provides pedagogical understandings relevant for early childhood science education and contributes to the limited body of research into infant-toddler learning of science.

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Chapter 7: Parents’ Perception of Small Science

“The social situation of development is nothing other than a system of relations between the child of a given age and social reality”.

(Vygotsky, 1998, p. 199)

Background of the fourth paper

In the first three papers, I have discussed the possibilities for small science moments in everyday contexts, social relations for developing the concepts, and the dynamic aspects of motives for the development of the science concepts in regular play contexts. However, these papers do not illustrate what parents think about the science concept formation at the infants-toddlers age. To understand the whole view of infants-toddlers’ science concept formation, it is significant to research parental participant’s perception. Since infants-toddlers are too young to express their views due to their developing language skills, I have conducted dialogue based interviews with parents in relation to small science moments. I analysed interview data for the fourth paper (Chapter 7).

Parents talked about their views that were relevant to small science concepts, as well as the children’s actions in relation to small science moments. I have used Vygotsky’s (1998) concept of the social situation of development for explaining the theoretical framing of the analysis of the data presented in this paper. According to the parents’ view, it is evident that they consider the child’s social situation for developing science concepts in the child’s life and combine the children’s experience in relation to science concepts, which also contributes to children’s social situation of development. Infants-toddlers show and express agency in these small science moments.

I have submitted the fourth paper to Early Child Development and Care and I am awaiting final acceptance after making small revisions. Since this paper is to understand children's science concept formation as part of their social situation of development, I have chosen the journal of Early Child Development and Care to publish my work. According to the journal website:

> Early Child Development and Care is a multidisciplinary publication that serves psychologists, educators, psychiatrists, paediatricians, social workers and other professionals who deal with research, planning, education and care of infants and young children. The Journal provides descriptive and evaluative articles on social, educational and preventive medical programs for young children, experimental and observational studies, critical reviews and summary articles (source: Early Child Development and Care website).

According to 2010 ERA journal lists, Early Child Development and Care is a "B" ranking journal. I am the sole author of this paper.

According to the parents' perception, small science concepts do not require any kind of artificial conditions rather they could be developed in the child's everyday life context with support from parents along with age related features.

Social situation of development: parents perspectives on infants-toddlers' concept formation in science (Submitted to Early Child Development and Care)

Shukla Sikder

Abstract

The social situation of development (SSD) specific to each age determines regularly the whole picture of the child's life. Therefore, we need to learn about the whole context surrounding children relevant to their development. The focus of the study is to understand parent's views on infant-toddler's science concept formation in the family context. Reviewed literature informs us that infants- toddlers experience small science concepts in everyday life. However, this work does not explain how these experiences contribute to the infants-toddlers' SSD. In this paper, parental interviews (three hours of video-audio data) have been analysed to understand this gap. The findings inform us that possibilities of science concept formation at the infant-toddler age are not any extra effort for parents; rather, the concepts could be developed as part of the SSD in everyday contexts. This research impacts on an under-researched area of infants' and toddlers' science concept formation in the family context.

Keywords: parents' perception; infants-toddlers; science concept formation; social situation of development; cultural-historical research

Introduction

A great deal of research has been directed towards infant-toddler cognitive development, language development, physical development, general child development, the developmental nature of play, communicational development, the effect of relations in development and curriculum development of subjects such as mathematics through everyday settings (see Appl, Brown, & Stone, 2008; Gloeckler & Cassell, 2012; Lee, 2012; Main, 1983; Mayer & Musatti, 1992; Page, Wilhelm, Gamble, & Card, 2010). These studies have individually focused on infants-toddlers' development through play or everyday activities. However, children's science learning and development through everyday activities including play in their family context is missing in this substantial body of literature. We know very little about the development of the infants- toddlers thinking in science within their everyday contexts at home.

There were many studies located on children's science learning within formal edu- cational settings, such as kindergarten, preschool and childcare centres (Bayraktar, 2011; Bulunuz, 2013; Chang, 2012; Fleer, 1996, 1997, 2009, 2010, 2011, 2012; Goulart & Roth, 2010; Kim & Lim, 2007; Martins & Veiga, 2001; Metz, 2011; Olgan, 2014; Ramsey & Fowler, 2004; Riojas-Cortez, Huerta, Flores, Perez, & Clark, 2008; Sackes, Trundle, Bell, & O'Connell, 2011; Shaji & Indoshi, 2008; Siry & Kremer, 2011; Smolleck & Hersberger, 2011; Traianou, 2006; Valkanova & Watts, 2007; Watters &

Diezmann, 1998; Watts & Walsh, 1997; Whitby, 1992). These studies focused on how science learning can be enhanced through scientific play, science attitudes, cognition and imagination in play, social construction, integrated play and science, specific science concepts, age-appropriate materials, science books and journals, science in curriculum, scientific environment, teachers' questioning, teachers' positiveness towards science teaching and teacher's awareness. However, effort has been concentrated on preschool or kindergarten children's science learning. There are many more features that need to be revealed to understand early childhood science education, such as science in everyday contexts (such as the home), science learning with parents and how infants-toddlers learn science.

There are very few studies informing science concept formation in an infants- toddlers' life in either formal contexts (e.g. preschools and kindergartens) or infor- mal contexts (e.g. the family home) (cf. Forman, 2010; Gopnik, 2012; Pramling & Samuelsson, 2010; Sikder & Fleer, 2015a, 2015b; Yoon & Onchwari, 2006). For instance, Yoon and Onchwari (2006) emphasise the importance of the teacher's knowledge of child development and learning, individual differences and the social cultural context of children's lives for teaching science to young children. In another study, Pramling and Samuelsson (2010) focus on one young child's (three-and-half-year old) experience with natural science in preschool. The contexts in both studies are formal education settings and the authors do not explain how science concepts can be developed in these formal contexts. Forman (2010) claims that children could develop their thinking as scientists through play and recommends that direct instruction in science is not needed. Gopnik (2012) comments that very young children (from age two) demonstrate scientific intelligence gained from everyday thinking and learning. These studies do not provide a whole picture of how the child develops science concepts in the family context. Sikder and Fleer (2015a) provide evidence that infants-toddlers experience science concepts through everyday activities and play. In another paper, Sikder and Fleer (2015b) discuss the parent's role in developing science in the infants-toddlers' life. The researchers focus on the possibilities of science concept formation in regular or play contexts (e.g. in the home and at playgrounds), and the parent's role in developing the concept in that context. In combination, these studies do not illustrate an overall under- standing on how scientific concept formation occurs in everyday life at home for infants-toddlers. However, the aim of this paper is to learn more about the parent's considerations with regard to children's social situation of development (SSD) when they introduce science concepts to their children in the regular everyday context at home. What do we mean by SSD and why do we have to consider the SSD in forming children's science concepts?

When discussing the child's SSD (Bozhovich, 2009; Vygotsky, 1998), there are many important aspects that need to be considered for any particular development at each given age.

These aspects include the child's age-related features, their social con- texts, the culture, particular experiences, relationships between others in the setting and internal learning processes. If we want to learn about the child's SSD from a particular developmental aspect, we need to learn about the child as a whole situated in a particular context.

For understanding the child as a whole, articles have been reviewed in relation to each aspect of the SSD mentioned above. This includes children's experiences in many different contexts such as within the family context (Becker, 2014; Fleer, 2004), cultural con- texts (Goncu, Mistry, & Moiser, 2000) and formal contexts (McInnes, Howard, Crowley, & Miles, 2013) and how these varied contexts influence a child's individual development (e.g. different domains, and behavioural and scientific development). Another aspect of the SSD concerns children's relationship with surrounding people such as parents and carers, in order to find out about children's development (Grammatikopoulos, Gregoria- dis, Tsigilis, & Zachopoulou, 2014; Marjanovicˇ-Umek, Fekonja-Peklaj, & Podlesek, 2012; Sumsion & Goodfellow, 2012). There has been some research on children's play and how their experiences influence their development (Edwards, 2013; Faulkner, 1996; Goncu & Gaskins, 2007; Hakkarainen, Bre˙dikyte˙, Jakkula, & Munter, 2013; Singer, 2013). However, these studies have provided some understanding of an individual idea of each context for supporting children's development and do not include the whole picture of a child's particular development at a given age (e.g. infants-toddlers or preschoolers). In this paper, parental views on the whole of infant-toddler's experiences in relation to science concept formation as part of their SSD are examined. That is, a holistic perspective of children's learning and development of science is undertaken (Hedegaard, 2008).

This study seeks to fill the gap of how science concept formation is supported through adults during the infants-toddlers life at home. However, rather than viewing science concept formation as purely a cognitive dimension of learning, this study seeks to conceptualise science learning as part of the infants-toddlers' SSD. Through taking a cultural-historical perspective, the study seeks to determine how scientific concept formation becomes part of the infants-toddlers' lived everyday experience at home at such a young age. The scientific lens that is developed by the infants-toddlers provides new possibilities for interacting with in the social and material world which is also examined. Since infants-toddlers are not old enough to express their views, parents have been interviewed in order to gain insight into the infant-toddler's understanding. Many research projects have sought to find ways to teach this concept to children.

Theoretical framework

In this paper, I draw upon cultural-historical theory to discuss scientific concepts in the context of the everyday activities that infants-toddlers participate in at home. Parent's perceptions in relation to science concept formation during infants-toddlers life are ana- lysed with concepts from cultural-historical theory. According to the parent's responses in this study, the SSD has an influential role in forming science concept formation in infants-toddlers everyday activities. In addition, parents suggest that infant-toddler's understandings of scientific concepts gain maturity through imitation and collaboration with adults, which can be linked to the concept of zone of proximal development (ZPD). The ZPD supports children to internalise the concepts and also describes the role of the adult in helping children to develop concepts through cooperation (Vygotsky, 1998). Therefore, the ZPD has been considered under the broad view of SSD in this paper.

