Children's and Teachers' Experiences of and Perspectives on Play in Primary Science

Woei Yng Tan

PhD

University of York

Education

January 2020

Abstract

This study investigates children's and teachers' experiences of and perspectives on play in primary science in Singapore. It specifically focuses on the nature and dominant types of all talk and science talk among children and teachers during play. The children in this study were Primary 3 pupils (aged 8-9 years old). A mixed-method, case-study research design was used, incorporating 15 minutes of free play into two science lessons. Observational data in the form of video and audio recordings were collected from five classes of children in three schools (n= 183 children). Five Primary 3 science teachers were interviewed individually using semi-structured interviews, once before the first play session and once after the last. Three groups of pupils in each class (n=15) were purposively sampled to participate in group interviews after all the play sessions. Emerging themes from both sets of findings suggest the feasibility and value of using play as a pedagogical tool in primary science classrooms in Singapore, catering to most pupils. The findings of this study showed that the children did most of the talking but that they mainly engaged in non-science talk. The teachers' role changed during the free-play sessions and they talked less to allow the children to exercise free-choice. The contribution to knowledge of this study was the creation of a new observation schedule based on the Falk and Dierking's Contextual Model of Learning and Simon et al.'s discourse analysis framework, to study the utterances of children and teachers. This study contributes empirical data about using play to learn science on the topic of magnetism for children in middle childhood. With both children's and teachers' perspectives being looked at and studied, the findings contribute to our understanding of how future play-based science lessons might be designed and carried out.

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Acknowledgement

I would like to thank many people who have been instrumental in this journey. They are:

My dear and sole supervisor Dr Lynda Dunlop, who has gone through the many ups and downs of my PhD journey with me, offering me endless support and encouragement, going the extra mile to help me in various ways, both academically and socially. It is her unwavering belief that keeps me going, and I have learnt a lot from her.

Dr Elpis Pavlidou, my TAP member, who has been very encouraging and supportive of me over the past few years.

I am also thankful for the whole UYSEG family of lecturers, administrator and PhD students, who have provided me with much support and love. They have been very warm and welcoming to international students like us. Special thanks go to Maria, who has spent many hours talking to me and advising me, and Mary, who always thought of me and invited me during festive seasons to be with her family and not spend them alone in the UK.

My group of wonderful and true friends: Manal Atesh, Kun Li, Estelia Borquez, Julio and Emmanuel, who have always been around with their valuable friendships and support during my studies in York, doing all the crazy things together.

Other lecturers such as J and K, who have been very encouraging to me as a friend and mentor all these years and have kept me going by offering suggestions and advice when the journey became challenging.

The group of welcoming and lovely choir ladies who made every choir practice and performance an unforgettable and memorable experience.

My wonderful friends back home who are so supportive and opened up their classrooms to me and catch up with me whenever I am back home.

Lastly, special thanks to all the teachers, the two lab technicians and all the children who so kindly came onto this study and helped me greatly. I really appreciated all of your help and treasured all the time we spent together, learning from one another. Thank you.

Author's Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

Dedication

This thesis is specially dedicated to my late grandfather, Mr. Tan Choon Tien, for his significant impact on my life, leading me to teaching as a profession and pursuing excellence in whatever I do with pride and integrity. *Ah Gong*, your staunch belief in education and philanthropic acts is the legacy you have left behind for our next few generations of overseas Chinese. You can hold your head up high because you have contributed more than anything a physical building like a school can do, contributing a teacher who is essential and impactful; for many generations to benefit from education.

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My sweet and loving family: my parents (Papa and Mummy) who have worked extremely hard and non-stop to provide the best for us, their children, my siblings (Ling, Lee and Kok) and my cute nephew and niece (Felix and Lecia), who have showered me with their unconditional love to fulfil my dreams. They had been very supportive and rooted for me throughout my PhD journey for all these years. It is their love and strength that have helped me to soldier on to complete this long PhD journey of mine.

Chapter 1 Introduction

1.0 Introduction

Play is a vital process for the holistic development of children (Lewis, 2017). It is linked to their cognitive, emotional and social development (International Play Association, 2014; Malone & Tranter, 2003). Play is not restricted to the young stage, humans and even animals play throughout their lifetimes (Else, 2009). Play is essential and it allows children to take fundamental ownership of their experiences, which are powerful and unique to each individual (Stone, Lorentsen & Schmidt, 2019). Play and scientific inquiry are important components of childhood (Ashbrook, 2010) because science has elements of play and there is ‘some cognitive value to the playful element in science’ (Laszlo, 2014, p. 400). Play is a key process (Johnson, Christie & Wardle, 2005) that helps to develop conceptual understanding in science (Brunner, 1983; 1985). Play reflects children’s learning through scientific inquiry and helps them make sense of the world (Ashbrook, 2010). Free play takes place when children are not restricted but get to decide what and how they want to carry out play (Play England, 2020). Moreover, free play given to children helps them to be self-directed and lays ‘the foundations for building larger conceptual structures and intuitive theories’ about science (Sim & Xu, 2017, p. 642). Moreover, children who have played with and explored science concepts creatively have developed sustained interest in understanding scientific concepts (Talib, Norishah & Zulkafly, 2013).

From a literature review perspective, it has been observed that many studies have focused on play for children in the early years (0-5 years), but few have been carried out exploring play with older children at the primary stage beyond the age of nine (Briggs & Hansen, 2012, p. 8). Moreover, empirical studies using play in primary schools were found for mathematics (Saber, 2016) and literacy (Martlew, Stephen & Ellis, 2011), but none for science (before the year 2019). This constitutes a gap in the literature on play and the learning of primary science.

The closest empirical study which explored play in science is Stone, Lorentsen and Schmidt's (2019) study, in which they observed Grade 3[1] and Grade 4[2] children from the middle childhood age group (6-12 years old) (Collins, 1984). Children exposed to the play approach showed greater understanding, with better and more active participation and positive affective displays, such as smiling and laughing, when they were able to explore and were given free play to learn science. Besides this empirical study, another empirical study that inspired this research was Bulunuz's study (2013), which examined how play helped to promote children's understanding of science concepts in kindergartens in Turkey. Play seems to have the potential to help children to learn science.

Having a dual identity as a postgraduate researcher in the United Kingdom (UK) and a primary school science teacher in Singapore, I was keen to explore the potential for play to help children in Singapore learn primary science. This gap is particularly interesting because children in Singapore begin to learn science formally as a subject when they are in the third year of their primary school education at the age of eight or nine. By this point, they are in Primary 3 and lessons have moved from a more play-based, hands-on nature to the formal approach of school, dominated by teacher-centred and didactic approaches (Luke, Freebody, Lau & Gopinathan, 2005) to learning science. They have started to play less when they start learning science. Since the empirical studies showed the potential for play to enhance science learning, children in Singapore have potentially missed out on the opportunity to learn science through play. This is the gap that I am interested in exploring. By introducing play into children's science lessons at this later age when they play less, I hope to discover how the children and teachers perceive play in primary science.

In this study, the research questions focus mainly on the children's and teachers' experiences of and perspectives on play in primary science. The observations were essential to discover what happened when children were allowed to participate in scientific play; whether they would use scientific language, ask scientific questions, or

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[1] Grade 3: 8-9 years old

[2] Grade 4: 9-10 years old

use science skills. In this study, scientific play is defined as the type of free play (Lim, 2010) given to the children to play in a science context based on Meckley's (2002) definitions (Section 2.15), Fleer's (2017) cultural-historical view (Section 2.13) and part of what purposeful play is (MOE, 2012). In this study, children were provided with rich provisions of science materials to choose from and to play with during their scientific play based on the topic of magnetism which is normally taught for this age group. These scientific play sessions were specially designed with children's perspectives in mind (Pyle & Alaca, 2018). More information on what scientific play entails will be described and elaborated in Section 2.8. These perspectives are critical because they could help to account for the success in learning science in a class. Children's perspectives are also essential because hearing their views could help to establish an important communication channel, with the adults consulting them (DfE, 2012). Besides, seeking children's perspectives also encourages them to participate more actively and prevents a power imbalance in the relationship between the teachers and the children, which is a danger (Creswell & Creswell, 2018) from the start.

On the other hand, teachers' perspectives could also give an insight into the understanding of what play means to them, the intended objectives they have as teachers and the decisions they would make to use play as a pedagogical method to facilitate students' learning (Fesseha & Pyle, 2016) during the scientific play sessions. These are important factors that can determine the effectiveness of the students' learning (Fesseha & Pyle, 2016). Thus, the research questions aim to look at these rich interactions between the two groups and contribute empirical data and knowledge to the gap in the literature on play in primary science.

A playful approach to science teaching has the potential to improve communication and relationships between teacher and child. In a meta-analysis of 800 studies by Hattie (2009), a student-teacher relationship was shown to have a large effect size of 0.72 and is highly linked and acts as an indicator of the children's learning and for the students' achievement. Moreover, with better common understandings between teachers and students, these understandings could help to build up and forge complex teacher-student relationships, thus strengthening them (McInnes, Howard, Miles, & Crowley, 2011). Therefore, the perspectives of both groups need to be heard and seen in order to bring about a better learning experience for both groups during a science lesson.

1.1 Personal interest and motivation for the study

I have been a primary school science teacher for many years in Singapore. Being curious and inquisitive, I love hands-on activities and like to tinker with things. Under the influence of my father and grandfather, I grew up in an environment that allowed me to be excited about science and I was able to enjoy many first-hand experiences, such as rearing fishes, catching insects, growing plants, making ice and experimenting with the many things that were available at home. I love science very much and when I was younger I wanted to be a scientist when I grew up. I also like to play and, when I play, I always find that time either passes by very quickly or freezes, like in the 'flow of play' (Csikszentmihalyi, 1991). Learning is enjoyable and effortless because, when one enjoys doing something, one will continue and repeat the act many times.

However, when I became a science teacher and watched my students over the years, I observed that their interest and enthusiasm for hands-on experience decreased as they were allowed to play less. This decrease in interest is a worrying trend because children at such an early age should enjoy play and be curious about the things around them. I tried to think from the children's perspectives and started trying various ways to teach, allowing my students to have more experiences with things. I could see the differences in their attitudes and knew what got them excited and interested. Experiencing further education is a dream for me as I want to spend more time designing and researching what play can bring about in science learning. In particular, I like the special sparkle in the children's eyes when they get excited and the unlimited energy they have when they are in the flow of play and play for a long time. Moreover, I also noticed that children tend to be restless towards the end of a one-hour lesson (approximately the last 15 minutes) and would stop paying attention to their teachers. Their rate of assimilation and their motivation to learn decreases over time. However, if the perception of the children's lesson were to be changed into something that they enjoyed, such as play, their energy levels might change, and the children might be more motivated to return to their lessons and learn, instead of wasting the last few minutes of the usual science lesson. I wanted to interest my students and let them enjoy science by trying play. I aimed to research on play in science and find out the impact of play.

This research is vital because the declining trend in students' interest in taking science, technology, engineering, and mathematics (STEM) subjects and going into STEM-related careers has posed a problem for many countries for economic reasons (McMahon & Showers, 2011). As reported in the ASPIRES project, the key to engaging these students (Archer, Osborne, Dillon, DeWitt, Willis & Wong, 2013) is to capture their interest when they are much younger, at primary school. Doing so could help to reverse the dropout rate in STEM subjects, as their decision to pursue STEM-related studies or a career sets in at the early age of 11. As play is 'an essential part of childhood' (Canning, 2007, p. 228), and is often perceived to be a pleasurable activity (Else, 2009) that the children choose to get involved in, this study aims to discover what play can do to enable our young learners to become engaged and self-directed in their science learning. More empirical data and insights into what children and teachers talk about during free play could provide good opportunities to inform teaching practices in primary science in Singapore or around the world. Due to my personal interest in play, my fascination with and passion for science, I would like to encourage more children to enjoy science from a young age.