In order to understand children, we have to know the social, cultural and historical practices in which they live and learn (Hedegaard, Fleer, Bang, & Hviid, 2008). Rogoff (2003) extends it as follows:

> Understanding development from a sociocultural-historical perspective requires examination of the cultural nature of everyday life. This includes studying people's use and trans- formation of cultural tools and technologies and their involvement in cultural traditions in the structures and institutions of family life and community practices. (p. 10)

For example, a child plays with play dough in the home and uses a rolling pin and a board to prepare a snack with different shaped cutters (e.g. butterfly shape, fish shape, etc.). The child uses the same rolling pin and board that the parents use for preparing chapatti as a traditional cultural practice. In this example, the rolling pin and board are cultural tools, which transfer to the child's play automatically as part of the family's culture. To understand the child as a whole, the family culture is important to reveal the historical practices of human development as a cultural process. Then what is the position of the child in social practices?

To discover the child's position in society, the child's SSD specific to each age regulates the entire picture of his/her life or social existence in a strict manner (Vygotsky, 1998). As extended by Fleer (2008a), the society and cultural context deter- mine the social situation of a child in which the child is embedded. Bozhovich explains further:

> Children's positions are determined by two conditions: first, by the demands of the social environment that have developed historically and are placed on children of a particular age (e.g. the position of the dependant, the pre-schooler, the school child, etc.); second, by the demands the people around them place on children based on the individual developmental features of a particular child and on the specific circumstances of the family. (2009, p. 78)

We have to investigate the children's experience in relation to individual develop- mental features and the specific family circumstances. Corresponding with the social situation, the child's experience was chosen as a unit for investigating children's personal development (Hviid, 2008).

Vygotsky (1998) states that there is a vibrant action of the environment behind every experience with respect to the child.

Bozhovich argues (2009) that the nature of a child's experiences must be under- stood by the effect of the environment on children and how it affects the course of their development. For instance, if we examine how a toddler plays with cooking toys for preparing chapatti, this can be interpreted as the child's individual experience in his/her social environment. In this example, the infant-toddler has experiences eating chapatti every day in the family. The child imitates or imagines the mother or father in the play. The adult's image influences the child and the experience s/he gains from everyday life. Another toddler may make bread in his/her cooking play because of a different family culture and different experience, which allows him/her to do so. Since the projects aim is to study infants-toddlers' development in science concept formation, I extend the example of chapatti or bread making in two cultural contexts in relation to science.

For example, a Bangladeshi child gathers experience regularly that his/her mother kneads flour for a long time so then the chapatti raises more. This is because kneading for a long time produces carbon dioxide which helps to raise the chapatti when it is roasted. An Australian child observes that his/her mother uses yeast in bread so that the bread raises more. This is because yeast is a microbe agent which helps to raise the bread more when it is baked. Thus, both children get scientific experience in their regular cultural or family context, which is constructed historically through long-term cultural or familial practices. If the children apply their scientific experience in play or similar activities, that means they are influenced by their SSD. Chaiklin (2003) emphasises that the interaction between historically constructed forms of practice and the child's interest and action at the given age is considered a way of the child's SSD. In play, children apply their collected experience and play is part of their regular activities. At infant-toddler age, children are engaged in many play activities along with their regular activities.

According to Vygotsky, in play, children employ their knowledge, understandings and practices that are socially or culturally constructed (Dockett & Fleer, 1998). Furthermore, play originates and is formed through social content and enters children's life naturally, without any conditions (Elkonin, 2005). Thus play experiences can be counted as part of social situation of a child if we would like to investigate the whole picture of a child. Subsequently, the SSD is a system of relations between the child of a given age and social reality (Vygotsky, 1998). Play is one of the leading activities (Vygotsky, 1966) between the age of 10 and 36 months in this social system. As argued by Fleer (2011), concept formation can occur at an early age through play. It has been evident (Sikder & Fleer, 2015a) that small science concepts can be developed through play and everyday activities. Experiencing small science moments at the given age (infant-toddler age) through play or everyday activities as part of their social experience could bring changes in the child's SSD.

In play or other everyday activities, the child imitates the adult and Elkonin (2005) states that imitation should facilitate the child's interactions with the conditions of life around him or her in which the child is growing and developing. Thus as Vygotsky (1998) states:

> Aided by imitation, the child can do more in the intellectual sphere than he/she is capable of doing independently and his/her capability of intellectual imitation is not limitless, but changes absolutely regularly corresponding to the course of his/her mental development so that at each age level, there is for the child a specific zone of intellectual imitation connected with the actual level of development. (p. 201)

For example, a 15-month-old child pretends to blow soup to make it cool in a play context. In this case, the child imitates the action of his/her father or mother from regular activities and applies the concept (blow) in play. We could say that the child does intellectual imitation to internalise the concept, which helps him/her to connect with the actual level of development (applying the concept in a different context). The intellectual imitation to internalising the concept is the child's ZPD.

Holzman (2009) says that creative imitation is a type of performance and imitation is connected to the concept of ZPD (Hedegaard, 2009). Vygotsky (1998) describes ZPD in the similar way that the diagnosis of development has occurred through the specific zone of intellectual imitation in the period of maturation. Holzman (2009) claims that the ZPD provides the opportunity to take a fresh view of imitation and its role in learning and development. The ZPD points to the phenomenon that, intellectually, a child can always do more with the help of a more competent person than he/she could do alone and this is accomplished through imitation.

Another example that explains the ZPD and the actual level of development in relation to small science concepts is two 30-month-old children starting to learn how to ride a bicycle with the support of an adult or through imitation. Learning to ride con- tains several small science concepts such as push, pull, body balance, motion and operating the handle to provide direction. A child understands the small science concepts and successfully rides a bicycle at the age of 36 months by applying the concepts with the help of an adult through imitation and cooperation. The other child learns to ride the cycle at 40 months of age. In this case, both children take, respectively, 6 months and 10 months to learn to ride the cycle which is their maturation period under the ZPD. When the children can independently ride the bicycle, it is their actual level of development. The role of adults is considered as creating the conditions for the ZPD in this context, and this also contributes to children's SSD.

Children's actual level of development depends on the process of maturation and the SSD contributes to the process of maturation (Vygotsky, 1998). Similarly, under- standing small science concepts (e.g. push/pull/motion) at the infant-toddler age begins the process of maturing their understanding towards future understanding of science concepts (e.g. force) at school age.

In this paper, an analysis of parent's views on children's (10– 36 months) experience in relation to science concept formation is examined during regular family activities and play where the child's SSD including ZPD is considered.

Research methodology

Research problems

The central aim of this study is to determine what conditions parents create when they tend to form scientific concepts in an infant-toddler's life. This paper examines the multi-dimensional features of infants-toddlers' science concept formation from a cultural-historical theoretical perspective. This perspective acknowledges all multi-dimensional elements of children's participation in everyday life (Hedegaard, 2008). The target children in this study are infants-toddlers (10–36 months). Since infants-toddlers depend on their parents or other adults, I have chosen to discuss the parent's perception of their infant-toddler's science concept formation as central for understanding the young children's SSD. The problem for this paper is to investigate:

- What are the parents' perceptions of the development of scientific concepts in everyday family life for infants and toddlers?

Participants

This paper is part of a larger study that has been carried out in the family context and researches an infant-toddler's development of science concept formation. Data collection occurred during the period of 2012–2013 in Australia and Singapore. The lead researcher originates from Bangladesh and has chosen Bangladeshi families as her understanding of the children's culture is in depth as she has life-long experience within this culture. The research project focuses on three Bangladeshi children who live outside Bangladesh with their Bangladeshi parents. The age range of children who participated in this study is consistent with infant-toddler period (10–36 months). The first focus participant, Barnan, was observed from the age of 10 months to 13 months. Joy, the second participant, has been followed from 30 months to 36 months of age. Both of these participants were residing in Australia. Jhumki the third focus participant, was followed from 23 months to 28 months in Singapore.

All names are pseudonyms according to the requirements of ethic protocols followed in this study. Parents from three families joined in my study because they are the main communication partners of the children. As supported by Hedegaard (2008), it is necessary to be involved with the everyday activity settings of the researched person's social situation, understand the communication partner and enter with a special intention in relation to the aim of the research project.

Data collection

Data were collected with the help of one volunteer research assistant, who originates from Bangladesh. A video camera, a still camera, an audio recorder and field notes were used to gather qualitative data. Occasionally, parents collected video data and still images at the weekends or night time when it was not possible for the researchers to attend the family context. Approximately 30 hours of video data (25 hours collected by researchers and 5 hours by parents) have been captured in the infant-toddler's every- day settings (e.g. meal time, play time, story time and bath time). Video and audio inter- views in relation to infants-toddlers' developing science concept formation were carried out with parents. Three final interviews were taken with three parents (three mothers) who were available and engaged in the researched activities during data col- lection. In addition, the researchers visited the families approximately 36 times for data collection purposes over a one-year period. During each visit, the researcher discussed the parent's opinion regarding the content of the data gathered at the end of each session. One hour forty-four minutes of video data and one hour twelve minutes of audio interviews with parents were collected, and necessary field notes were gathered over this one-year period.

For studying children's everyday settings, it is essential to investigate the different perspectives of the participants and digital video observation can help to do this (Fleer, 2008b). Fleer states that the researcher can observe video clips from different perspectives and discusses the observations with participants either informally or formally with interview questions. Since the focus participants are too young to discuss interview questions, interviews with the parents have been included. We have explored two different perspectives in two papers (Sikder & Fleer, 2015a, 2015b) to report on video clips in everyday settings. In this paper, I examine interview data to understand a holistic perspective of infants-toddlers' science concept formation.

The interview data were gathered in three different ways keeping in mind parental comfort and convenience. Initially, interviews were conducted through informal conversation in relation to particular play episode and the researcher collated field notes. The second way was using a voice recorder during interviews with parents after collecting video data; this was dependent on time availability of the parents. The final inter- view was conducted at the end of all data collection and the video camera was used to record the final interview. During the interview period, the researcher discussed all activities carried out by the infants-toddlers after observing all video clips.

Interviews

In a cultural-historical research study, the interview process is not a formal process of questions and answers, but rather shared knowledge construction and deconstruction between two people while dialoguing (Hviid, 2008). For example, at the beginning of data collection, when the researcher discussed science concept formation in their children's life, the concepts were not very clear to parents. In addition, the researcher did not have in-depth practical ideas regarding science concept formation at the infant- toddler's level. The researcher and parents advanced their knowledge while collecting data in their family contexts to focus the project aims. Dialogue was shared from time to time to understand the science concept formation at the everyday level.