1.2 Purpose of the research study

This research study investigates children's and teachers' experiences of and perspectives on play in primary science. The study focuses on children's voices and agency when they were given the freedom to decide and play in the way they wanted and learn what they wanted. This freedom to choose and play is an unusual practice in schools in Singapore. The freedom of choice offered in free play here means that the ownership of learning was returned to the children. My interest is to find out how children would think and what they would do when they were no longer specifically instructed on what to do. When the children are given free choice and autonomy to decide for themselves, what would they do or talk about.

Instead of the usual instruction-laden science lessons, the teachers' role was changed, and they were instructed to allow the children to play freely without any instructions stipulated in the play protocols (which will be described in detail in Chapter 3 and can be found in Appendices 1.1 and 1.2) in their scientific play sessions. Giving children an opportunity to play freely in science lessons changes the power relationship between the children and their teacher. I was also interested in discovering what the teachers would do during such ‘scientific play’ sessions. What were the children’s and teachers’ experiences of and perspectives on play in primary science? Hence, this research study aims to identify the gaps in the literature on play and the learning of primary science in an Asian classroom. These gaps informed this study and formed the basis upon which its four research questions were framed.

1.3 Research questions for this study

Four research questions were crafted and framed for this study. These four questions are given below.

Research Questions:

Q1. What are the nature and dominant types of talk among (a) children and (b) teachers during the scientific play sessions?

Q2. To what extent do children and teachers talk about science during the scientific play sessions?

Q3. What are the children’s perspectives on play in primary science?

Q4. What are the teachers’ perspectives on play in primary science?

This study aims to answer these four research questions. The detailed write-up presented in this thesis provides a fuller context, giving the background of the breadth of literature on play, the methodology, the new framework that was designed, the findings, analysis, discussions and conclusions of this research study. Before moving to the next chapter, the context of the study will be presented to allow the reader to understand where this study was located and the roles played by the educational system and science syllabus in situating this research study.

In order to answer the research questions, this study utilises a mixed-methods strategy where the primary data were collected from the scientific play sessions in the classrooms, children’s semi-structured group interviews and the teachers’ individual interviews. Quantitative and qualitative methods were combined and a multiple case studies research design was used to give the research its breadth and depth. Further information about the methodology used in this study is explored in Chapter 3, the methodology chapter.

1.4 Context for the study

This research study took place in three primary schools in Singapore. In this section, the context of this study is elaborated. First, the chapter introduces the educational system in Singapore (Section 1.41), followed by a particular focus on the science syllabus (Section 1.42).

1.41 Singapore's educational system

Singapore's educational system has long been highly regarded internationally because it consistently performs well in international tests such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). For nearly 20 years, Singapore has been well placed (Lee, 2018), and usually in the top ten. This success is attributed to the quality of both the school curriculum and the teaching workforce (Lee, 2018).

In Singapore, schools are mostly run by the government and are highly regulated and administered by a central governing body: the Ministry of Education (MOE) (Lee, 2018). There is a national curriculum that all schools follow (Poon, 2014). In recent years, schools have been given some flexibility and autonomy to decide or tailor the curriculum for their students due to the decentralisation of school authority (Lee, 2018). Primary education in Singapore is compulsory from 7 until 12 years old (from Primary 1 to 6). Almost all children are enrolled in state-run primary schools and only a small proportion are enrolled in special education schools, religious institutions (such as the Madrasah), or are home-schooled (Lee, 2018). At primary school level, private international schools are only for expatriates' children or returning Singaporean children who had resided overseas for a period of time.

The language of instruction in schools in Singapore is English. In Primary 1 and 2, class size is limited to 30 (this was reduced from 40 in 2006) to enable a lower student-to-teacher ratio so that the children, being very young, can better ease into formal schooling from their pre-school education, with more attention from the teachers (PERI, 2009). In Primary 3–6, the class size increases and usually ranges from 35–40 students in a class. Children take four main academic subjects: English, mathematics, science and mother tongue (Poon, 2014). Singapore's policy of bilingualism means that all children learn two languages as well as the other two subjects. Children take a national examination at the end of Primary 6 (Year 6), called the Primary School Leaving Examination (PSLE) (Poon, 2014), which determines their placements into secondary school based on merit.

1.42 Singapore science syllabus

Science is taught formally from the third year of primary education at Primary 3 (Grade 3), when the children are eight or nine years old (Poon, 2014). This decision was made for economic reasons following Singapore's independence in 1965. The teaching of science was delayed in order to enable children to consolidate their literacy due to their diverse home language backgrounds (Poon, 2014), as well as their numeracy skills during the first two years of education (Lee, 2018). As Singapore's education system values bilingualism, children need to learn two languages (English and their mother tongue, which can be Chinese, Malay or Tamil). With more time set aside to allow the children to learn two languages and mathematics in the lower primary years (Primary 1–2), learning English and mathematics helps to lay a foundation to enable them to learn science in the coming years, starting when they reach Primary 3 (Lee, 2018), their middle primary years. Science is considered a valuable subject in Singapore, and it is one of the four compulsory subjects that have been given the same importance in the Primary School Leaving Examination (PSLE). Science is favoured due to its close association with STEM and the great wealth this area has generated for the country's economy (Lee, 2018). Hence, science in school is seen as essential to prepare children for their place in the future workforce.

The amount of time devoted to science lessons ranges from 90 minutes (for Primary 3–4) to over 150 minutes (for Primary 5–6) per week (Lee, 2018). The science syllabus is divided into a lower block (Primary 3–4) and an upper block (Primary 5–6). It is classified into five integrated themes (Diversity, Interactions, Systems, Cycles and Energy) and the main feature of the curriculum in primary science in Singapore is 'inquiry-based learning' (CPDD, 2013). As well as the acquisition of scientific knowledge, scientific skills, processes, ethics and attitudes are also emphasised in the subject (Lee, 2018). The science curriculum is revised every six years to ensure that the syllabus is current. The last update was in 2014 (Lee, 2018) but due to ongoing changes in primary and secondary curriculum, the next update is projected to be in 2023. In schools, the children use approved, commercially produced textbooks and workbooks which have been 'prescribed' and regulated by MOE (Lee, 2018, p.159).

Although science is not a formal or examinable subject before Primary 3, it is embedded in the English language subject as a component under different genres, such as information texts or narratives (refer to Table 1.1).

Primary 1 (Year 1)	
Title	**Type of Genre**
1. My River	Information text
2. Walking through the Jungle	Narrative text
Primary 2 (Year 2)	
Title	**Type of Genre**
3. Tools	Information text
4. What Will the Weather Be Like?	Information text
5. Slither and Slide	Information text
6. Magnetic Max	Narrative text
7. A Butterfly is Born	Information text
8. Life In a Shell	Information text
9. The Underground Dance	Narrative text

Table 1.1*: The science-themed books that P1 and P2 use during their English lessons

*PS: This is an example of a list of books that one of the researched schools was using. The list varies from school to school as they are given autonomy to choose their books (from different genres) from a list given to them by MOE.

With the context set up for the research study in this chapter, I now move on to detail the structure of this thesis.

1.5 Structure of the thesis

This thesis has eight chapters. Chapter 1 has provided a general introduction to the research study, my personal interests and motivations and the purpose of the study, which led to the research questions. It has introduced the context for the study and given an overview of Singapore's educational system and science syllabus.

Chapter 2 presents a review of the literature. The key areas are: defining play, learning magnets, the relationship between play and primary science, free-choice learning linked to the theoretical framework – Falk and Dierking's (2000) Contextual Model of Learning (CML), children's talk and primary science, children's and teachers' perspectives on play in formal settings, and the definition of the nature of scientific play used in this study.

Chapter 3 is the methodology chapter where the research scope, strategy and design are described. Background information about the participants is provided to set the context for the study. Next, sections detailing the methods (quantitative and qualitative), data collection and analysis, the role of a researcher, ethical considerations, quality of data, validation and triangulation, and a summary of the chapter are presented.

Chapter 4 presents the new adapted framework (which was designed by the researcher) used in this research study – the 'Primary Science Talk Framework with Play' (PSTFP). This chapter traces the development of this framework and how it was created through various developmental and iterative actions to reach the final step where it could be used as the main framework for the quantitative part of this study.

Chapter 5 reports on the nature and dominant types of all talk and science talk by both the children and teachers. In this chapter, the findings are predominantly quantitative data with excerpts provided from the qualitative data as evidence to support them. Appropriate statistical analyses are used and justified.

Chapter 6 looks at the qualitative findings about children's perspectives on play in primary science that were obtained through the groups' semi-structured interviews after the scientific play sessions. Here, the data were analysed using sociocultural discourse analysis as a whole method with thematic analysis and presented using Falk and Dierking's (2000) Contextual Model of Learning (CML) model as a framework to capture the children's perspectives on play in primary science. The personal and sociocultural contexts were the two key headings, and the themes generated from the data were classified under these contexts.

Chapter 7 reports the qualitative findings for the teachers' perspectives on play in primary science. These were obtained through semi-structured interviews with individual teachers before and after the scientific play sessions. Here, the data were also analysed using sociocultural discourse analysis as a whole method with thematic analysis and presented using Falk and Dierking's (2000) CML model as a framework to capture the teachers' perspectives on play in primary science. The personal and sociocultural contexts were the two key headings and themes generated from the data were classified under these.

Chapter 8 is the discussion chapter and discusses the findings found in the three data chapters, Chapters 5–7, linking them to the literature reviewed in Chapter 2. This is followed by interpretations of the integrated findings and the discussions. Here, the four research questions were answered, and the key findings for each research questions are presented, with links to theory and practice.

Chapter 9 is the concluding chapter where the answers to the four research questions are convened, summarised and presented. This chapter also addresses the researcher's three main contributions to knowledge, provides a critique (limitations) of the study and the implications of this research for future policy, practice and research. Recommendations for further research are made and the chapter ends with my final thoughts and reflections upon this research study.

Chapter 2 Literature Review

2.0 Introduction

> *Every child has the right to relax, play and take part in a wide range of cultural and artistic activities.*
>
> Article 31 of the United Nation's (UN) Convention on the Rights of the Child (UNCRC, 1989)

Under the United Nation's Convention on the Rights of the Child (UNCRC), Article 31 fully recognises play as one of the essential children's developmental needs in our society, which no child or young person under 18 should be denied (UNCRC, 1989). Similarly, Jamison (2004, p.69) writes:

> *Children need the freedom and time to play. Play is not a luxury. Play is a necessity.*

Play is a basic right of every child, a fundamental need. It is therefore imperative to ensure that space and time are factored in and provided for play. In addition, Cohen (2019) argues that play is a vital learning experience (Moyles, 1989; Smilansky & Shefatya, 1990; Wood & Chesworth, 2017) which can be crucial for children's development (Aras, 2016; Else, 2009; Gunnarsdottir, 2014; Whitebread, 2005; Whitebread, Basilio, Kuvalja & Verma, 2012; Wood & Attfield, 2005). Play enables children to emulate the behaviour of people around them (Else, 2009; Fatai et al., 2014; Groos, 1985) and helps them to build up their social skills (Fatai et al., 2014; Fleer, 2007; Malone & Tranter, 2003; Robson, 2010; Singer, 2006; Smilansky & Shefatya, 1990; Weisberg, Hirsh-Pasek, Golinkoff, Kittredge, & Klahr, 2016).

Play has been researched and written about in hundreds of books and thousands of journals (Burghardt, 2011) over the past 100 years and identified as integral to human experience (Bergen, 2014), but even with the 'idealised status' (Wood, 2013, p.13) accorded it by professionals in early childhood, play still has many limitations which restrict its implementation in learning settings (Shoaga, 2015), including in schools. Brock (2019, p.29) argues that there are many skills that educators need to acquire in order to meet learners' needs: a fundamental understanding of the nature and purpose of play; an understanding of "psychological, sociocultural and ecological theories"; and an understanding of how all of these factors and others interact with each other. Play is nebulous and complex (Bergen, 2014): due to the wide variations in the forms that play takes in different cultural settings, it is not easy to define or measure (Fleer, 2017). The intangible nature of play has masked the impact it can have on children's learning and development (Gunnarsdottir, 2014) and has resulted in its not being implemented in the curriculum (Fleer, 2017).