The researcher developed a questionnaire to gain information about science concept formation in an infant-toddler's life after observing the video clips at the end of the data collection process. According to Bang and Hedegaard (2008, p. 163), the questionnaire needs to address the child's SSD in which we can find (a) how an individual child participates in institutionally valued activities; (b) the relation between child and other children; (c) the relation between the child and significant others (teachers, parents, etc.) and (d) how the child thinks and feels about their own participation. In my study, the family context is the main focus. As stated by Hedegaard (2008), family is considered as a societal institution. These aspects were considered when develop a questionnaire. Infant-toddler's perception is gained through the parent's interviews as the children are very young. The researcher's focus is to understand the aspects of the participant's life related to the research aim by conducting meaningful dialogue (Hviid, 2008) with parents.

Data analysis

Being a researcher in a cultural-historical research study, it is important to understand the difference between data collection in the field and data interpretation at the desk. Hedegaard (2008) argues that the researcher holds a pre-conception about the research aim while collecting data but when the researcher starts to interpret data, the field data and theoretical concepts need to be linked in an explicit way. Hedegaard (2008, pp. 58– 61) suggests three levels of data interpretation for interview data as follows:

(1) Common sense interpretation: This is the first level of interpretation where the researcher comments on understanding of the interactions in the activity set- tings. It does not demand explicit concepts but links between the research aim and activity settings are required. In this study, the researcher established a link between the project aim (infants-toddler's scientific concept formation) and dialogue with parents by applying a common sense understanding.

(2) Situated practice interpretation: The second level of interpretation demands explicit conceptual understanding of the researcher. The researcher transcends the single activity settings and links together observations taken across several activity settings within the same project. In this study,

the researcher investigates dialogues between the researcher and parents and explicitly relates the conversations with the concepts of the SSD including the ZPD. The researcher views all interview data to examine the concept of SSD including the ZPD. In addition, the researcher visits the video clips of everyday activity settings and links them with interview data for gaining the conceptual understanding.

(3) Interpretation on a thematic level: The concepts have been connected with the research aim in a thematic level. Explicit relations are formulated by using theoretical concepts to find patterns in the situated complexity of the institutional practice level of interpretation. First, the researcher links parents' view of science concept formation and the SSD including the ZPD potentially answering the research question in relation to conceptual understanding. Finally, the findings could be concluded in a thematic level reflection how the SSD including the ZPD influenced infant-toddler's development in science concept formation.

Findings

The findings derive from the dialogue between the researcher and parents in relation to the project aim: that is, infants-toddler's development of science concept formation. In addition, the researcher reviewed video data of infant-toddler's everyday activities for linking parents' interviews and to find the parent's perception in relation to the research problem. In the next section, each question and answer combined with interpretation of the video data and the concepts of this study are considered. The following is an interpretation of the dialogue between the researcher and parents, as each child is an individual and their activities and perspectives are different as well. Here, I have presented some of our dialogue as a question–answer to make it concise.

As I have discussed in the theory that the formation of small science concepts is maturing through the SSD including the ZPD. The SSD influences several aspects of child's social existence which are cultural contexts, age-related features, child's individual experience in relation to concept formation and roles of the parents. Table 1 summarises the parents' view in relation to the SSD in developing small science concepts in their regular context as follows:

Parents	Parents' view in relation to SSD					Concept formation	
	Cultural context	Age related features	Children's experience	Roles of surrounding people	ZPD	Everyday concept	Small science concept
Q 1. Do you have any purpose while you play with your children or in other regular activities?							

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Response of Nita /Sima/ Jhuma	Family context	Age specific toy or tasks/ Questions-answers	Play with rattles/ Doctor–patient play/ Cooking play	Parents create the conditions for children's learning (e.g. purposefully buy the toys). Sometimes child initiated then parent extends the play	Imitation, explanation, co-operation	1. Animal name, Sound concept 2. Application of materials 3. Name of Ingredients,	1.Soft, hard 2.Push, pull 3.Change of state of matter
Q 2: Does your child understand the concept what you teach him during play/ regular activities/ actions?							
Response of Nita/Sima/ Jhuma	Family Context / Social environ ment	Age related toy/ Age related conversation	Musical toy/ Observes butterfly / Context of food habit	Parents create the conditions. Sometimes child initiated then parent extends the play.	Imitation and explanation	1. Different sound concept 2. Rules for flying 3. Rules to feed young baby	1. Press, sound 2. Life cycle of butterfly 3. Food habit
Q 3. Have you noticed any scientific concepts develop through everyday experiences or in play of child's life?							
Response of Nita /Sima/ Jhuma	Family context/ Social context	Age related toy/ Age related conversation	Pressing cat/ Reading story book/ Play with dolls	Similar to previous answer	Imitation, explanation and action through collaboration	1. Cat's sound, Colour concept 2. Knowing different stage of butterfly 3. Rules of feeding baby	1. Press, push and pull, sound/ 2. Life cycle of Butterfly/ 3. Heating and cooling continuum
Q 4. What do you think about your (as parents) or other children involvement in your child's play?							
Response of Nita /Sima/ Jhuma	Family context	Age related play	Lego play/ Family gathering/ Different examples of play/ Conversati on in play	Parents and other senior play mates' involvement motivate the child to play	Imitation, explanation, and question-answer approach	Help to learn everyday concept	Help to learn science concept

Table 1: Parents' views in relation to the infants-toddlers social situation of development in developing science concept formation

In Table 1, parents describe their view on the conditions they set for their children to achieve a particular concept. Following the answer to Question 1, parents' views are different. For example, Nita (mother) chooses age-specific toys (rattles) for enriching Barnan's (son) individual experience in the family context and Barnan imitates his mother to internalise the everyday concepts of animal and sound as well as scientific concept of textures (soft/hard). In some cases, the activity is initiated by the child but it is extended by parents for developing concept formation as Jhuma describes. Responding to the question 2, Sima (mother) describes that Joy (child) learns the small science concept of life cycle of a butterfly through the mother's explanation in their social environment. The conversation in relation to a butterfly is presented from the data-set as follows:

Context: Joy, Sima (Joy's mother), Joy's friend, and Joy's friend's mother were walking to the playground. Sima found a caterpillar in the tree beside the path.

Sima: Look, this is butterfly (she was pointing her finger to butterfly)

Joy and her friend seem excited to see the caterpillar and say, "Caterpillar".

Sima: What does caterpillar eat?

Joy is silent.

Sima: Leaf.

Joy: Yes, Leaf.

Sima: Joy, Caterpillar comes from what? Sima repeated the questions three times.

Joy: Caterpillar comes from butterfly.

Following, one Question (3) and answer from each parent is presented in detail from the interview data as follows:

Question 3: Have you noticed any scientific concepts developed through the every- day life experiences or in play of your child's life?

Nita: Yes, scientific concepts actually come along with our everyday life prac- tices. Children gather experience on the science concepts every day at every moment in their life. We pass the concepts regularly to them through our everyday life experiences. I provide you an example about a toy. Recently I have bought a toy for Barnan (13 months). The toy has two sides, one side you press the cat's head with finger or stick then other side the cat's head comes out gradually high up (demonstrate the toy and function).

I have showed him the toy and done the actions like press/push one side then cat's head comes out from the other side. Then he does the same thing press, press, press and then the other side pulls up. Sometimes the other side does not pull up high, then he uses his hand to pull it up high. He also pushes them down with hand. He understands the concept press or pull or push here. He imitates all the things and understands the concepts well. If you look at this toy then Barnan learns cat's face here and also the concept of push or pull. He gets the feeling how the toy works in his head.

Sima: For example, I read a story book about life cycle of caterpillar. I explain Joy each step (how caterpillar becomes butterfly) and she learns the concepts of life cycle. She learns all this concepts because I assist her or explain to her. For example, she learns one picture of mum Giraffe and one picture of baby Giraffe in story book. Then I explain her that the baby giraffe is grown up day by day and one day she could become mummy giraffe. Sometimes I show her baby pictures and explain how she is grown up from baby age to toddler age.

Jhuma: Jhumki (twenty three months to twenty eight months) likes to play with dolls and teddy bears. She plays take care of baby with her dolls and teddy bears. She just imitates me as I do with her younger brother (4 months to 9 months). Once I observe, she pretends to feed bottle milk to her doll and testing the milk with her skin. Then I ask her what she does. She replies she is checking either the milk is very hot or just warm so then she could feed her doll. She understands that if it is very hot then it is not good for doll. She also pretends to blow the milk for making it cool as I do. She gets the concept of warm and cold from this real life experience and she applies her learning into play.

Overall discussions regarding parents' view in relation to all questions

It is evident in Table 1 that the parents have certain goals while playing with children. Nita (Barnan's mother, age period 10–13months) focuses on purposeful play or tasks with her child. Thus the child understands the concept (e.g. science concept). When Joy was very young Sima (Joy's mother, age period 30–36 months) always explained facts behind the concepts. Jhuma (Jhumki's mother, age period 23–28 months) states that questions–answers or explanations help Jhumki to understand the concept. As supported by Bozhovich (2009), purposeful play or task creates conditions for the child's SSD through their everyday experiences. Children's experiences depend on the family context, which influences the infant-toddler's personal development. As claimed by Vygotsky (1998), children's development is the result of child's experience in their social situations. All parents give different examples of their children's experiences through different situations for learning concepts.

According to the parents' perspective in this study, concepts are clarified in a very simple narrative so that the child begins to understand the concepts as we have seen in Jhumki's example of food. Sikder and Fleer (2015a) claim that children understand small science concepts (e.g. push, pull, water is essential for plant, etc.) through simple scientific narration. The social situation is not an environment in its totality but includes the child's understanding, meaning-making of and engaging in specific aspects of the environment (Hviid, 2008). As we have seen, children are engaged in various tasks during their regular life and understanding the concepts (everyday concepts – rules of life, sound concepts and small science concepts – water is essential for plant) are embedded in their experiences.

In each example presented from by the parents, children are experiencing science concepts in their everyday context or through their toy or in play, which relates to Question 3. Everyday concepts contribute to the development of scientific concepts (Vygotsky, 1987) as the examples provide evidence with the parent's response such as feeding milk to a doll, push and pull concepts, and the life cycle of a butterfly. Sikder and Fleer (2015a) argue that it is impossible that infants-toddlers understand the abstract concepts of science (e.g. scientific explanation of force) but they begin to progress with the small science concepts (e.g. push/pull) through their everyday life experiences.

In addition, children learn small science concepts from play (e.g. pressing) and apply the concept in real life and vice versa (e.g. heating and cooling continuum con- cepts from real life to play). The development of spontaneous concepts and scientific concepts are closely connected processes that continually influence one another (Vygotsky, 1987). As extended by Sikder (2013), small science concepts and everyday concepts influence each other in a dialectical way. Both sets of concepts are united in a single system that is formed in the course of the child's mental development (Vygotsky 1987).

Parents consider children's age with in regard of what to teach or not. Parents also talk about the level of understanding of science concept formation according to children's age. Nita explains about age-related toys and how much she explains to her son according to his age. Children's age and experiences need to be considered when developing the level of the child's science concept formation. As reinforced by Bozhovich (2009, p. 61), 'children's age-related features are important to address to grow the orderly course of mental development and qualitative distinctive structure'. Vygotsky (1998) emphasises age-related features need to be considered for each child's SSD.

According to the parents in this study, parent participation encourages children to play and concepts can be formed through parental involvement. Vygotsky (1998) describes how children become mature with understanding when they work in cooperation with adults or others. In a period of maturation when the child learns through imitation, cooperation of adults/others, explanation, questions–answers and collaboration, the child is in the ZPD (Vygotsky, 1998). In many cases, evidence is pro- vided of the ZPD in Table 1. For example, Barnan imitates his mother for understand- ing textures, Joy learns about the life cycle of a butterfly through explanation of her mother, and Jhumki does creative imitation in dolls play.

As reinforced by Sikder and Fleer (2015b), parents' conscious collaboration with infants-toddlers creates the possibilities of science concept formation in their everyday life. In addition, children like to imitate others, especially adults or other children in their play or in real-life situations according to parent's perspectives. Imitation is the first form of the child's cultural development (Vygotsky, 1997) and children can examine the social rules through the imitation of everyday life experiences (Fleer, 2012). In addition, the relationship between parents and children or peers creates a system of human relationships, which supports a child's personality development (Bozhovich, 2009).

Through parent's views in this study, children need to know basic concepts in relation to regular activities or play. Pre-concept is essential for future schooling or learning about other concepts as supported by Vygotsky (1987). In particular, Vygotsky (1987) states that scientific concepts develop gradually along with other pre-concepts. For example, a child learns about force in school and it would be vague if the child does not have any prior knowledge related to force such as push, pull and spin. Young children learn concepts in relation to their age and experience but abstract concepts they learn later at school age (Vygotsky, 1987). So, if we consider 'force' as the actual level of development in relation to the abstract science concept, then the small science concepts would be push, pull and press. In learning these small science concepts, infants-toddlers move through the process which is considered as ZPD in children's life (Vygotsky, 1987). This is how the child's SSD occurs; as Bozhovich (2009) argues, a concept is a reflection of the objective world that surrounds us and our experiences are products of the reflection of our relationship with surrounding reality.

Family culture is a part of the child's development, as Vygotsky (1994) emphasises; the child masters cultural experiences along with habits and forms of cultural behaviour in the process of development. Therefore, the child's culture develops through their everyday experience and in play, which they apply their cultural behaviour as one of the parents describes (the child uses fingers to eat food in the play). According to cultural-historical theory, 'individual development constitutes and is constituted by social and cultural-historical activities and practices' (Rogoff, 2003, p. 51). The full data-set shows that infants-toddlers use their family culture such as language, food, habits and talking style. Cultural practices are embedded in children's every experience as parent's perspective shows and children's experiences are the central nexus in their mental development (Bozhovich, 2009). The child's SSD is influenced by the child's experiences as part of family cultures.

Conclusion

Children gather many experiences in their everyday family life. Parents carefully con- sider the infants-toddlers' age as they play and do actions with them and whether or not they can learn concepts. One of the important aspects of the SSD is the age-related features (Vygotsky, 1998). Considering science concept formation, parents like to provide a simple explanation behind the facts related to their children's experiences. As reinforced by Sikder and Fleer (2015a), infants-toddlers understand simple scientific narration in relation to their experiences. Parents believe that abstract concepts are too difficult at the infant-toddler age. As supported by Bozhovich (2009), 'if we accelerate the development of abstract thinking in an untimely and artificial way, we destroy the orderly course of mental development and the qualitatively distinctive structure of children's age-related features' (pp. 60–61).

It has been evident from the parents' perspective that they are purposeful when considering individual developmental features as they teach children about certain concepts. For instance, the rattle toy is used for understanding texture (hard/soft), and the doctor–patient toy helps the child to understand the doctor's environment and the small science concepts of push, pump and press hard. The question–answer approach creates the conditions for enhancing small science concepts in infants-toddlers learning. Parent's purposeful actions in relation to science create the conditions for individual infant-toddler development as claimed by Bozhovich (2009). Children are learning concepts (or/and small science concepts) through the purposeful actions of parents, as extended by Sikder and Fleer (2015b). The authors argue that small science concepts can be learned by infants-toddlers with the support of parents' conscious collaboration in the family context.

Family or social context needs to be considered as part of the infant-toddler's SSD (Bozhovich, 2009). How does environment influence a child? If a father waters the garden daily and the infant-toddler likes to do the same, they learn water is essential for the growth of flowers. Jhumki's family environment creates the context of raising a baby, which is applied in her play. In other studies (Sikder & Fleer, 2015a), small science concepts about the pushing and pressing hard have been developed through this familial context.

Culture is embedded in the family environment. As highlighted here, the infant- toddler imitates her mother's cooking or the sounds made such as 'booh' during play episodes. Children like to imitate what the people surrounding them participate in from an early age (Vygotsky, 1998). Imitation is one of the important aspects of the ZPD in an infant-toddler's life and is part of their SSD (Vygotsky, 1987). Children's imitations of talking, eating, sleeping, playing and bathing are part of a family's culture. The family is considered as a societal institution (Hedegaard, 2008) and is part of the infant-toddler's SSD in everyday life.

Parents hold the view that infants-toddlers' experiences enhance development when they play with adults or other children. Infants-toddlers want to be like adults (Elkonin, 2005). For example, the infant-toddler feeds milk to her doll as her mum does with her younger sibling or the child feels interested to play with more senior playmates. Children are learning small science concepts through collaboration with their parents (Sikder & Fleer, 2015b). Vygotsky (1998) clarifies that children can do more with the cooperation of others and infants-toddlers' SSD, which is influenced by surrounding people (Bozhovich, 2009).

At the infant-toddler age, play is one of the dominant experiences in their life as Vygotsky (1966) says; play is the prototype of children's activities during the early age of childhood. Age-related toys and play actions motivate children's learning in different ways. For instance, a child learns push and pulls concepts through playing with a particular toy. Concepts need to be relevant to the experience (Bozhovich, 2009). Thus the child would possibly learn the concepts. Small science concepts also can be developed through a variety of play experiences (Sikder & Fleer, 2015a).

Considering infants-toddlers' science concept formation, there are many areas to consider such as age-related concepts, purposeful toys, play actions, focused collaboration of parents, special circumstances of the family and family culture for understanding the whole picture of the infant-toddler. Small science concepts do not require any kind of artificial conditions or extra burden to be placed on infant-toddler's life. Rather the concepts could develop along with the infant-toddlers' age-related features, family or social environment, parental support and relevant experiences. Therefore, infant-toddler's experiences in relation to science concept formation could contribute to their SSD. This research is based on empirical data from infants-toddlers' everyday life, and it is suggested that parents or pedagogues can apply the study findings to infant- toddler's development of science learning in their everyday context. It is important to consider different aspects of the infant-toddler's SSD. The limitation of the study is that the data only provide knowledge of the context of three Bangladeshi families living outside their home country. Further research within Bangladeshi children in the country of Bangladesh is needed. The study's findings are not generalisable and cannot be imposed in different cultural contexts such as Westerners including Australian, American and English, or other Asian countries.

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Part III: Finalizing the Research

Chapter 8: Conclusion

“Cultural-historical research into science education seeks to examine the relations between the child/teacher and the concept/contexts as a dialectical process, where the learner is shaped by, but also shapes the social and material conditions for science learning”.(Fleer and Pramling, 2015, p. 14)

Introduction

This chapter draws the thesis to a conclusion by presenting an integrated discussion and summarization of the four papers. In this chapter the findings are discussed in the context of the significance of the study, the limitations of the research approach adopted, and recommendations for future research. The process of child development in relation to science concept formation has been conceptualised in this study from a cultural-historical perspective. The synthesis of findings of the papers sum up how each paper answers the overarching research question, “what conditions are created in the everyday family life for the development of infants-toddlers’ (10 to 36 months) science concept formation”.

It will be shown how the overall findings contribute to the field of early childhood education and in particular to the literature on infants-toddlers science learning and development. Conducting the study with infants-toddlers is a dynamic and complex process and as a researcher working within a cultural-historical paradigm, I always had to think from the child’s perspective. Therefore, I faced some challenges while collecting data. Moreover, there are some other challenges that I will discuss in the limitations section. Finally, suggestions for future research will be presented.

Integrated discussion

Synthesis of findings: Implications of the study.

This study has examined the process of how some infants-toddlers develop science concepts as part of their everyday activities in their family home. The research was undertaken as a qualitative case study of three Bangladeshi families who live abroad (either Singapore or Australia). The documented interactions provided rich data for studying the child in a holistic way. Therefore, child development has been obtained not from the outside view but rather from a comprehensive and insightful understanding of a cultural-historical theoretical perspective.

The research problem of the study has been derived from the gap in the literature on early childhood science education. The study draws on cultural-historical theory to shape the study design, which was developed to answer the research questions. Findings of the study, in responding to the main research question on examining the conditions that are created for supporting the development of science in the infant-toddler period, have been turned into four papers that were presented in Chapters 4-7.