Riley (2003) has proposed that, with clarity about what play is and is not, the issues around the educational value of play could be resolved. However, although Riley's propositions may help to resolve the situation by clarifying the definition of play, it is rather too simplistic to handle the complex nature of play itself. Moreover, Whitebread, Basilio, Kuvalja, and Verma (2012) contend that our ignorance about what exactly play is and its importance has seemed to have resulted in creating this significant barrier to children's play. Research has indicated that, when children's play-based curriculum ceases at the end of the early years, at around eight years old, there is an absence of play in the curriculum from then onwards during their middle childhood. This does not imply, however, that children will abruptly stop learning through play (Olusoga & Keen, 2019). Children and people of all ages can learn through playing; it is not only reserved for children (Else, 2009).

This study aims to explore children's and teachers' experiences and perceptions of play in primary science in Singapore. A review of the literature on play (Section 2.1) and science education (Sections 2.2-2.3) reveals that, although play is well-studied in the early years, there are some gaps for older children in middle childhood. A few studies have been identified that attempt to understand play in middle childhood in Literacy and Mathematics, but very few in Science (Stone et al., 2019). Therefore, the ultimate objective of this study is to contribute to the empirical evidence in this identified gap in the research literature.

This chapter begins with an introduction to play, followed by definitions of play and primary science. Then the chapter moves on to talk about how children learn science and the relationship between play and primary science. Next, Falk and Dierking's

(2000) Contextual Model of Learning (CML), which is the main theoretical framework underpinning this study, is discussed. Then, the literature review explores what is already known about children's and teachers' perspectives of play and (primary) science. The chapter then moves on to the literature on children's talk. Using a combination of the Falk and Dierking's (2000) CML and Simon, Naylor, Keogh, Maloney and Downing's (2008) Discourse Analysis Framework, this study reveals a new framework for the exploration of children's talk in a science class. Finally, the chapter concludes with a summary of the contents reviewed.

2.1 Defining play

Although play has been studied for over a century (Bateson, 2011; Gordon, 2009), its complexity and multifaceted nature (Jenvey & Jenvey, 2002; Smith & Vollstedt, 1985) does not allow it to have a definite or universally agreed definition in the literature (Reed & Brown, 2000), or to be defined by a single feature. Different scholars have perceived and conceptualised it in many different ways; Bruce (1991) argue that play is an 'umbrella word', while Hutt, Tyler, Hutt, and Christopherson (1989) argue that it is a 'jumbo category' which can comprise a great variety of activities that are beneficial to learning as well as many which are not so favourable. However, these two definitions of play were deemed too broad and lacked details. A more promising definition is Fleer's (2013), in which she describes the concept of play to be ever-changing, not static and has instead progressed and transformed over time. The concept of play has become a theoretical construct which captures and analyses what children are doing while they learn (Fleer, 2013). Fleer (2013, 2017) proposed that play encapsulates:

> *[…] a philosophical stance, pedagogy, approach, or teaching strategy that taps on the natural curiosity of children, about new objects and events happening around them and inclination to have fun.*
>
> (as cited in Teo, 2017, p.321)

On the other hand, many early childhood professionals have referred to definitions and categories of play located in psychology and sociology in order to come up with their interpretations of play (Fleer, 2013). Generally, there are three ways to categorise and define play (Fleer, 2013). These are: (a) a developmental view of play (Burghardt, 2001; Bruce, 2005; Siraj-Blatchford & Asani, 2015), (b) a critical view of play (Ailwood, 2010; Blaise, 2010; Grieshaber & McArdle, 2010) and (c) a cultural-historical view of play (Fleer, 2014; Lindqvist, 1995; Hakkarainen & Bredikyte, 2014). Next, one example will be used to elaborate on these three main categories. These definitions have shaped my own definition of play which I will present in Section 2.17.

Scientific play is quasi-free play in a science learning context. It is a child-chosen activity [informed by Meckley's (2002) definition of play], shaped by the materials provided and the science classroom context [informed by Fleer's (2017) definition of play]. Whilst the intention of scientific play is to stimulate play on the theme of the science learning taking place at the time, children have free choice so their play may include investigation, play purely for enjoyment, the construction of things and pretend play.

2.11 Developmental view of play

This view has a naturalistic perception of play, where the idea of playing is natural and something that a child often does (Fleer, 2013). Play is perceived as intrinsically motivated and focused on the meaning-making of the child through their experience of play (Bruce, 2005; Kennedy & Barblett, 2010; Moyles, 2005). What is vital here is that, in this view, play development is believed to follow particular stages that are universal in all cultures and during all time periods (Fleer, 2017).

An example is Burghardt's (2011, p.10) definition of play, which is based on five criteria (refer to Table 2.1). In this definition, Burgehardt stated that all five criteria must be fulfilled to characterise play behaviour across species and contexts.

1. The behaviour is not fully functional in the form or context in which it is expressed.
2. The behaviour is spontaneous, voluntary, intentional, pleasurable, rewarding, reinforcing, or autotelic ("done for its own sake").
3. The behaviour is incomplete, exaggerated, awkward, precocious, or involves behaviour with patterns with modified form, sequencing, or targeting.
4. The behaviour is performed repeatedly in a similar, but not rigidly stereotyped form.
5. The behaviour is initiated when an animal (or person) is adequately fed, clothed, healthy and not under stress.

Table 2.1: Burghardt's criteria for recognising play

This definition of play is an intuitive conception where 'seemingly purposeless behaviour that is enjoyable' (Burghardt, 2011, p.10) is carried out. The strengths of this definition are that the criteria are real observations of activities which almost all children will often do and can be observable. On the other hand, the weaknesses are that some of the criteria are not easy to operationalise to make them visible and, being intuitive, it may not be easy for different individuals to 'feel' it and get it. Moreover, the condition stating that all five criteria must be present to be considered makes it challenging to use because some categories are not visible to quantify. Further critiques by scholars such as Göncü and Gaskins (2011) have argued against it. They have challenged this definition as not valid because children from different cultures have been shown to play differently and their activities vary from the fixed stages of play that the developmental view suggests that all children will go through at a fixed stage. This notion of non-fixed developmental stages is further supported by studies carried out by Fleer (1999) on Australian aboriginal children. The findings of her studies showed that these children do not play; nor is there an obvious place for it. This suggests that play is not necessary for child development and points out a flaw in this view of play.

2.12 Critical view of play

The critical view of play is also known as the post-structuralist view. This view can include either critical theories which allow early childhood educators to challenge assumptions about the curriculum and reflect upon their decisions, taking measured decisions (as they may have an impact upon the children) or post-structuralist theories, where the importance of this definition is to include equality and social justice. Play is examined carefully and equality (e.g. gender equality) is put into action through the ways in which play is facilitated by a practitioner (Ailwood, 2010; Blaise, 2010; Grieshaber & McArdle, 2010). Power relations are also considered in this view of play, but they are also disputed and challenged. Ailwood (2002) challenged the view that play is a separate activity for children and strongly opposed the binary between work and play. This is because she argued that, although adults or practitioners would like to respect and consider children's perspective on play, the irony is that the definition of what is play and what is work to children is still often defined by adults but not by children. A greater emphasis on social justice, where power and politics can live and relive through play, is emphasised in this definition (Fleer, 2013).

An example of this view comes from Blaise (2010), who examined the data collected from a year-long project on gender bending. In this project, what Blaise (2010) did was to ensure that the girls and boys in the study had the freedom to take up any role they wished, and were not constrained to ‘being a girl’ or ‘being a boy’, based on the typical gendered or stereotypical approaches. Thus: a girl (like Madison in her study) could play the role of a brother if she wished and did not have to play the role of being a girl, whom she was stereotypically expected to be by her gender. In short, Blaise (2010) ensured that both girls and boys could follow their desires and were able to break away from the taken-for-granted ways of playing to take on whatever roles they wished and be given access to an alternative gender discourse.

The advantages of this view are that this definition helps to depict what play is – the power relationships to be expressed (Grieshaber & McArdle, 2010). From this perspective, children are given access and choice to move out of the typical stereotype that usually comes with play and engage themselves in free roles not restricted to the stereotypical ‘boy’ or ‘girl’ roles they often play. This view of play also focuses on the children’s perspectives and listens to them. This allows teachers to study the children in a greater variety of ways and to observe them. This view of play is considered a ‘disciplinary gaze’ and feminist to a certain extent because it focuses on gender and the role of socialisation in gendered behaviour (Fleer, 2017, p.132). This is an important approach, but for play in schools ecologically, it is not a very accurate or real picture of what happens in a usual classroom setting.

2.13 Cultural-historical view of play

In this view, children’s play activity is “culturally constructed and culturally enacted” (Fleer, 2017, pp.144). There are four central concepts that underpin the cultural-historical view of play. They are:

- Children create an imaginary situation based on real-word experiences in play
- Children change the meaning of objects and actions in play
- Children move in and out of imaginary situations in play – from the real world to the pretend world and back
- Collective imaging as well as individual imaging occurs in play

Table 2.2: Fleer’s cultural-historical view of play (2017, pp.145)

This view of play fits into many of the settings where children are studied in places such as schools. These venues are normally culturally constructed and how the children will react can be influenced by their environment. Depending on the age of the children, the four central concepts seem to correspond well to early years settings, but are also applicable to primary school settings. Besides imaginary play, this view proposes the notion that the motivation for play does not come so much from the intrinsic motivation of the children, but rather from motives developed from their cultural communities (Fleer, 2010; Lindqvist, 1995; van Oers, 2010). I would disagree to some extent and propose that, in the cultural-historical view of play, there can be the possibility of a combination of both; in a play setting, children can be influenced by their cultural communities and at the same time have their own intrinsic internal motivations and agendas to inform their play. The limitation of this approach is that it does not draw attention to existing power structures, nor does it attempt to challenge them; it is more focused on the children's behaviour and how this relates to their natural world.

2.14 Smith's definition of play

As well as the three ways of defining play covered above, there are also other definitions that have surfaced to define what play is and what it is not. When examining approaches to research on play, Smith (2010, pp.4-5) proposed another way to understand play. He identified three ways of observing play: a functional approach, a structural approach and a criteria-referenced approach. In the functional approach, researchers centre on the apparent or actual purposes of the behaviour and its potential benefits. In the structural approach, researchers focus on the behaviours, how they are classified and ordered and what differentiates play from non-play. Lastly, the criteria-referenced approach is based on the observer's perspective for defining whether a behaviour sequence is play or not play (Smith, 2010, pp.4-5). The more criteria are identified, the more likely it is that the activity or behaviour will be seen as play.

The position taken in the present study is to include all the behaviours exhibited by children when they were asked to play freely. By comparing Smith's definition with the first three ways of defining play (Developmental, Critical and Cultural-Historical) in this

Section 2.1, we can see that Smith's definition has a slight resemblance to them. The developmental view can be matched with the functional approach, where the purpose of the behaviour can be connected to the naturalistic behaviour that a child will exhibit during play. Next, the critical view overlaps with the structural approach, where the focus will be on the behaviour observed, albeit with a critical focus, and lastly the cultural-historical matches with the criteria approach, where play is described as culture-laden or informed. Although these definitions of play may have some similarities and overlap with the ways of understanding research on play, both perspectives on play can be vastly different in the emphasis on the concepts behind them. An example would be the requirement to fulfil all five criteria in the developmental view before an activity is accepted as play, as opposed to the focus on observations of children when they are given the opportunity to play. The critical view focuses on social justice and gender-free research on play, while the structural approach is on how to classify play. Lastly, the cultural-historical view of play is very specifically linked to culture and surroundings, while the criteria-referenced approach is based on the observer's perspective. Furthermore, critics have deemed Smith's way of defining play to be inappropriate because the definition was created by the researcher from an adult's theoretical position and not from the focus of the play – the children.

2.15 Meckley's (2002) definition of play

Unlike Smith (2010), Meckley (2002) has considered the role of children, who are the ones playing, taking into account their perspectives and their voices in the play contexts. This has resulted in Wood (2013) arguing that Meckley's seven characteristics of play are a better fit for the definition of play. The seven characteristics of play are listed in Table 2.3 below (Wood, 2013, pp.6-7).

(1) Play is child-chosen
(2) Play is child-invented
(3) Play is pretend but done as if the activity were real
(4) Play focuses on the doing (process not product)
(5) Play is done by the players (children) rather than the adults (teacher or parents)
(6) Play requires active involvement
(7) Play is fun

Table 2.3: Meckley's (2002) characteristics of play

In Meckley's (2002) characteristics of play, the definition of play can be seen to centre more around children than adults. This definition corresponds well to the cultural-historical view of play discussed in 2.1 (c). Both definitions are placed side by side and compared in Table 2.4:

	Fleer's (2017) Cultural-Historical (CH) View of Play	**What CH Matches With M**		**Meckley's (2002) (M) Characteristics of Play**
(a)	Children create an imaginary situation based on real-word experiences in play	(1), (2), (3), (4), (5), (6), (7)	(1)	Play is child-chosen
(b)	Children change the meaning of objects and actions in play	(1), (2), (3), (5), (6), (7)	(2)	Play is child-invented
(c)	Children move in and out of imaginary situations in play – from the real world to the pretend world and back	(1), (2), (3), (4), (5), (6), (7)	(3)	Play is pretend but done as if the activity were real
(d)	Collective imaging as well as individual imaging occurs in play	(1), (2), (3), (4), (5), (6)	(4)	Play focuses on the doing (process not product)
			(5)	Play is done by the players (children) rather than the adults (teacher or parents)
			(6)	Play requires active involvement
			(7)	Play is fun

Table 2.4: A comparison table between Fleer's (2017) cultural-historical view of play and Meckley's (2002) characteristics of play

What this comparison shows is that both are closely related and have an overlapping relationship. Meckley's characteristics of play can be considered as an example of a cultural-historical view of play, culturally based on the play context of the children. However, although Meckley's characteristics of play claim to focus more on the children's perspectives, an observation of Table 2.4 shows that CH's view starts with the word 'children' while Meckley's characteristics of play, on the contrary, starts with 'play' instead of children, overturning the claim that Meckley's characteristics are more focused on children. Looking at Meckley's characteristics of play (5 to 7), these three characteristics fit with the CH's view; The CH perspective focuses on the children who are the players (characteristic 5), and how they move in and out of play (characteristic c), are actively involved (characteristic 6) in collecting images, and finally identify play as being fun (characteristic 7), which is often associated with most play.

2.16 Purposeful play

Purposeful play was created by the Ministry of Education (MOE) Singapore (2012) in curriculum documentation to combine play and learning together during the early years. According to MOE Singapore (2012, p.52):

> *The concept of purposeful play seeks to ensure that teachers purposefully plan for learning and interact with children in their play with the intent of achieving desired learning goals.*

In purposeful play, although teachers try to centre their interest and motives on the children, the play has been pre-planned and teachers will direct the children in a manner that leads them to achieve the expected learning goals (Fleer, 2017). MOE Singapore (2012) claims that purposeful play is an authentic learning experience which makes learning fun and engaging. The five characteristics of purposeful play are:

1. Authentic contexts are created to support learning and play.
2. Collaborative learning is supported in play-based settings.
3. Children take risks, make mistakes and manage their own learning when playing.
4. In play-based situations, learning is enjoyable.
5. Play develops children’s imaginations and creativity.

Table 2.5: Five characteristics of purposeful play

This definition of play has been used to meet country-specific needs, particularly during the early years, when play is being used to serve the purposes of learning. A similar approach can be seen in Australia, where intentional teaching takes place through play and in Sweden, where the system emphasises the playing learning child (Fleer, 2017). This type of play is not a free-play form, where children can go freely and do what they desire without any restrictions. This version of play contrasts with the meaning of free play; it starts with an intention and ends with the learning objectives in mind, i.e. it serves the teacher’s rather than the child’s purpose. This form of play is pre-planned especially by the adults to ensure that learning outcomes are met. The advantages of this form of play come from the fact that, although the play is designed by adults, teachers will still acknowledge the children's interests and allow them to explore in their play. Teachers will also interact with the children and set up an authentic and engaging environment to support their learning. This connects to the concept of guided play, which is like a subset of purposeful play and will be discussed in more detail in Section 2.31.

Comparing purposeful play and Meckley's definition of play, purposeful play contrasts with some of Meckley's characteristics. These characteristics are:

- purposeful play is focused on the product – the planned objectives from an adult, as compared to the focus on process professed by Meckley (characteristic 4).

- purposeful play is planned by adults and supported by them, with the intention of guiding and steering the children towards the projected learning objectives, with the emphasis of the play done by both adults and children and not, as Meckley claims, done more by the children (characteristic 5).

Lastly, for characteristics 1 and 2 of Meckley's definition, purposeful play is only able to match and fulfil Meckley's definition after the essential premise that the play has been designed and controlled by adults is created first before the play, making it not child-chosen (characteristic 1) or child-invented (characteristic 2) from the start.

2.17 Definition of play in this study

Although purposeful play is the perspective taken by the government in Singapore (the context for this study), the definition of play used in this study is based on Meckley's (2002) definitions, supported by Fleer's cultural-historical (2017) view and part of purposeful play (MOE, 2012). This is because the aim of this study was mainly designed with children's perspectives in mind [which Meckley's (2002) definitions underpin]. Moreover, McInnes, Howard, Crowley and Miles (2013) also suggest that considering play as an approach to a task is the most beneficial perspective.

Play in this study took the form of 'quasi-free play', where the children were allowed to choose freely (free-choice) what they wanted to do, play or learn (self-directed learning) in the free play they engaged in. It is called ‘quasi’ because the children’s play was not totally free due to their physical location and the constraints of a classroom or science laboratory. Moreover, sets of pre-prepared materials relating to the topic being taught in science were provided, and teachers were able to help children during their play – but only upon the child’s request or when they saw the group struggling. Only then was this form of scaffolding available to the children (Weisberg, Hirsh-Pasek & Golinkoff, 2013), making play in this study ‘quasi’. According to Mercer (1994, p.96):

> *Scaffolding represents the kind and quality of cognitive support which an adult can provide for a child’s learning, which anticipates the child’s own internalisation of mental functions.*

All the teachers were advised not to ‘interrupt or disturb’ the children’s play if possible and to allow them to have full control and ownership of their play. This was to retain the free choice element of play and prevent it from being used to serve the teacher’s agenda or intended learning objectives. The free play planned in the play protocols (Appendices 1.1 and 1.2) for teachers in this study is in line with Lim (2010, p.144) who reported how free play is featured in a western country:

> *Sometimes teachers intervene, other times they leave the children alone, sometimes teachers purposefully direct children’s play; other times they make a few suggestions to steer children’s play in certain direction.*

As free play was encouraged to focus on the doing, the process (Meckley, 2002), the intention was that children would have free choice about being actively involved in playing as they wanted, including imaginary play; pretending and assigning meanings to things and actions during play. This radical approach was necessary to distinguish what was called the “scientific play” sessions in this research study from a science class, which might typically involve lots of teacher talk, teacher demonstrations and some highly directed step-by-step practical activities.

The cultural-historical approach to understanding play was also used to underpin the definition of play in this study. The context of play is often “culturally constructed and culturally enacted” (Fleer, 2017, pp.144). With imaginary play taking place and based on children’s prior experiences and the influences of their culture and national contexts, children move in and out of the imaginary situation from the real world to the pretend world. Central to the definitions of Meckley (2002) and Fleer (2017) is free play. Free play happens when children are allowed to choose, take risks and decide what they want to do. In free play, children can do anything they want; they can involve themselves in pretend play, stretching their imaginations and creativity. Collective or individual imagining of things can take place because children are not restricted in how they play; they have the option to either play alone or to collaborate by playing in groups.

Although the approach to play enacted in this study has some characteristics in common with, for example, purposeful play, and it was anticipated that children would have fun, collaborate, take risks, imagine, create and learn, there were a number of key differences. These included the fluidity of the learning outcomes because it was intended as free play to allow the children to play and learn or acquire positive experience. Part of the aim of this study was to give children a safe space to play with materials associated with their topic, to make mistakes, and to talk freely with others in an informal situation.

Play was intended to be fun for the children in this study, where they were free from the worry that a product needs to be made, and in cases where the children had questions or concerns, the teachers were there as facilitators to help them to get on by asking questions rather than telling them what to do, in order to respect the voices of the children.

2.18 Play in formal educational settings

The literature review now proceeds to the next part – the significance of play in formal educational settings. From the perspectives of evolutionary theory, developmental psychology and ethology, play has been theorised as an urge which is essential to young animals and humans (Brown & Vaughan, 2009). This is because play helps to provide the young with essential practical experience which they can develop into skills that are useful in adulthood in order to increase the survival potential of themselves and their offspring (Jarvis, 2014). Play motivates children and leads them to repeat playful activities, which are known as behaviour schemas (Athey, 1990). A schema is defined as a pattern of actions and mental structure (Athey, 1990). This repetition of activities helps to provide the “psychological foundation for […] social and intellectual skills" (Jarvis, 2014, p.6) in children. Play allows children to build positive relationships with their peers (Hartup, 1993; Rubin, 1990). Through play, children can also pretend and imagine when they assume different roles and explore situations from different angles or other perspectives (Bateson, 1955). When the children's social skills improve, they can regulate themselves (Else, 2009); affording a better play experience with improved cooperation and connectivity with their peers (Humphreys & Smith, 1987).

Play contributes to the development of positive peer relationships (Hartup, 1993; Rubin, 1990). By engaging in pretend play, children take on different roles and experiment with different perspectives (Bateson, 1955). Children learn how to cooperate and get along with others through play experiences (Humphreys & Smith, 1987). Play helps to prepare children for their future, as they adjust to an increasingly complex adult world (Jarvis, 2014). Play is enjoyable (Diamond, Lee, Senften, Lam, & Abbott, 2019). This suggests that it may have a place in educational situations.

On the other hand, scholars such as Thomas (1994, p.32) push for more formal approaches to learning:

> *No matter how far one takes informality or child-centredness, there is simply no point in children coming to school unless they are learning something. Learning to read, write and figure will enable children to become independent citizens and to contribute to the society in which they live, playing some part in changing it for the better.*

This presents a false dichotomy: schooling does not need to be exclusively play or exclusively formal teaching and learning. There is space for both, and there is a particular need to consider the transition from play in early childhood education to formal learning in primary school.

Thomas (1994) and Bodrova and Leong (2015) have argued against play in formal education because they see play as a childhood activity instead of a teaching strategy. They argue that it is crucial not to lose sight of the real essence of play (Bodrova & Leong, 2015), i.e. to ensure that play is not corrupted by a focus on formal learning. It has been argued (Stone et al., 2019; Zaporozhets, 1986) that it is important to ensure that play is not laden with too many adult objectives and that it does not become a task, and to ensure that play belongs to children and not teachers, who in the process have a tendency to make play into a teacher-directed, rather than child-centred activity.