As was illustrated in the introduction and presented in each of the papers that followed, “in a dialectical-interactive approach, the aim is to research the social and material conditions as well as how children participate in these activities” (Hedegaard & Fleer, 2008, p. 35). The subsidiary research questions have been narrowed down to find out the specific conditions for the research outcome through four papers (Chapter 4, 5, 6, and 7) as part of my thesis including publications. These findings are summarised in Table 4, with a presentation of argument in each paper.

Table 4

Summary of arguments and findings of four papers

Chapter 4/ Paper one	Argument of the paper	Science concepts can be developed from infants-toddlers age with help of parents and other adults in family home and the main conditions for developing science in this context is the simple scientific narration of the everyday moments that infants-toddlers experience at home with their families which has been termed as *small science* (Sikder and Fleer, 2015a)
	Finding of the paper	*Small science* moments are not only a dialectical relation between every day and scientific concepts but this concept also explains the process of learning science within this early age period
Chapter 5/ Paper two	Argument of the paper	The argument presented in the paper uses empirical evidence for showing purposeful social interactions for the development of higher mental functions; from the real form to ideal form in infants-toddlers science learning with their parents in everyday settings at home
	Finding of the paper	A special form of narrative collaboration between parents and infants-toddlers, which create the conditions for the development of small science concepts, where the environment can be considered from a scientific perspective.
Chapter 6/ Paper three	Argument of the paper	Any single aspect of motives in a child's play cannot be ignored because play is central for a child's social situation of development and new demands afford new developmental possibilities.
	Finding of the paper	The play motives enhance the child's scientific learning motives when all the aspects of motives fulfil the child's demand at that moment.
Chapter 7/ Paper four	Argument of the paper	For understanding the whole picture of infants-toddlers science learning and development, there are many things to consider which are: age related concepts, purposeful toys, play actions, focused collaboration of the parents, special circumstances of the family and their culture
	Finding of the paper	Possibilities of science concept formation at the infant-toddler age are not any extra effort for parents; rather, the concepts could be developed as part of the social situation of development in everyday contexts.

All four papers (Chapter 4, 5, 6, and 7) discuss the different conditions for developing science in infants-toddlers life and in so doing answer the central research question of what are the conditions created to support science learning in family homes. The development of science concept formation in infants-toddlers life has been viewed in a holistic way in my thesis. When taken together, the findings of this study have shown that:

1. Infants and toddlers can learn small science as they interact with their families in everyday situations.
2. How infants and toddlers learn science is based on the ‘in the moment’ narrations that adults make as they play or interact with their infants or toddlers when doing everyday things.
3. Infants and toddlers appear to pay close attention to adult narratives and it is thought that this helps children to interpret the adult actions and explanations of everyday life from a scientific perspective, such as to ‘push or pull’.
4. Infants and toddlers experience adult science narratives and science interactions that appear to create a motive for the learning of small science concepts.
5. Infants and toddlers do engage with small science and recognising these moments as important opportunities for learning science, contributes positively to the literature and to pedagogical practices in an under researched area.

Evidence of these five conditions for Infants and toddlers learning science was captured across all the papers but particular elements were found in select papers only. The first paper looks at possibilities of infants-toddlers science concept formation in everyday life. The second paper provides the details of interaction patterns between parents and infants-toddlers for developing the science concepts. The third paper is a comment on the motivational factors that enhance infants-toddlers' science learning in play context and the fourth paper reflects on parents' perception of infants-toddlers science. The five conditions for infants and toddlers learning small science can be captured through one illustrative example where the conditions for developing science in infants-toddlers life as a holistic phenomenon are shown:

"One infant-toddler plays with sand in the beach and he uses some toys such as spade, bucket, and patterns. The child tries to make sand castle but the sand was not condensed/thick. The child loses interest to make the castle. The child's father comes and helps the child to make a sand castle. The father shows the child how to make the castle and narrates that add some water with sand for making sand condensed/thick, pull sands into bucket using spade, put sand for making castle by pushing hard then you will see the castle shape. The child follows his/her father by doing the actions again and again. Finally the child makes a new sand castle independently."

Through this example, it explains clearly that the father's simple scientific narration of the moment improves the child's understanding on small science concepts such as push, pull, add water to make sands thick. The child understands the concepts as s/he applies his/her understanding to make a new castle independently. Both father and child were conscious and purposeful in the play moment where fathers acts as ideal form and the child follows the ideal forms in the real context. First the child loses his/her interests because s/he failed to do it. Thus we need to understand the dynamic aspects of motives in the context. The whole play context is derived from their regular playful context at the beach where the child can develop small science concepts as part of his/her social situation on development. The father does not need to provide any extra effort for developing small science concepts in the moment.

The context of my project is to investigate family practices for the development of infants-toddlers science concept formation and I have tried to find out all the possibilities for developing infants-toddlers science concept formation in the family home context. Therefore, I have claimed that the project has examined and found the process of child development in science from a holistic stand point for the children of this study in the context of the home. However, there are other conditions that could have been examined in everyday family practices for understanding infants-toddlers science concept formation, such as the physical and material conditions, which could influence the social interactions. These are worthy of future investigation, as they could reveal other dimensions of infant-toddler engagement in science in everyday life. The study has found five key conditions that capture the learning of small science concepts in family homes for infants and toddlers. In each paper, the child's perspective has been considered and through this orientation, the study has allowed for the formulation of science development (see the vignettes and discussions in Chapter 4, 5, 6, and 7). According to cultural-historical theory, child development reflects the process of development and investigates the processes in their wholeness and complexity from a developmental perspective (Veresov, 2014a).

Significance of the study

The overall findings from this study have contributed to the literature of early childhood education in four ways theoretically, methodologically, empirically, and pedagogically.

Theoretical contributions:

The study mainly focuses on Vygotsky's (1987) theory of the development of everyday and scientific concepts and uses this as the central theoretical framework for the entire study. Vygotsky (1987) introduced a theoretical discussion of everyday and scientific concept formation and showed how everyday and scientific concepts influence each other. In particular, Vygotsky (1987) argues, scientific concepts can be learned in formal settings for school aged children. However, this study has revealed that the process of scientific concept development can begin from an early age in childhood. It is impossible that the child could provide the definition of abstract science concepts (e.g. Insulation) at the infants-toddlers age but the child could learn the small science concepts (e.g. hot and cold concept) in relation to the abstract concepts (e.g. Insulation) from their everyday moments. Simple scientific narration of the small science concepts can help infants-toddlers to understand the concepts if it is relevant in their everyday life context. In this study (Chapter 4, Paper 1), I have termed this as *small science* concept.

According to the literature review in this thesis, there is a big gap in the development of scientific concepts at infants-toddlers age. In particular, there is no theoretical literature found to understand scientific conceptual development at this early age. *Small science* is a theoretical contribution to the almost non-exist literature into infants-toddlers scientific development. In addition, *Small science* has been categorized in four ways these are: multiple possibilities for science, discrete science, embedded science, and counter intuitive science (For details see Chapter 4, paper 1). Vygotsky (1987) discusses influential relations between everyday concepts and scientific concepts. I have added how everyday and scientific concepts are dialectically related, as well as the dialectical relation between *small science* and academic concepts through the visual model shown in figure 1(Chapter 4, Paper 1).

In Paper two (Chapter 5), I have developed a visual model (see figure 1, Chapter 5) by adapting Vygotsky's (1994, 1997b, 1998) philosophical discussions on the development of higher mental functions. This model explains how purposeful social interaction can support children's scientific development of higher mental functions from real forms to ideal forms. This visual model also contributes to understanding theoretically child development from real forms to ideal forms in early childhood education specifically in science education.

The third paper/book chapter (Chapter 6) provides theoretical understandings of the relationships of dynamic aspects of play motives in children's play, including an adult's engagement in the moment. The play motives enhance the child's scientific learning motives when all the aspects of motives fulfil the child's demand at that moment. Therefore, for achieving a successful outcome of the play moment, one might consider the dynamic aspects of a play motive (Hedegaard, 2012), and the successful play motives that create the rich possibilities for infant-toddler's development of science concept formation in their everyday culture.

In paper four (Chapter 7), the social situation of child development has been discussed from the perspective of parents. I have added to this conception by showing how infants-toddlers everyday experiences in relation to science concept formation can contribute to their social situation of development. This theoretical understanding enhances knowledge on infants-toddlers science development in early childhood education.

The overall theoretical findings from this study not only contribute to filling a gap in the theoretically fuzzy zone of early childhood science education but also expand theoretical knowledge in the cultural-historical research paradigm.

Methodological contributions:

Following the cultural-historical research methodology, this study applies dialectical-interactive research framework in each phase of research design. Dialectical-interactive research methodology provides an opportunity to understand child development in a holistic way. This methodology discloses a child's everyday activities in detail, interactions between adult and children, collaborations among children and the cultural development of the child. It also focuses on the aim of the project in depth.

Digital tools (video camera, still camera, audio recorder) have been used for data collection as this captures the whole picture of the child. The researcher can revisit the data as needed and can interpret the data in-depth. There is full evidence for research reliability and validity through digital data analysis. It is important to understand child development from a child's perspective. Since infants-toddlers expressions are important to understand and these very young children do not express everything verbally, it is necessary to use digital video tools for capturing their each and every moment. It could happen that the researcher may not understand infants-toddlers activities in the research context but the researcher could understand it through revisiting video data later at the research desk. Using digital methods for researching children makes a methodological contribution to a cultural–historical research methodology for early childhood education.

This study also used a case study approach. I have developed a visual model (see Figure 3, Chapter 3) regarding the cultural-historical case study approach. This model provides insight into the case study method and how this method examines particular development in a comprehensive way.

Hedegaard and Fleer (2008) have discussed the idea of the double role of the researcher in the research context. I have explained the multiple positions of the researcher in the methodology section (see Figure 4, Chapter 3). The explanations contribute to research by specifically outlining the role of the researcher when using digital technologies in the research context and through this contributes to better understanding the role of the researcher who may be participating in the research context as an active participant. The visual model (see Figure 4, Chapter 3) provides the essence of the researcher's role in a holistic way as part of dialectical-interactive research framework.

I have introduced the four categories of small science as a theoretical contribution in early childhood science education (Chapter 4, Table 3). But this finding also adds value methodologically in early childhood education. In the second paper (Chapter 5), I have used the table in relation to categories of small science (see Table 2, Chapter 5) as an analytical framework. This table contributes as an analytical framework in early childhood science education.