A concept that is important when considering play in educational settings is the “behavioural threshold of play” (Howard & Miles, 2008). It has been found that if a child perceives a task to be play, he or she will find it easier to approach the tasks with confidence and more fluently, solving problems better than they would if they did not perceive it as play (McInnes, Howard, Miles, & Crowley, 2009). McInnes et al. (2009)’s study is underpinned by this concept. They conducted a research study on 32 children aged between 3 and 5, in three early-years settings, using jigsaw puzzles in both playful and formal conditions. The study revealed that children showed more significant improvement in performance (measured by the time taken to complete the jigsaw) when engaged in play. The children also exhibited more positive affective behaviour such as smiling more, speaking positively and cheering each other on, as compared to children in a formal play situation who displayed negative affective behaviours such as frowns and sighs (McInnes et al., 2009). The explanation provided by McInnes et al. (2009, p.36) is that the children in the playful condition will have their ‘behaviour thresholds’ lowered; they believed that the task was easier (because it was presented as play), and were thus more confident about doing the jigsaw and able to be more on task; more deeply involved in the activity, more persistent with problem-solving, resulting in a better learning experience (McInnes et al., 2009), through the fluency achieved in a play situation. The findings summed up that there was a difference noted in the children involved in the playful conditions, as these children displayed smoother and more purposeful problem-solving behaviours than those children placed in the formal conditions. The behavioural threshold of play theory (Howard & Miles, 2008) suggests that free play which is communicated to children as such is potentially useful in learning situations as it provides a space for experimentation, risk-taking and learning because the children feel playful (Howard, 2010). The way in which children perceive situations from their perspectives as being ‘play’ or ‘non-play’ is important for teachers because what the children perceive as ‘play’ may be very different from the teachers’ point of view. With this knowledge, teachers can then create playful environments (Howard & Westcott, 2007) for the children in order to have the desired effect. In addition, the teachers could also develop their own playfulness to fit in as co-operative play partners when working with children during play (Ceglowski, 1997).

McInnes et al.'s study (2009) is an example of many research studies exploring play in early childhood. However, when we move on to middle childhood, from the ages of seven to 11 years old (Howard, Miles, Rees-Davies, & Bertenshaw, 2017), beginning with the age of entering primary school in most countries, the research on play starts to peter out, at around age 11 or 12 (Cohen, 2019, p.13). This could mean that the research is sparse, but also that play is sparse. It has been argued that, somehow, playful learning has slowly vanished from school classrooms (Bergen, 2009). In contrast to the belief that play is only for young children and the assumption that older children do not play (Cohen, 2019), Else (2009) argues that play is for people of all ages; play has become more organised and taken on different forms which it is harder to easily recognise as play as we age. Play presents itself in various forms across the whole human lifespan (Bergen, 2009).

Play is well studied in early childhood from birth to eight years old, particularly in pedagogies such as play-based learning (Gunnarsdottir, 2014). According to Menntamálaráðuneytið (2011, p.37), "play is inseparable from childhood and therefore the focus of all preschool activity". A general scan of early years' curricula across different countries from both international and European countries indicates that early years' curricula are generally play-based (McInnes, 2018), which presents an opportunity for research studies. The play-based curriculum typically ends at around the age of eight.

Roberts conducted a review to locate research on play in middle childhood funded by the Economic and Social Research Council (ESRC) in the United Kingdom (UK) during the period 1982-2014 by using the search terms 'play' and 'child' (Roberts, 2015). The findings retrieved a limited number of studies on play in middle childhood (Roberts, 2015). Examples of middle childhood research on play typically focused on play outside of school (Valentine & McKendrick, 1997; Valentine, 1997; Holloway & Valentine, 2000), interactive technological play using digital toys (Luckin, Connolly, Plowman & Airey, 2003) and the business of play spaces (McKendrick, Fielder &

Bradford, 1999). These studies mainly focused on the barriers and enablers of play outside of classrooms, and digital play (Roberts, 2015) and, from the low numbers of studies found, a gap in the research literature on play in school lessons in middle childhood was evident (Roberts, 2015). Where schools were mentioned in Roberts' review, it was in relation to organised play (sports and games) (Chamberlain, George, Golden, Walker, & Benton, 2010; DfE, 2013), what happens on the playground (McKendrick et al., 1999; Giroux 2000) and the journey to school (Hillman, Adams & Whitelegg, 1990).

Middle childhood is important because it is during this stage that children learn to develop social relationships, cultural understanding and a sense of citizenship (Sandberg, 2001). However, in middle childhood, most studies on play focus on break times in school (Pellegrini & Bohn-Gettler, 2013), social and antisocial behaviour (Vlachou, Andreou & Botsoglou, 2013) or how children use outdoor spaces (e.g. Holt, Spence, Sehn & Cutumisu, 2008), rather than on during timetabled classes. The research on play targeting subjects relates to literacy (Diamond et al., 2019; Martlew et al., 2011) and mathematics (Saber, 2016; Vogt, Hauser, Stebler, Rechsteiner & Urech, 2018; Wager & Parks, 2014) but not science. This is the gap in the literature concerning play and the learning of primary science.

Play-based learning and play have met with implementation problems such as those reported in empirical studies in Northern Ireland (Walsh, Sproule, McGuinness, Trew, Rafferty, & Sheehy, 2006; Walsh, McGuinness, Sproule, & Trew, 2010), where a 'developmentally appropriate', play-based and child-centred curriculum called the Enriched Curriculum (EC) was implemented. The purpose of the EC was to ease the transition of children from pre-school or home to formal schooling in Year 1 (Walsh et al., 2010) in response to the developmental stage of individual children. Using a play-based curriculum, it was aimed to promote children's sense of self-competence and self-esteem through play and activity-based learning, mainly in areas such as literacy, mathematics and outdoor play (Walsh et al., 2010). The traditional and formal class is predominantly teacher-centred, with an emphasis on literacy and numeracy, learning through individual work, repetition and practice to achieve learning (Wood & Bennett, 1999). In this study, 38 classes following a traditional Year 1 curriculum and 32 classes from the EC Year 1 were compared and observed (Walsh et al., 2006) over two days for two full sessions. The findings from the 32 classes of EC Year 1 showed that children from the EC classes exhibited “higher levels of emotional, social and physical well-being” (Walsh et al., 2006, p.201) than the ‘traditional’ class.

The findings from the above research indicate the potential advantages of play in formal learning. Another, follow-up research study conducted by Walsh et al. (2010) on the evaluation of the first four years of the EC found that the educational value of play was well accepted by stakeholders such as the children, teachers, parents and principals of the Year 1 group. However, when the evaluation reached teachers of Year 2, some concerns and discomfort with the educational value of play in the reinforcement of the children’s literacy and numeracy skills were expressed by the teachers (Walsh et al., 2010). Among teachers of Years 3 and 4, they found discomfort with the EC, with doubts about the effectiveness of EC in ensuring the readiness of children for more formal learning (Walsh et al., 2010). Year 3 teachers showed the greatest anxiety about children’s progress in attainment (Walsh et al., 2010). This evaluation of the four years of the EC showed that the teachers’ mental models and understandings of child development were important to enable the teachers to reap the rewards of a play-based curriculum – a curriculum where a greater emphasis on play and activity-based learning was encouraged in classes on literacy, mathematics and outdoor play (Walsh et al., 2010).

Different countries have different starting ages for their Year 1 or Primary One; with a range between four and seven years old. In Singapore, children start their primary education at seven years old; therefore, the studies selected and focused on will be relevant to this age group. From the literature reviewed, only seven empirical studies on using play in science were found (Bulunuz, 2013; Desouza, 2017; Fleer, Gomes, & March, 2014; Hao & Fleer, 2016; Lim, 2010; Stone et al., 2019; Teo, Yan, Ong, & Goh, 2018). Six of them were on children in the early years group, while only one was on primary school age.

In the kindergarten age group, Bulunuz’ study (2013), working in Turkey, examined the effectiveness of play in science activities in kindergarten at ages five and six. Two classes of kindergarten children were involved. One class (the experimental group) experienced play and the other group (the comparison group) experienced didactic teaching. Both groups were taught eight topics over 14 weeks. His findings showed that the group of children who had been exposed to the play approach had shown greater understanding with better and more active participation than the children taught with direct instruction, as measured through pre- and post-interviews using semi-structured questions. In the classes incorporating play, as recommended by Clark (2001), children were exposed and encouraged to explore and have hands-on experience of the different aspects of science concepts using a wide range of activities linked to many other subjects such as art, literacy, music and drama, integrating science across the curriculum. In addition, the children were also encouraged to explore more about the concepts by asking questions and making predictions. The control group, which is called the comparison group here, was taught using didactic approaches such as “narrative, question and answer, and demonstrations” (Bulunuz, 2013, p.233). The children in the experimental group displayed greater positive behaviour changes than the comparison group in making and testing predictions as well as explaining and reflecting on their observations. Bulunuz’ study suggests that play in science teaching helps to promote children’s understanding of science concepts. There was no control group in the study in this thesis; the classes that participated were given the same materials and protocols to follow to start with and, since data was collected in the form of post- interviews, there will be limitations when trying to draw inferences from Bulunuz’ study.

The only empirical study of play on primary science was Stone et al.’s (2019) study, in which free play was used with children in the third (8-year-old) and fourth (9-year-old) grades (n=130) in their science classrooms in two schools in the southwestern United States. The aim of the study was to investigate whether free play has any impact on children’s learning on the topic of electricity. Of six classes, three were assigned to experience play and three were designed to experience ‘traditional instruction’ (reading science content) (Stone et al., 2019, p.97). Across two weeks, the classes were given 35-50 minutes to engage with either the direct instruction (“in the form of reading in the content area of static electricity”) or direct instruction with free play, respectively (Stone et al., 2019, p.97). A three-question prior knowledge survey on static electricity and an authentic assessment in which children were given the play materials and had their verbal responses (in the form of a one-to-one interview) and outward behaviours recorded, were used to assess 54 randomly chosen children from the two groups. Observational findings indicate that children in the play groups had shown conceptual understanding through their actions and their talk (Stone et al., 2019). Moreover, the children in the play group also displayed high engagement of scientific processing skills such as critical thinking, problem-solving, inquiring, discovering and comparing (Stone et al., 2019). The play group children were more engaged in the activities and were more confident in using the materials to demonstrate (Stone et al., 2019). Furthermore, the play group children also demonstrated a slightly higher conceptual base of knowledge (Stone et al., 2019). The only item in which the traditional counterparts did well was on the recall of terms, but these counterparts displayed less confidence in demonstrating the concepts that they had learnt (Stone et al., 2019).

The strengths of Stone et al.'s (2019) study are that the prior knowledge of the children was tested and obtained before the start of the study, and that just a few, focused questions were asked. Also, the sample size of the children was good at 130 and there were six classes involved. As for the limitations, the usage of 'authentic assessment' may seem like a problem when the researcher tested the children by getting them to do a one-to-one interview. This was a limitation because, with the assessment mentioned and the set-up, which was like a test with a 'stranger' (the researcher who was not a teacher at the school), the children would be likely to be confused and unsure whether what they were doing was considered 'play'. The children might also be stressed because it was rather intimidating for them when the word 'assessment' was used, which might evoke negative feelings. Research such as that by Howard and Miles (2008) and McInnes et al. (2009) has also shown that children's perceptions of whether something is play have important consequences for how they approach their tasks. Although the children were allowed to play in the authentic assessment, the presence of an adult in close proximity, as in McInnes, Howard, Miles and Crowley (2010)'s study, would have resulted in the children's performances being lower because that presence would signal to the children that it was not play.

The gap in Stone et al.'s (2019) research was identified and through the study in this thesis, a more naturalistic manner of observing the children was used via audio recordings. The recording devices became 'inconspicuous' after some time, and the children talked freely and communicated naturally in the free play settings. They were not assessed, and with the fun that play had brought for most children without much teacher intervention during their activities, what was recorded was the actual utterances of the children in a free-play setting. My research will also contribute to studying the nature of the utterances that the children spoke during their scientific play sessions. I looked at the percentages of science talk that occurred. Moreover, the perspectives of the children on play was also collected and this will help us to delve deeper into what matters to the children and how they perceive play and primary science.

Similar research in other curriculum subjects that has made use of play-based pedagogies has also shown promising results, with pupils engaged in play achieving higher attainment than a control group. These pupils who had played had achieved more in numeracy (Presser, Clements, Ginsburg, & Ertle, 2015), literacy (Van Oers & Duijkers, 2013; Diamond et al., 2019), cognitive outcomes (Kogan, 1983; Stone et al., 2019; Sylva, Bruner, & Genova, 1976; Walsh et al., 2006) and school achievement (Pellegrini & Galda, 1993; Pellegrini, 1980; Williamson & Silvern, 1990). Pellegrini (1980) argued that the level of children's play is a good indicator of their literacy level in their pre-reading, language and writing. The research in this thesis relates to kindergarten (Presser et al., 2015) as well as those studies which involved children from kindergarten level to the first few years at primary school (Van Oers & Duijkers, 2013; Walsh et al., 2006).

An example of a study dealing with learning mathematics through play is Presser et al.'s (2015) longitudinal cluster-randomised controlled trial, which was used to collect data over two academic years in New York city. A total of 762 children from the pre-kindergarten year (four years old) and kindergarten year (five years old) participated in their research; the children were randomly assigned to childcare centres which either provided mathematics instruction using the Big Math for Little Kids (BMLK), a play-based mathematics curriculum, or the usual curriculum (Presser et al., 2015). The findings of their research showed that the scores of the BMLK group children, who were engaged in play, increased significantly more than did those of children in the comparison group. Although Presser et al.'s study (2015) did not focus on science, what can be learnt from their study is that play-based, developmentally appropriate subject instruction can have a positive impact on young children's acquisition of subject knowledge. What could be better is if the instrument or the test used to measure young children's subject knowledge were more aligned with the curriculum for a fairer and better comparison to provide a valid test of the children's knowledge.

Even at pre-school level, the review of the literature shows that there are few studies on using play to learn science (Bulunuz, 2013; Fleer et al., 2014; Lim, 2010; Teo et al., 2018). More research has been carried out in developing programmes on teaching science through inquiry (French, 2004; Gelman & Brenneman, 2004; Van Hook & Huziak-Clark, 2008). At primary level, the situation is similar, and there is more literature on learning and teaching science through inquiry (Dunlop et al., 2015). Inquiry as defined by Minner, Levy and Century (2010, p.476) has three distinct categories of activities: 'what scientists do', 'how students learn' and 'a pedagogical approach that teachers employ'.

There are substantial differences between inquiry and play. Play as defined in this study (refer to Section 2.1 (C), (E) and (G)) contrasts with inquiry in that inquiry is often pre-planned and with specific intentions, procedures or activities decided by the teachers, not the children. Play may include inquiry in the sense of asking and finding the answers to questions, but scientific inquiry is associated with formal procedures and methods. 'Fun' is less important in inquiry than in play. The difference between these terms that stands out most distinctly is the more limited space for imagination and creativity in inquiry as used in science education, and the greater role of free choice for children in play.

When sufficient time and space is given to children, they can learn through play and develop thinking skills (Johnston, 2014) and, if extended time is given to the playful activities, they can be motivated and made to think (Cremin, Burnard & Craft, 2006). Subsequently, children will develop the observational and questioning skills which are important science process skills (Glauert, 2009). Through conceptual conflicts (Hand, 1988), debate and argument (Alexander, 2008; Naylor & Prescott, 2004) and sustained shared thinking (Siraj-Blatchford, 2009), children's conceptual understanding can develop.

In conclusion, there is a range of definitions of play, emphasising different features of the activity. The definition central to this study is Meckley's (2002) definition of play, supported by Fleer's cultural-historical view and part of purposeful play. Play has the potential to support children's learning (McInnes et al., 2009; McInnes et al., 2010; Walsh et al., 2006; Walsh et al., 2010) and has shown promise in supporting learning in science (Bulunuz, 2013; Desouza, 2017; Fleer et al., 2014; Hao & Fleer, 2016; Lim, 2010; Stone et al., 2019; Teo et al., 2018), although little is known about what children do when they are given the opportunity to play in science. However, for play-based activities or a play-based curriculum to be successfully implemented, it is important to equip teachers with professional knowledge of child development. When children knowingly enter a play situation, their behavioural threshold is lowered such that the confidence needed to approach a task is lower than in formal learning situations. As such, awareness of being in a play situation can help children to experiment, take risks and develop persistence with problem-solving.

2.2 Learning about magnets in primary science

Many theories have been advocated to understand and explain learning in primary science, including behaviourism (Scaife, 2018), cognitive theory (Agarkar & Brock, 2017) and constructivism (Matthews, 1998). However, many teachers do not act consistently with a single theoretical approach (Lunetta, Hofstein & Clough, 2007). Practice is variable across schools (Lunetta et al., 2007), with conventional teaching approaches incorporating practical work, demonstration, teacher's explanations and teacher's instructions. This study took place in the context of a unit on magnetism in Primary 3 in Singapore. In this section, what is known about children's ideas about magnets and magnetism will be discussed.

From the perspective of learning science, a person's current knowledge and ideas will strongly influence what they learn (Scaife, 2018). Children do not come to school as 'tabula rasa' (blank slates) waiting for teachers to fill them up with information (Pine, Messer & John, 2001). Different children bring with them a rich and wide array of experiences which can differ significantly due to different factors, such as culture. Children's experiences can inform or result in the children's ideas about science making sense for them, which can sometimes be useful, but at the other times can lead to misconceptions (Vosniadou & Ionnades, 1998) or alternative conceptions which are retained and prove difficult to remove (refer to Section 2.2). Furthermore, Preston (2016) also argued that primary children's learning is individualistic and a 'one size fits all' type of learning may not fit in with the learning of science.

Magnetism is a commonly introduced key concept (Van Hook & Huziak-Clark, 2007) in kindergarten and primary curricula around the world. It is often included in the curriculum for children between kindergarten to Grade 4 in countries such as the United Kingdom, Singapore and the United States. Magnetism is usually included under the theme of forces in the physical sciences section (Van Hook & Huziak-Clark, 2007). A literature review conducted on this area indicates that children's conceptual understanding of magnetism is an under-researched field (Driver, Squires, Rushworth & Wood-Robinson, 1994; Hickey & Schibeci, 1999; Preston, 2016; Van Hook & Huziak-Clark, 2007) compared with other physical phenomena.

Magnetism is not an easy topic for children to grasp (Preston, 2016). This is in part associated with common preconceptions the children have – such as linking magnetism to gravity (Driver et al., 1994). In the next few paragraphs, a review of the literature on how children perceived magnetism will show the various models of preconceptions and alternative conceptions that children have.

In an early study, Haupt (1952) found that children (Grade 1 (6-year-olds) to Grade 7 (12-year-olds)) tend to explain magnetic interactions in three ways: in terms of structure, or of chemical composition or of physical characteristics. In terms of structure, children from Grades 1-7 (n=25) explained that one end (N) of the magnet holds onto the other end (S) because "it's like thin; has paint on one side" (Haupt, 1952, p.164). As for chemical composition, the children explained how a magnet works by saying that it has something chemical in it (Haupt, 1952, p.164) to make it 'stick'. This corresponds to a later study by Barrow (1987), who carried out a study on 78 children (across all age groups) to investigate the children's awareness of magnets and magnetism. A key idea recognised in this study was that children associate magnets with 'sticking', which corresponds to attraction rather than repulsion. He found that all the children knew how magnets were used in their daily lives: picking up pins or nails or 'sticking' to the refrigerator. Some children reported that it was the chemicals within the magnets that made them 'stick' (Barrow, 1987). Moreover, he found that most children did not offer any explanation of magnetism before they were taught the topic (Barrow, 1987). Barrow's (1987) study can thus be shown to have revalidated Haupt's (1952) findings where, after 33 years, children still have the same perceptions and use chemical composition to explain how magnets work.

For physical characteristics, children in Years 2, 4 and 6 (n=119) thought that age and size affect magnetic interactions (Bailey et al., 1987): old magnets are weaker in magnetism than new magnets (53%) and larger magnets are stronger and can hold more paper clips than the smaller size magnets (60%).

Besides Barrow (1987) and Haupt (1952), Erickson (1994) also proposed three models of magnetism based on the ideas of Canadian children aged 9-14 about magnetism. These were the 'pulling model', the 'emanating model' and the 'enclosing model'. In the 'pulling model' children perceived magnets to be something that can pull other objects towards them or stick to the object. The 'emanating model' is one in which the magnet emits energy or rays in the direction of the object it attracts. The 'enclosing model' is a continuation of the emanating model except that in this case the rays or energy emitted spread out to cover the object attracted (Erickson, 1994).

In addition, Cheng and Brown's (2010) research with Grade 4 and 6 children (n=6) comes up with two explanatory models to develop the conceptual understanding of magnetic phenomena: composition-based explanations and terminology-based explanations. Composition-based explanations, like Barrow's (1987) and Haupt's (1952) model of chemical composition, mention something within the magnet that makes it work. "Black metal powder, metal and special lead" are what the children thought was inside the magnet. The terminology-based explanation includes words linked to magnetism such as "magnetic material" and "the invisible force of gravity" (Cheng & Brown, 2010, p. 2377). Cheng and Brown (2010) argue that intuition and rich imagination are important in model construction. They discovered that there was no relationship between children's prior knowledge about magnetism and their intuitive knowledge. The fourth graders were found to be more intuitive and capable of coming up with a more creative explanation than the sixth graders, who were inhibited by their prior knowledge and refrained from trying because they thought they knew and were afraid of making mistakes (Cheng & Brown, 2010).

Contrasting with the studies presented above, Van Hook and Huziak-Clark (2007) used a visual representation of a magnet as an arrow in a series of hands-on, inquiry-based lessons to learn about magnets with two kindergarten classes (n=59). A 5E learning cycle model (Bybee & Landes, 1988) was used. The children were intentionally taught the vocabulary of “tip and tail” (Van Hook & Huziak-Clark, 2007, p.48): where the tip refers to the north pole of the magnet and the tail refers to the south pole. The intention was to use an arrow as a visual representation to associate magnetism with the arrow in a compass. However, the vocabulary of ‘tip’ and ‘tail’ poses some problems. Labelling them as tip and tail does not show why the north pole has to be the tip and the south pole has to be subservient as the tail, giving a different emphasis to the poles, when actually both poles are exactly similar in functions, strength or hierarchy. Next, although magnetism is strongest at its poles, this does not mean that the two poles are the only locations that can attract magnetic objects such as paper clips. The rest of the magnet also attracts magnetic materials, just more weakly. Therefore, instead of helping the children to gain a good conceptual understanding of the topic, this visual representation could create misconceptions.

Magnetism, being an abstract scientific phenomenon, needs to be taught with some degree of mental images or visualisation (Preston, 2016). Ramadas (2009) argues that this is an integral part of learning science. Although what the children do is observable, the causal elements are often invisible (Preston, 2016). A lack of conceptual understanding of this phenomenon can lead to children memorising key facts, achieving surface learning, rather than engaging mentally and actively with the concepts (Wilcox & Richey, 2012).

Therefore, in order to make these causal elements visible, the usage of science diagrams (Preston, 2016) or something visual such as a representation of a magnet in the form of an arrow (Van Hook & Huziak-Clark, 2007), are ways that scholars have come up with to enable children to develop a functional conception of magnetism in order to learn about this abstract phenomenon. Besides that, by knowing how children learn about magnets, such as Haupt’s (1952) three kinds of explanation for magnetic interactions, Bailey et al.’s (1987) physical characteristics, Erickson’s (1994) three models of magnetism, and Cheng and Brown’s (2010) two explanatory models, we can also get to understand what the possible alternative conceptions are and guide the children appropriately.

2.3 The relationship between play and primary science

It is thought that science has some elements of play (Laszlo, 2004; Johnston, 2014), such as exploratory play, for example, where children make use of their senses to explore scientific phenomena (Johnston, 2014, p. 160). Exploratory play is a type of play often associated with scientific development because exploration is closely related to play (Johnston, 2014). Exploratory play is without agenda or structure and can mimic free play in which children use their senses to explore scientific phenomena in the world around them. It is through these playful elements that cognitive value is achieved (Johnston, 2014; Stone et al., 2019). Talib, Norishah and Zulkafly (2013) argue that exploring scientific concepts creatively, such as through play with the integration of performing arts and multimedia, has the potential to empower children to develop a sustained interest in understanding scientific concepts, based on their findings with 14 Year 4 children (aged 9-10) in Malaysia.