The interviewing of parents is a traditional means when collecting data in qualitative research. However, I have used dialogue based interview techniques with parents, which bring new insight into cultural-historical research methodology. In particular, I have discussed with the parents about the conditions for the development of scientific concepts. They have developed their own conditions in relation to their children's interests and motives. Since children are very young (10 to 36 months) in my study, I have interviewed parents after each home visit in relation to the activities to understand the child from their own perspectives. Therefore, I could capture the child's perspective in a holistic way and this approach reflects an approach of undertaking research *with* infants-toddlers rather research *on* infants-toddlers according to the principles of cultural-historical research methodology (Veresov, 2014a). Creating conditions with parents for developing the research design and dialogue based interviews, makes a methodological contribution to early childhood education research as well as to a cultural-historical research methodology.

Empirical contributions:

The study has provided a broader understanding of how Bangladeshi-Australian or Bangladeshi-Singaporean everyday family practices, including play activities, create the conditions for infants-toddlers development in science concept formation.

By investigating the individual child during each family's everyday activities, the study has endeavoured to find the in-depth possibilities for the developmental process of science learning in the child's individual context. Therefore, I have examined each and every aspect of the child's overall activities in daily family life. The data includes morning time (e.g. wake up time, brushing teeth, breakfast), play activities (e.g. favourite play, family play, cultural play, peer play, play with parents, individual play and collective play), outdoor activities (e.g. gardening, play in the playground, swimming in a pool, shopping and beach play), meal times (e.g. breakfast, lunch, dinner and snacks), sleep time (e.g. nap time at day and night sleep), transition periods (e.g. preparation for going outside, from play activities to lunch time), family practices (e.g. story time, TV time). In addition, the dialogue based interviews with parents have been undertaken to understand each aspect of the above context.

I have developed a data table (Appendix A: Table 5) about the everyday activities of each child, possibilities of everyday concepts and scientific concepts and interactions between child-adult and child-child. From this table, I have created a table (see Table 2, Chapter 4) on a range of small science possibilities in everyday settings at home. This table (see Table 2, Chapter 4) provides details and in-depth empirical findings of early childhood science education. The vignettes and parent interviews (Chapter 4, 5, 6, and 7) delivers the details of interactions and activities of the context. These vignettes and dialogue based interviews empirically enrich our understanding of the cultural-historical research context and how children can culturally-historically develop their learning of science in the family home. In addition, the figure (see Figure 1, Chapter 4) on dialectical relations between everyday concepts and through everyday activities and scientific concepts has been established based on empirical understanding of children's regular activities. This visual figure affords insight about the dialectical relations between everyday concepts and scientific concepts theoretically as well as practically and is a useful tool to support the researcher or practitioner.

I have developed a table detailing sampling and data gathering (see Table 1, Chapter 4) and discussed how many times I have visited (e.g. 15 times, 11 times, and 10 times) the family's home for data collection purposes, as well as for understanding the child in their own context. Although it is obvious I visited the families four to five times extra, beyond the data collection purposes planned because I wanted to build up a relationship with the child and the child's family. Researching with children is not a simple task as traditional research with adults. Being a researcher in cultural-historical paradigm, the study recommends empirical knowledge for understanding the research context from the child's perspective. Understanding infants-toddlers in a holistic way as has taken place in this study is the central empirical contribution to the field of early childhood education.

Pedagogical contributions:

In thinking through the pedagogical aspects of my study, the process and the findings link home pedagogy to the pedagogy of the formal settings of early childhood education. Educators who are working in child care centres can consciously introduce science to infants and toddlers if they have deeper insight into what experiences children already have at home that are scientific. As I have discussed in table 2 (see Chapter 4 and also Table 5 in the Appendix A) about the activity settings, there are many activity settings such as playful contexts (e.g. play dough, pretend play, riding scooter and mirror play) and everyday routines (e.g. sleep time and meal times) already available in childcare centres. Through these contexts, the caregivers (or educator) can incorporate science teaching in infants-toddlers routines. In paper two (see Chapter 5), I have explained how parents could create conditions for infants-toddlers science learning through conscious narratives and collaborations. In similar ways, caregivers or teachers could create the scientific pedagogical conditions for supporting infants-toddlers in childcare centres as one of the pedagogical recommendations from my study.

The third paper/book chapter (Chapter 6) explains the dynamic aspects of motives for developing science concepts formation through one play event (musical toy). In the childcare centre, infants-toddlers have regular access to some toys or play events such as musical toys for exploring vibrations of different sounds, caregivers or teachers can use their scientific knowledge to teach infants-toddlers science understanding through the musical toys, considering dynamic aspects of motives in the play moment.

The main focus of paper 4 (Chapter 7) is to outline the social situation of infants-toddlers development where parent's perspectives have been analysed. Parents consider many aspects, such as their cultural context, the child's age and experiences in relation to the activities, roles of people, in the context of developing small science concepts in infants-toddlers life. Care givers or educators could consider these conditions in their centre as small science strongly contributes to infants-toddlers social situation of development. Thus, this research adds to our understanding of the pedagogy of science teaching in child care centres for such young children.

Challenges.

As mentioned previously, the present cultural-historical study undertook to do research *with* children not research on children (Veresov, 2014a). As I already discussed I have visited families for a total of 36 visits (See Table 1, Chapter 4) specifically family homes as part of my data collection and an additional four or five times beyond data collection for improving my relations with the children. I visited the family home at a convenient time to the family. According to my study design, parents create the conditions or set the context for infants-toddlers science learning and I am supposed to collect the data smoothly. However, data collection was found to be challenging. Infants-toddlers may be emotionally unhappy for some reason, the child may become suddenly sick, the child may be very curious about the digital tools rather than the activities the parent is undertaking with them, the child may feel that the researcher is a stranger. According to cultural-historical paradigm, the researcher always needs to be conscious about the child's perspective (Hedegaard & Fleer, 2008). Therefore, being a researcher in this paradigm, I had to face these challenges and give careful consideration to the child in order to determine if the visit would go ahead on arrival and data would be gathered as planned. Therefore, to increase the opportunity for gaining data, I visited the family home many times to build a friendly relationship with the child. I took the video camera to fulfil the children's curiosity and allowed them play with it.

As introduced throughout this thesis, I have collected a total 30 hours of video data from children's family home. I have developed a long data table (see Appendix A: Table 5) by focusing my study aim which covers activity settings, interaction patterns, and small science possibilities, in the everyday context. However, I could not analyse each and every single video clips because of the constraints of the PhD timeframe and the structure of the thesis including publications, which together does not allow for analysing and publishing all the findings form the data within four publications. There are more findings, which will be written as journal articles and submitted in due course. I have collected data from Bangladeshi families who live outside Bangladesh (Australia and Singapore). I have chosen these two countries because of the difference of demographic structure (small land vs wider land), weather conditions (warm vs cold), and construction of home structure (e.g. flat vs high rise). However, I have collected maximum data from family context whereas the outside context has been neglected. Therefore, I could not provide any guideline about a country's (either Singapore or Australia) particular cultural influence in infants-toddlers science learning. In addition, although the families were from Bangladesh and they practice Bangladeshi culture in their home, children may have access to Western toys in their home abroad, whereas Bangladeshi children living in the Bangladesh context may not use the same toys in their play. Therefore, my study cannot generalize knowledge beyond the context of the Bangladeshi families I studied.

The data only provide knowledge on the context of Bangladeshi family culture abroad and further research within Bangladeshi children in the country of Bangladesh is needed. I am unable to generalize my findings regarding different family cultural contexts such as Western, Australian, American, England, and other Asian countries.
I have collected data only from three children in three families, which only allows me to understand these three children's individual cases in-depth. Therefore, the findings discussed about the Bangladeshi family context in Australia and Singapore can only provide a general picture of the learning of science in the families in this study from the community in which they reside.

Suggestions for future research.

While it is clear that researching with infants-toddlers science learning in a family context provides new insights and further understanding of the process of science development in the family home, I would like to focus this discussion on possibilities for further research using cultural-historical theory in science learning for child development.

Firstly, I have completed research in the context of Bangladeshi family, which provides in-depth knowledge about this cultural context for science learning in infants-toddlers home life. Further research is needed to investigate the phenomena in other cultural contexts such as other Australian families, European families and English families.

From my study, there are some important theoretical findings that have emerged which are small science, categories of small science, dynamic aspects of motives in science learning, relations between ideal and real forms for developing science concepts, which together contribute to a child's social situation of development. A recommendation for future research is that these concepts need to be tested in early childhood science education research and in particular, for the development of cultural-historical research paradigm.

The visual figures and tables are a significant outcome of this study as indicated in chapter 4, 5, 6, and 7. It can assist as an influential analytical tool and a worthwhile framework to understand infants-toddlers development in relation to science concept formation. Further research on the applications of the figures and tables across a broader sample set and contexts is recommended.

As discussed earlier regarding the pedagogical contribution of the study, it is recommended that conducting further research in infants-toddlers science learning in childcare settings is needed. Further research into this area in the childcare centre may bring new insights that help to fill the gap in understanding with science learning in early childhood education.

Concluding Remarks

Family is the first institution for the child's learning and development (Hedegaard & Fleer, 2008). In my study, I have shown how parents create the conditions for infants-toddlers science learning in the home context. When I started my data collection with parents, they were a little worried about how a child at this age could develop science concepts. Then we (the parents and I) had lots of discussions regarding what we understand science to be in our everyday life. The parent's practical knowledge and my theoretical understanding provided some ideas about science at the infants-toddlers age.

Through conversations, we concluded that infants-toddlers may not understand abstract concepts but could understand the actions or processes. It was found that parents did simple scientific narration to their children in particular contexts. As I started data collection, the parents became more excited than me, as they felt their child had begun to collaborate with them in science learning. One parent (data collected from age of 30 months to 36 months) told me that “My daughter has started to ask me about the reason behind the facts (e.g. why it happens and how the process works) in each context” and she felt that her daughter was developing a scientific attitude.