Play helps children to reflect upon their learning through scientific inquiry and to make sense of the world around them, engaging them as scientists (Ashbrook, 2010). Play and scientific inquiry are essential components of childhood and free play allows children to use their imaginations and develop self-regulation, symbolic thinking, memory, language and understanding of the world, as well as specific aspects of scientific development (Johnston, 2014; Stone et al., 2019).

Research on the learning of science in the past has always demonstrated how children’s preconceptions or alternative conceptions were often dismissed and replaced with scientifically accepted ideas (Cheng & Brown, 2010). Then, recent research has started to propose learning as an active sense-making which builds on meaning construction and explanatory competence (Preston, 2016). This sees the children’s alternative conceptions differently, as the source of productive ideas which can be used as a base to develop further (Preston, 2016). The way in which children construct knowledge now is more complex and is an interaction between the intuitive and conscious elements (Preston, 2016).

According to Gopnik (2012), real science is a highly social endeavour. It is through social interaction – a current, established and popular approach – that children are being taught school science. During social activities, such as practical sessions or activities which are usually done in small groups, children will most probably talk to each other during the process (Scaife, 2018). However, to get the children to start talking to each other, they need to be engaged and interested in science to start with. This engagement is often missing, and it has been regarded as the most neglected aspect of science teaching (Wellington & Ireson, 2018). The affective domain needs to be targeted because it is closely linked to the cognitive domain (Wellington & Ireson, 2018) of the child. Without motivation, interest or engagement, there will be little achievement to begin with (Wellington & Ireson, 2018).

Play has some relationship to science. This is because, psychologically, when children experience a surprise or a novelty, like play does, they may try to make sense of it and relate it to what they already know, a process known as 'assimilation' (Scaife, 2018). Then, if the children find it conflicts with what they know, they may amend what they know so far as to make sense of the novelty. It is through this process of 'accommodation' that the change has resulted in them learning something. However, this theory of cognitive conflict may or may not work for all children as it can inflict two opposing effect: the child takes up the challenge and pushes it to the accommodation stage, or the child gives up totally due to an inability to cope with the challenge (Scaife, 2018). Children need to have their ideas sufficiently shaken to prompt them to move on to a new conceptual belief. This is normally aided by time for the children to digest and reflect upon what they have experienced (Scaife, 2018). On the other hand, a word of caution: the expectation that children will develop scientific understanding simply through this cognitive conflict or laboratory experiences is too simplistic because there is a multitude of other factors or other supporting follow up that are important in learning science (Wolpert, 1992; Matthews, 1994). What practitioners can do is to introduce children early to science, to encourage scientific reasoning from a young age and to build it up gradually over the years to promote a better understanding of science when the children study it more formally in the upper grades (Bulunuz, 2013).

On the other hand, how play fits in with science is also dependent on how play is perceived and incorporated into the curriculum. For example, when the curriculum is more academic, 'work-based' and subject-focused, the official view of play in primary school would be:

> *[…] a peripheral, additional activity that has little to do with learning and more to do with recreation.*
>
> Olusoga and Keen (2019, p.191)

In primary schools, beyond the lower primary levels such as Primary 1 and 2, where a play-based curriculum is used, there is little trust amongst teachers about using play in an educational context. An example is Walsh et al.'s study (2010), where the teachers using the EC became increasingly uncomfortable and apprehensive when the play-based curriculum moved up the levels from Primary 2 to 4, with the greatest level of discomfort experienced by the teachers in Primary 4. These teachers questioned the effectiveness of the EC because they felt that the children were not well-prepared for the next level when they followed the EC. Many teachers are sceptical about play due to the incongruence of how schools teach and play works. Their "mistrust of play" is, according to Wood (2013, p.19), due to three sources:

(a) The lack of a precise operational definition of play,

(b) The persistent view that play is the opposite of work and

(c) The fear of play as subversion

When play is used as a pedagogy, it is challenging to quantify in terms of numbers to show concrete, visible and physical evidence towards the learning outcomes, which are highly prized in a curriculum framework (Wood, 2013), although the evidence discussed in earlier sections (Sections 2.18 and 2.20) shows that there are promising results among their findings from their studies (e.g. Howard & Miles, 2008; McInnes et al., 2009; McInnes et al., 2010; Stone et al., 2019). Less research has been carried out in relation to middle childhood. Thus, there is a visible strain between the "rhetoric and reality of play", whereby teachers have to decide between the "educational and policy-centred versions of 'purposeful' play", the "ideological versions of free play and free choice" (Wood, 2013, p.14), a mixture of a bit of purposeful play along with free play into the guided play, or no play. Miller and Almon (2009) proposed that play is best viewed as a continuum, with guided play at one end and free play at the other in the context of school. With these three types of play, playful learning (Bodrova & Leong, 2010; Reed, Hirsh-Pasek, & Golinkoff, 2012) can take place. In the next few paragraphs, these three types of play, which are commonly used in science teaching, will be examined and discussed.

2.31 Guided play/ purposeful play

Guided play is mainly child-initiated but involves an adult providing a scaffold for the children so that they can begin the play with help to achieve the learning outcomes by the end (Weisberg, Hirsh-Pasek & Golinkoff, 2013). Purposeful play, although not used extensively in the research literature, is often associated with the Singapore pre-school system and used in accordance with the Singapore context, and can be seen to correspond to 'guided play' as discussed in the literature. Guided play overlaps with purposeful play (as described in the curriculum documentation from the Ministry of Education Singapore (2012)) and has similarities: such as providing support (scaffold) and authentic contexts, such as providing simple objects which are linked to children's daily lives (Teo et al., 2018). According to Teo et al. (2018), guided play is similar to purposeful play in that both have clear learning outcomes that are introduced into play-based settings and both focus on the interactions between teacher and children.

Guided play has been the subject of several studies, including Fisher, Hirsh-Pasek, Newcombe & Golinkoff's (2013) study, involving 70 children aged four to five in the USA. Children were assigned to one of the three types of play or instruction: free play, guided play, and didactic instruction, and they were taught a topic on shapes. After the intervention, the children were tested on their knowledge about the four shapes. The findings showed that children following the guided play condition showed improved definition of knowledge about shapes compared to the other two groups. Furthermore, after a week had passed, this group of children showed no decline in learning (Fisher et al., 2013).

Purposeful play is a pedagogical approach which entices children to explore and investigate, carrying out activities in a pleasurable way in Singapore (MOE, 2012). Teo et al. (2018) argued that purposeful play when properly devised and taken advantage of, can result in children's "experiential learning and understanding". For example, in a study of 17 kindergarten children (aged 6 years) from Singapore, children were observed on a visit to a botanical garden to collect different types of leaves and classify them later (Teo et al., 2018). Within this naturalistic learning context, each group of children was followed by a teacher and involved in the teacher-children and student-children social interactions as they went through the activity (Teo et al., 2018). The findings showed that, through planning, purposeful play had provided the children with an authentic science learning experience and actively engaged them as learners in the process (Driver & Easley, 1978; Duit & Treagust, 1998). Through the affordances of play, the children were introduced to some basic scientific ideas and learned that certain scientific ideas were based on consensus among themselves (Abd-El-Khalick, 2012; Kuhn, 1996). Moreover, the interactions also helped the children to refine their scientific process skills, which included communicating their ideas when they tried to talk and negotiating with one another to reach an agreement (Teo et al., 2018).

2.32 Free play

As the term suggests, free play is a type of play in which control of the play is in the hands of the players (Hewes, 2014). According to Hewes (2014, p.286), the characteristics of free play are: control, uncertainty, flexibility, novelty, and non-productivity. Free play provides the player with a high level of pleasure and at the same time motivates them to continue playing (Fronczek, 2009).

An example of research on free play is a study of 10 children (in the Early Years Foundation Stage) in which their choices of play activities during periods of free choice and free play in school were examined in England (Wood, 2014). The study was a naturalistic, non-participant observer type of observational study. Through the study, the researcher looked at how the social dynamics of power work in different contexts; how the child's individual or group choices were informed, how activities got started, how they got themselves involved, who were involved and how they continued or terminated their activities. The findings showed that children's choices are dependent on the power relationships in which they were involved: "conflict, negotiation, resistance and subversion" (Wood, 2014, p. 4). Through free play, children can gain knowledge, experience and social skills, for example, through imitation (Fatai et al., 2014). Moreover, free play also affords opportunities for children to learn in non-threatening surroundings; through trial and error, gaining new insights (Fatai et al., 2014). Free play helps to create contexts for children to exercise and affirm group or individual agency (Wood, 2014). The freedom of the child's choice in play is an important factor in its success (Stone et al., 2019). The effectiveness of play in learning will decrease with decreased ownership by the children (Stone et al., 2019). Researchers have shown that a child's autonomy in free-choice learning during play helps the child to engage in "building larger conceptual structures and intuitive theories", supporting higher-order generalisations (Sim & Xu, 2017, p.642).

However, a note to look out for and acknowledge is that freedom to choose may advantage some while disadvantaging others because children bring with them the different complexities of their prior experiences (Wood, 2014). In addition to this, depending on the nature of the activity planned, free play may not be perfect or suitable for all learning, for example in the study by Fisher et al. (2013) (discussed in Section 2.31 'Guided Play'), where the findings indicated that children learned more within the scaffolding provided by an adult in a playful context to learn about geometrical concepts, instead of just free play alone. The findings have shown that appropriate help rendered by the teacher via dialogical inquiry and engagement helps the children to learn about geometric shapes, improving their definition of shapes. The group that engaged in free play failed to extract key concepts when playing with the materials. The children engaging in free play were more creative and chose to create designs or tell stories with the shapes and construction sticks, rather than following the actual task of classifying the shapes (Fisher et al., 2013). This may be seen as a limitation to free play, depending on the 'task' in their play, and on the learning experiences they have had prior to the play.

The teachers' roles in free play vary according to their professional knowledge and understandings about children's development (Lim, 2010). For example, the teacher needs to be systematic in observing the children, to take note of the group dynamics, remain as an attentive observer to capture the children's conversations, be self-reflective, engage in inner dialogue with self, invite the children or their parents into a dialogue on their observations, and lastly be aware of the various experiences and perspectives that different children bring to the class (Lim, 2010, p.149). It is the quality of such contributions put in by the teacher that help to reinforce the probability of children learning through play (Zigler, Singer, & Bishop-Josef, 2004). Wood has argued that play has to be resource-rich and requires great expertise from the teachers to observe, assess and interpret children's actions in order to deduce meaning and intention (Wood, 2013). For the teachers to effectively incorporate play into a classroom and maximise learning, they need to have a comprehensive understanding of the children they are teaching (Johnston, 2014) and to be aware of the pedagogies that support science learning (Fleer, 2007; Johnston, 2005). Teachers can act as facilitators and provide scaffolding for the children to encourage independent enquiry and problem-solving (Kogan, 1983; Metz, 2004; Sylva et al., 1976). With sufficient time and space given to the children, they can learn through play and develop thinking skills (Johnston, 2014) and, if extended time is given to the playful activities, they can be motivated and encouraged to think (Cremin et al., 2006). Subsequently, children will develop observational and questioning skills which are important scientific process skills (Glauert, 2009). Through conceptual conflicts (Hand, 1988), debate and argument (Alexander, 2008; Naylor & Prescott, 2004) and sustained shared thinking (Siraj-Blatchford, 2009), conceptual understanding can develop among the children. The next section moves on to how these different types of play can take place in primary science education.