Another mother told me that her son (data collected from age of 10 months to 13 months) responded scientifically when the video camera was on. Then I asked her “Do you think it happen because of video camera or because of your full engagement with your child in the particular activity?” The parent tested the same event with her involvement and without her engagement in front of the video camera. Finally she realized that the child responded scientifically because of her conscious involvement in the task. In particular, she felt that her simple scientific explanation and involvement in the task supported her child to understand the process of development in science learning.

I believe, if parents start simple scientific narration of each context to their children from the early childhood period in the family home, children will grow up with a scientific attitude that they will take into their future life.

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Appendix A: Data Table

The table shows the data at a glance as below:

Table 5 *Data Table*

Folder Name	Everyday Activities	Interaction Pattern of Parents	Everyday concepts and scientific concepts are being promoted within the particular everyday context
Participant child: Jhumki (Pseudonym), Date of Birth-18 September 2010, Location Singapore			
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR040312water play	Water play (different flow of water) in the Marina Bay	They extended their activities through collaboration nd communication which is sustained shared thinking	1. Flow of water 2. Water Force
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR300312playground	Play in the city square playground (seesaw, sliding)	They extended their activities through collaboration and communication which is sustained shared thinking	1. Force (Push, Press)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR250812balln balloon	Playing with ball and balloon	Mum-child positing- above, equal, below, independent	1. Force (change direction, push) 2. Rules of games 3. Characteristics of balloon (balloon can fly)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR010912flour n cook	Preparation of snacks	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Force (push hard, press, roll) 2. Correlation 3. Naming 4. Measurement (Mixing Ingredients)

			5. Change of state of matter 6. Fire 7. Insulation (hot to cold) 8. Concept of shape 9. Differentiate of shapes 10. Follow the instructions
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR100912book	Reading the story book with mum	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Force (jump) 2. Correlation 3. Discover new things through reading 4. Feel n touch
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR170912play dough	Making shapes by Play dough with MUM, creating birthday party, Playing with doll	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Living habitat of human (play doll) 2. Force (press, cut the cake, blow candle)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR200912pool	1.Swimming in the pool: sliding in water, body movements for swimming with the help of parents 2. Play sliding, climbing, seesaw, spinning, swing in the playground 3. Mum shows how to swim to the child then child also follows mum. Mum use tub for child's swimming in the Swimming pool	Mum-child positing- above, equal, below, independent	1. Force (floating, move forward) 2. Rules of swimming 3. Flow of water 4. Floating and sinking 5. Push and Pull 6. Motion (spin) 7. Force

S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR220912birthday	Birthday party, blow the candle, cut the cake, sing the song	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Air pressure (blow candle) 2. Rules of birthday party 3. Correlation
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR290912kyte	Flying kite in the ground	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Air 2. Rules of flying kite 3. Force (run)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR161012drawing	Drawing in the white board	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Drawing 2. Use of white board 3. Application of marker 4. Unknown to known (draw balloon, ball)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Jhumki\SR231012home n car driving	Making different shapes with play dough, drawing pictures with water colour, Riding car	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Force 2. Correlation 3. Identification 4. Use of Substances 5. Change of state of matter 6. Differentiate of shapes 7. Safety Rules 8. Sound (horn) 9. Force (press horn, close door) 10. Rules of driving car
S:\R-EDUC\Shukla-Sikder\Data\V	Cycling at home	Mum-child extended their activities through	1. Force(push, pull)

ideo Data\Jhumki\SR140113cycling		collaboration and communication which is sustained shared thinking	2. Navigation
Participant child: Joy (pseudonym), Date of Birth-28 July 2010, Location-Australia			
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\JA200213 Beach	Playing in the beach, swimming, sands play	Parents-child extended their activities through collaboration and communication which is sustained shared thinking	1. Concept of shape (triangle, round) 2. Discover sand, shell, stone 3. Force (try to float with ball)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J280213puzzle, garden, cycle, animal	Playing alphabet puzzle, gardening and other toys, playing with animals' toys	Sustained shared thinking by communication, collaboration. Imagination and concept formation is extended through collective mind	1. Identification 2. Correlation 3. Insulation 4. Life cycle of zucchini plant 5. Discover plant name
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J210313 playdough n other toys	Play with playdough and other toys	Sustained shared thinking by communication, collaboration. Imagination and concept formation is extended through collective mind	1. Change of state of matter 2. Colour concept 3. Concept of size(big/small) 4. Use of technology(camera) 5. Push, press(force) 6. Counting 7. Logical order 8. Solving problem(puzzle) 9. Sound (animal sound)

			10. Safety rules(seat belt) 11. negotiation
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J27032013 making zoo, block, picnic	Making a zoo, develop a playground with blocks, picnic in the park with all the animals	Sustained shared thinking by communication (question-answer), collaboration. Imagination and concept formation is extended through collective mind	1. Animal habitat(food habit, movement habit) 2. Insulation (blow food to make it cold) 3. Construction (making playground with block e.g. sliding, seesaw)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J180413playdough, rainbow	Making rainbow with play dough, food preparation in oven	Sustained shared thinking by communication (question-answer), collaboration. Imagination and concept formation is extended through collective mind	1. Logical order 2. Force(rolling) 3. Correlation 4. Colour concept 5. Rainbow 6. Food preparation in oven 7. Life cycle of butterfly
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\JA190513 play with friend, taking shower	Play with friend, writing alphabet with dad, taking shower	Sustained shared thinking by communication (question-answer), collaboration. Imagination and concept formation is extended through collective mind	1. Drawing/Writing 2. Concept of texture (soft/hard) 3. Concept of weight (heavy/light) 4. Force(floating/sinking)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J220	1.Wake up n brush, breakfast 2. breakfast	Sustained shared thinking by communication (question-answer), collaboration.	1. Insulation 2. Brush help to clean the teeth

513 morning to all day	3. cooking and playing 4. Drawing 5.walking to playground 6.play in playground 7. return home	Imagination and concept formation is extended through collective mind	3. Discover nature(tree name, plant name, flower name), insects (caterpillar) 4. Life cycle of butterfly 5. Negotiation 6. Rules in games 7. Identification 8. Application of materials
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J280513 reading story book, doctor-patient, drawing	1.Reading story books with mum 2. play doctor-patient 3. drawing picture	Sustained shared thinking by communication (question-answer), collaboration. Imagination and concept formation is extended through collective mind	1. Identification 2. Correlation 3. Number concepts 4. Concept of textures(floppy jacket) 5. Time concept 6. Rules of games 7. Application of doctor's instrument 8. Force(Push)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy\J280713Birthday	Joy's birthday celebration	Parents-child extended their activities through collaboration and communication which is sustained shared thinking	1. Force (blow the candle) 2. Rules of birthday party
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Joy \J230313 cooking in the park	Cooking with sands in the park. Mixing ingredients as sands then cooking and eating	Sustained shared thinking through question-answer approach	1. Concepts of ingredients 2. Concepts of mixing
Participant child: Barnan (pseudonym), Date of Birth-17April 2012, Location-Australia			

S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W170313 activities with mum n play	Play with car, activities with mum	Mum-child positing- above, equal, below, independent	1. Colour concept (blue car) 2. Sound (car sound, rattle sound, sheep sound) 3. Force (Push, spin) 4. Identification of car's materials (window, back glass, door) 5. Correlation 6. Discover the materials of the box
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W050413Dicovering box	Discover toy box. There are many toys in the box such as –duck, flute, ball, Tiger, rattle frog…	Mum-child positing- above, equal, below, independent	1. Discover toy box 2. Force(press the button, blow the flute,) 3. Sound (tiger roar, flute sound, making sound with box) 4. Colour(orange and black) 5. Identification 6. Texture 7. Use of mobile 8. correlation
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W080413 new toy	Playing new toys with mum	Mum-child positing- above, equal, below, independent	1. Sound of duck 2. Identifying new materials 3. Object meaning-meaning object(basket become car)

S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W100413 rhyming, toys, keys	Activities with rhyme, play with toys	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Matching 2. Correlation 3. Rolling 4. Pressing 5. Shake 6. Different Sound concepts
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W170413Birthday celebration according to culture	Birthday celebration according to culture	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1, blow candle(force)
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W220413 toy garden n mirror	1. A toy like a garden and they are discovering the things in the garden. 2. Identifying body parts through mirror	Mum-child positing- above, equal, below, independent	1. Discover garden's insects and other things (lady bug, mushroom, flower) 2. Force (Spin, knock knock 3. Colour concept 4. Identification of body parts
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W140513 morning to day activities	Wake up at morning, brushing, breakfast time, play activities, taking shower	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Correlation 2. Identify 3. Colour concept 4. Concept of shape 5. Water flow

S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W150513 activities with dad and playing with mum	Activities with dad and play in the play zone with mum	Parents-child positing- above, equal, below, independent	1. Colour concept (Diffèrent colour Ball) 2. Construction (building Tower) 3. Operation of machine (switch on/off) 4. Direction 5. Push/ pull/ blow 6. Concept of shapes
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W170513 play with dad	Play activities with dad and mum	Parents-child positing- above, equal, below, independent	1. Follow the instruction 2. Correlation
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W240513 play sound with dad n ball	Making sound with mouth, imitate dad, play ball	Dad-child extended their activities through collaboration and communication which is sustained shared thinking	1. Creating different kind of sounds
S:\R-EDUC\Shukla-Sikder\Data\Video Data\Barnan\W290513 mirror play, rhyme with mobile	Mirror play, play with mobile, see rhyme in mobile, toys with push n pull	Mum-child extended their activities through collaboration and communication which is sustained shared thinking	1. Identification of body parts 2. Reflection 3. Force (push/pull) 4. Switch on/off 5. Knowing new things

Appendix B: Ethical Approval

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

Date:	**23 August 2012**	
Project Number:	**CF12/1569 -2012000846**	
Project Title:	**Toddler development of scientific concepts through play in family practices**	
Chief Investigator:	**Professor Marilyn Fleer**	
Approved:	**From: 23 August 2012**	**To: 23 August 2017**

Terms of approval

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, and a copy forwarded to MUHREC before any data collection can occur at the specified organisation. **Failure to provide permission letters to MUHREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research.**
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. **Amendments to the approved project (including changes in personnel):** Requires the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

[redacted]

Professor Ben Canny
Chair, MUHREC

cc: Ms Shukla Sikder

[redacted]

Inclusion of another two Participants in Ethics Approval

From: **MRO Human Ethics Team** [redacted]
Date: 26 June 2013 14:28
Subject: MUHREC Amendment CF12/1569 - 2012000846: Toddler development of scientific concepts through play in family practices
To: [redacted]

Dear Researchers

Thank you for submitting a Request for Amendment to the above named project.

This is to advise that the following amendment has been approved:

Changes to Recruitment

– Inclusion of another two participants

Thank you for keeping the Committee informed.

Professor Ben Canny
Chair, MUHREC

Human Ethics
Monash Research Office

Our aim is exceptional service

Monash University
Level 1, Building 3e, Clayton Campus
Wellington Rd
Clayton VIC 3800, Australia

Appendix C: Explanatory Letters and Consent Forms

MONASH University
Education

Explanatory letter for families who wish to participate in the project:
CF12/1569 – 2012000846: Toddler development of scientific concepts through play in family practices

Dear Parent/Guardian,

I am a student researcher at Monash University in the Faculty of Education. I am writing to you regarding my 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. I am looking for families who may be interested in participating in my study. The research will be carried out in Melbourne, Australia and Singapore with two families who have children aged between 1 and 3 years.

The purpose of the project is to learn more about how children learn and develop in play. I am interested in home play and other important family activities that contribute to children's scientific development. Knowing more about how children play is important for better understanding how to plan for children's scientific development. We will be inviting 2 families who were originally from Bangladesh but who now live abroad and speak Bengali at home.

We would like to observe your child in your home or outside of your home:

- Participating in their regular play or other everyday events (4 visits lasting each 1-2 hours in each month and a total 4-8 hours).

Participation will involve a series of 4 visits to your home or outside of your home at a time that is convenient to you. Each visit is likely to last between 1-2 hours. We will invite you and your child to share their favourite play activities and any other everyday activity you normally do together that may involve science of some kind (e.g cooking together). With your permission we would like to record these play events through field notes, and some photographic and video recordings.

At the end of the research we would like to prepare a CD of your child's as a a record of their participation in this project. At this time we would like to give you the opportunity to view all of the images (still and video) of your child and family, so that if there are any images you would like us not to use then we will not use these images from the data set. It is possible that some of the photographic images you have approved (not video) may be selected for publication in a journal article or a book for early childhood professionals who may be interested in new research about how to prepare young children for scientific learning. It may also be possible for short video clips (e.g. of up to a minute) taken from the video material you have approved 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 research or relevant debate among early childhood professionals who may be interested in new research about how to prepare young children for scientific learning. No image of your child 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. You can withdraw consent at any point in the future, and have the right to do so, and the researcher will arrange for the removal of any material

Faculty of Education Peninsula Campus
PO Box 527 Frankston Vic 3199
McMahons Road, Frankston Vic 3199
[redacted]
www.monash.edu.au
ABN 12 377 614 012 CRICOS provider number 00008C

that could include your child as an identified participant in the recordings produced in the context of the study.

The video data and other photographic recordings will be stored by the university researchers in a secure place on the university's premises, for ten years, 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 the researchers use of this material will be for the sake of enhancing knowledge within the field of early childhood education. The data will be destroyed after ten years.

The data will only be used by the student researcher and her supervisor. The supervisor's role is to the student in the preparation of a thesis and publications, such as journal articles and book chapters, and presentations at conferences.
If you have any queries or would like to be informed of the aggregate research findings please contact my supervisor Marilyn Fleer 03 99044235 or by email at [redacted] or me on 03 99052988 or by email at

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 **CF12/1569 – 2012000846**. The details are:

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Building 3e Room 111
Research Office
Monash University VIC 3800

Tel: +61 3 9905 2052 Fax: +61 3 9905 3831 Email [redacted]

If you agree to participate, please keep this letter for your records and return the consent form to me directly or by email at shukla.sikder@monash.edu.au or by mail at unit 3/653 blackburn road, clayton 3168, VIC, Australia in Australian or 661 Buffalo Road, #22-28, Singapore 210661 in Singapore .

I will phone and arrange a time that suits you and your family. Please note, Participation in this project is voluntary.

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

Yours sincerely,

[redacted]

Shukla Sikder

August 2012

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MONASH University
Education

Explanatory letter for families who are indirectly involved in the project:

CF12/1569 – 2012000846: Toddler development of scientific concepts through play in family practices

Dear Parent/Guardian,

I am a student researcher at Monash University in the Faculty of Education. I am writing to you regarding my 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. I am looking for families who may be interested in participating in my study. The research will be carried out in Melbourne, Australia and Singapore with two families who have children aged between 1 and 3 years.

The purpose of the project is to learn more about how children learn and develop in play. I am interested in home play and other important family activities that contribute to children's scientific development. Knowing more about how children play is important for better understanding how to plan for children's scientific development. We will be inviting 2 families who were originally from Bangladesh but who now live abroad and speak Bengali at home.

In the process of following the selected families, the focus child may play with your child. I am seeking your permission to video record or take still picture your child (ren) should they interact with the children who are part of my study.

At the end of the research we would like to prepare a CD of the focus child's along with indirectly involved children as a record of their participation in this project. At this time we would like to give you the opportunity to view all of the images (still and video) of the focus child, indirectly involved child and family, so that if there are any images you would like us not to use then we will not use these images from the data set. It is possible that some of the photographic images you have approved (not video) may be selected for publication in a journal article or a book for early childhood professionals who may be interested in new research about how to prepare young children for scientific learning. It may also be possible for short video clips (e.g. of up to a minute) taken from the video material you have approved 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 research or relevant debate among early childhood professionals who may be interested in new research about how to prepare young children for scientific learning. No image of your child will appear on a website.

Please note, Participation in this project is voluntary. 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. You can withdraw consent at any point in the future, and have the right to do so, and the researcher will arrange for the removal of any material that could include your child as an identified participant in the recordings produced in the context of the study.

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The video data and other photographic recordings will be stored by the university researchers in a secure place on the university's premises, for ten years, 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 the researchers' use of this material will be for the sake of enhancing knowledge within the field of early childhood education. The data will be destroyed after ten years.

The data will only be used by the student researcher and her supervisor. The supervisor's role is to the student in the preparation of a thesis and publications, such as journal articles and book chapters, and presentations at conferences.
If you have any queries or would like to be informed of the aggregate research findings please contact my supervisor Marilyn Fleer 03 [redacted] or by email at [redacted] or me on 03 [redacted] or by email at [redacted]

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 **CF12/1569 – 2012000846**. The details are:

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Tel: [redacted] Fax: +61 3 9905 3831 Email: [redacted]

If you agree to participate, please keep this letter for your records and return the consent form to me directly or by email at shukla.sikder@monash.edu.au or by mail at unit 3/653 blackburn road, clayton 3168, VIC, Australia in Australian or 661 Buffalo Road, #22-28, Singapore 210661 in Singapore.

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

Yours sincerely,

[redacted]

Shukla Sikder

August 2012

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INFORMED CONSENT FORM FOR FAMILIES OF PROJECT PARTICIPANTS (Directly or Indirectly involved)

CF12/1569 – 2012000846: Toddler development of scientific concepts through play in family practices

I understand that the purpose of the project is to learn more about how children learn and develop scientific concepts in play. I further understand that the way in which the researcher will use this data will be limited to discussion with other interested early childhood professionals or students of early childhood education who may benefit from the study of approaches to understanding how young children learn about science and the relationship between science and young children's play.

I understand that I am consenting to the researcher's use of data collected in this study in a variety of settings, and I give permission for the following (please tick) purposes:
☐ a doctoral thesis
☐ a scholarly journal articles or book chapters
☐ conference presentations
☐ in the researcher's teaching practice at a university, specifically in undergraduate coursework programs dedicated to the study of scientific education in young children

I also understand (please tick) that:
☐ images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood research or relevant debate among early childhood professionals who may be interested in new research about how to prepare young children for scientific learning

☐ the video data and other photographic recordings will be stored by the university researchers in a secure place on the university's premises, for ten years, 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. The data will be destroyed after ten years.
☐ if I should wish to withdraw consent at any point in the future, I have the right to do so, and that the researcher will arrange for a removal of any material that could include my child as an identified participant in the recordings produced in the context of the study.

☐ 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 or family at the conclusion to the research. At this time I have the opportunity to view video or other photographic material which may be used by the researcher for public access ie with the understanding that "public access" will always mean scholarly or professional discussions in the field of early childhood education.

I agree for my family to take part in the above named project. I understand clearly that participation in this project is voluntary. The project has been explained to me and I have read the Explanatory Statement, which I have shared with my family. I also understand that the researcher will interpret the data in line with the theory of the research topic.

I understand, The data will only be used by the student researcher and. I understand , the data will be held for at least 10 years, whilst analysis and writing of the thesis and subsequent papers occurs. I am fully aware about the implications of participation in the project.

Children's name and Date of birth

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....……………..………………   ....……………..………………

Parents'/Guardians' names and Signature

....……………..………………   ....……………..………………

....……………..………………   ....……………..………………

Other family members (name and signature)

....……………..………………   ....……………..………………

....……………..………………   ....……………..………………

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

Date: ....……………..………………

MONASH University
Education

CONSENT FORM FOR USING VIDEOS AND IMAGES
(Directly or Indirectly Involved)

CF12/1569 – 2012000846: Toddler development of scientific concepts through play in family practices

I have viewed the data of my child and family and I agree that the videos and images to be used for the following purposes (Please tick):

☐ a doctoral thesis
☐ a scholarly journal articles or book chapters
☐ conference presentations
☐ in the researcher's teaching practice at a university, specifically in undergraduate coursework programs dedicated to the study of scientific education in young children

I give permission for the videos and images to be used for the above-mentioned purposes. I am fully aware about the implications of participation in the project

Children's name and Date of birth

...……………..……………… ...……………..………………

...……………..……………… ...……………..………………

...……………..……………… ...……………..………………

Parents'/Guardians' names and Signature

...……………..……………… ...……………..………………

...……………..……………… ...……………..………………

Other family members (name and signature)

...……………..……………… ...……………..………………

...……………..……………… ...……………..………………

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

Date: ...……………..………………

Thank you, Readers!