Free play promotes curiosity, divergent thinking (Johnson, Christie, & Wardle, 2005), motivation to learn (Henniger, 1987), and excitement and engagement with the subject of science (Saracho & Spodek, 1994; Smith, 2010). In addition, free play also allows children to experience 'flow', an experience during which they become unaware of fatigue and time appears to 'freeze'. They seem to have been 'transported' to another place where they become oblivious to what is happening around them (Csikszentmihalyi, 1991; Hewes, 2014). The experience of flow is an exciting experience "physically, emotionally and cognitively", which is highly enjoyable and can result in the desire to engage in such activity repeatedly (Csikszentmihalyi & Hermanson, 1995, p.70).

Braund (2004) has argued that the play experience might reinforce children's misconceptions or alternative conceptions, but that it also has the potential to contribute in hindsight to the teachers' teaching repertoires, whereby they can draw upon the enjoyable activities that the children have experienced in order to help them "construct new meanings and understanding" (Braund, 2004, p. 117). In some cases, play can support the teacher in identifying and addressing the child's alternative conceptions and point them in the right directions (Braund, 2004).

If play is to be connected with learning, it is important to understand how learning happens in non-formal spaces, where there is a range of possible learning outcomes depending on how children engage with an educational experience. It is a challenge to enable children to gain better control and agency in determining their own learning in schools. With play in mind, in the next section, in the discussion of the teacher's role, Falk and Dierking's (2000) Contextual Model of Learning (CML), which can be used as a theoretical framework to look at play, will be discussed.

2.4 Free choice learning: Falk and Dierking's (2000) contextual model of learning (CML)

The type of play central to this study is (quasi-)free play, in which children have the freedom to play as they wish, using a set of materials linked to the topic of magnetism. Many of the studies looking at learning and play report on the differences in achievement between two or more groups. The problem with this approach is that they use pre-determined (by the teacher) learning outcomes to assess performance. A model that helps to understand learning in free-choice settings is the CML. This has been used to study learning in museums and in formal settings where children or young people have freedom over what they learn, but it has not been used to understand what happens in free play settings.

According to Falk and Dierking (2002, p.9):

> *Free-choice learning is the most common type of learning in which people engage. It is self-directed, voluntary, guided by individual needs and interests – learning that we will engage in throughout our lives.*

Free-choice learning draws attention to the importance of focusing on each individual's unique, lifelong journey, and the role of the individual and his/her social context in determining the direction of that journey. Free-choice learning is usually not straightforward; it is personally motivated and essentially very dependent on the learners' choice on the contents, the contexts and the timing of what they want to learn (Falk & Dierking, 2000; Bamberger & Tal, 2007). However, due to the interplay of extremely individualised prior knowledge and experiences with the social interactions between the children, peers and teachers, together with the physical background, understanding learning in free-choice settings is challenging (Falk & Dierking, 2002). Falk and Dierking's Contextual Model of Learning (2000) explains that an individual's personal, sociocultural context and the physical context of the learning environment overlap with one another, interact and result in a unique learning experience for each individual, depending on the degree and type of engagement (Falk & Storksdieck, 2005). Learning is seen as a cumulative process in which the learner makes meaning and finds connections (Falk & Dierking, 2000). Learning is also a contextually driven effort that is:

> *[…] a continuous, never-ending dialogue between the individual and his or her physical and sociocultural environment. The Contextual Model of Learning portrays this contextually driven dialogue as the process/product of the interactions between an individual's (hypothetical) personal, sociocultural, and physical contexts over time.*
>
> Falk & Storksdieck (2005, p.745)

Falk and Dierking's (2000) Contextual Model of Learning (CML) is a model that has been used to understand how learning takes place in informal settings, such as museums, away from formal settings in school. As there have been a lot of problems with the term 'informal', which is often tagged with the external agencies or institutes, to differentiate it from learning in school, Falk (2005, p.272) argued that this term should be replaced by the term 'free-choice' learning, which is more apt and is able to withstand "the positive and negative biases that currently surround schooling". In the context of this study, play is used as a medium to carry out the activities that the children wished to pursue. As the children were engaged in free play, they were not restricted and could have a free choice to decide what they wanted to do. Therefore, with power relationships minimised in free play, the children can make their own decisions and engage in free-choice learning (Wood, 2014). The CML is therefore appropriate for understanding learning through play because it is a free-choice situation.

The CML can be used in any situation, as long as the learners have an element of free choice in deciding what they want to do (Braund, 2004; Falk & Dierking, 2000). According to Falk and Dierking (2000, p.10), this model is like an organiser for arranging the complexities of learning within free-choice settings into "a manageable and understandable whole". According to Dunlop et al. (2019, p.13), CML ensures the "totality of students' experiences" can be taken into consideration while recognising the "complexity of free (er) choice spaces" situated within a series of contexts (Falk & Dierking, 2000).

In the following, the three overlapping contexts found in the model will be elaborated upon briefly. There are 12 key factors in the CML model (Figure 2.1).

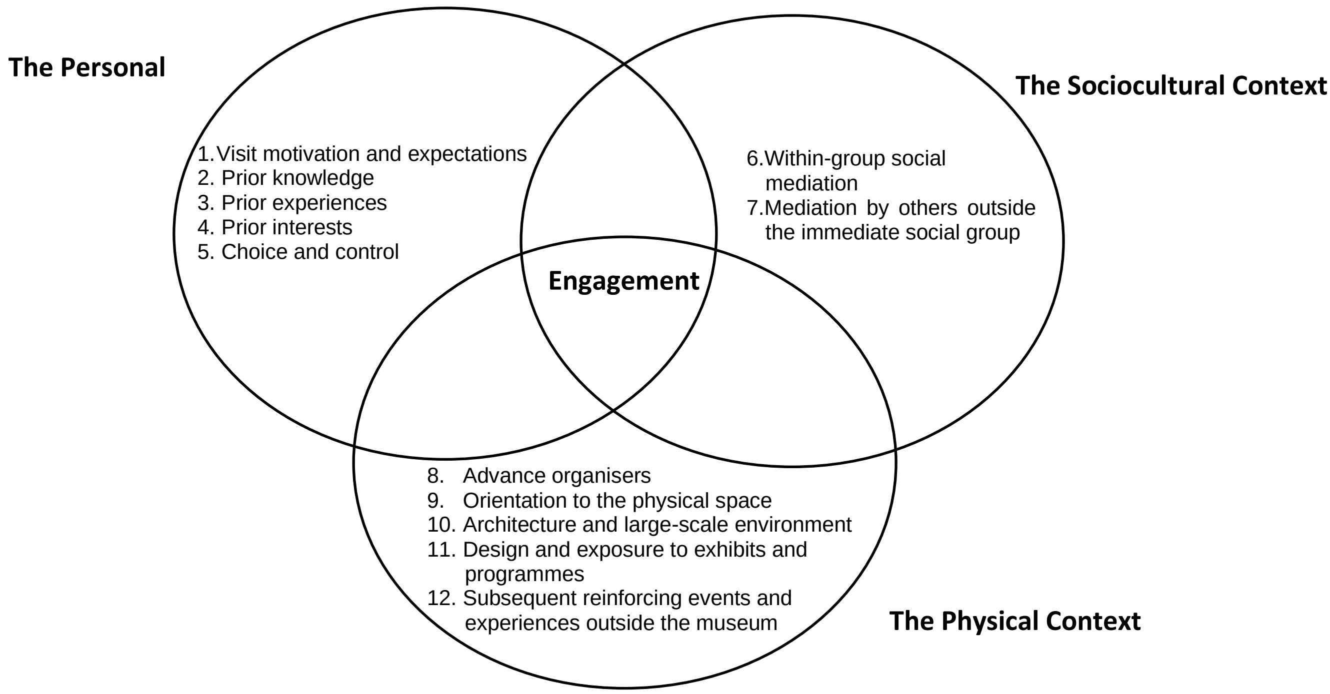


Figure 2.1: The 12 keys factors of Falk and Dierking's Contextual Model of Learning Model (Falk & Storksdieck, 2005, p.747)

2.41 The personal context

In this context, the learning stems from the affective domains where motivations (intrinsic and extrinsic), emotions resulting from connectivity with the things, interest, attitudes to learning, and their existing knowledge and ideas are all classified here (Falk & Dierking, 2000). The learners, when engaging in meaningful activities in a supportive environment that is freed from anxiety or fear and within their skill level, will be self-motivated as they exercise choice and control over their learning. The meaning of skill level is that the challenges of the task must match or be attainable using the skills of the individual; if the challenges are too great, anxiety occurs, but if skills are greater than the challenges, boredom occurs (Falk & Dierking, 2000). This context targets the affective domains of the children and it often leads to the child being inquisitive and to explore by using many senses and finding out more about new things or going deeper into a deeper conceptual understanding (Braund & Reiss, 2004; Johnston, 2011). This context can be impactful: long-lasting and life-enhancing (Braund & Reiss, 2004). In play, children bring with them different pre-knowledge, exposure and experiences that are culturally influenced and informed by factors that lie beyond school settings (Broadhead, Wood & Wood, 2010, pp.178.).

However, since every learner is different due to the complexity of emotions that they experience and the pre-existing experiences – prior knowledge – that they bring with them, an appropriate context is needed to trigger the learning (Falk & Dierking, 2000).

2.42 The sociocultural context

Here, what children learn is mediated through gestures and conversation with others (Falk & Dierking, 2000). These conversations could be with their peers or teachers or any adult. As everyone is brought up in a particular place or culture, the way in which a learner reacts to different learning situations is largely determined by his or her culture (Braund, 2004). The norms and expectations of school, as well as the context or place, will affect and cue how learners will behave or learn (Braund, 2004). Different influences on individuals and groups will result in different behaviours being seen (Braund, 2004). Conversations often take place when the children get into groups and, according to Falk and Dierking (2000), these groups are known as a community of learners. Conversations are an important feature of the culture of free-choice learning and they can make key contributions to the outcomes (Braund, 2004). However, they depend on the type of play involved. Therefore what is said in free-choice learning situations is an important way of understanding what the children learn through the sociocultural context.

2.43 The physical context

The physical context refers to the physical settings of the space or environment providing the learners with access to the materials through which learning will occur (Falk & Dierking, 2000). The location of the place, and the people whom the learners will be with are important considerations for ensuring the learners will feel a sense of ease and safety about being involved. Accessible design and inclusion for various learners at varying entry levels and with different learning needs are examples of important considerations where the physical context can come into action.

However, as the present study was carried out as part of the children's science lessons in schools in venues such as the classroom or the science laboratory, the freedom of choice to enter these venues was omitted because the children were not given the choice of refusing to enter them – but they did have the freedom to choose what they did, and which materials they used during the scientific play sessions. Play has been found to motivate children to explore new materials and ideas and engages them for substantially longer on a task (Iverson, 1982).

The CML model was derived from observations of real people in real settings, so its authenticity is high (Falk & Dierking, 2000). In order to have a more comprehensive look at the children's learning, Falk and Dierking (2000) proposed a fourth dimension of 'time' to be added to enable a better and longer view of the learners – the children – because learning takes time and does not happen all at once. The present study took account of the issue of time because the play protocols (Appendices 1.1 and 1.2) were planned to take place across a few lessons and the children were observed over time to allow the researcher and the teachers to observe, experience and reflect.

In this study, the three contexts (personal, sociocultural and physical) were used to understand free play in science lessons.

2.44 Falk and Dierking's (2000) CML and Simon et al.'s (2008) discourse analysis

In the study conducted for this thesis, children were taught for 45 minutes and allowed to play freely during the last 15 minutes of their lessons. They were given free choice and could decide what they wanted to do.

As science is both a practical and a theoretical subject, hands-on and minds-on approaches are needed (Wellington & Ireson, 2018). Hands-on situations stimulate questions and speculation as children are able to explore the materials with freedom, making use of their senses (Braund, 2004). Although the present study was conducted in school, the nature of the scientific play sessions does allow the children to have autonomy to make choices, fulfilling the definition of 'free-choice' learning, mimicking the free-choice learning in science in a quasi-free-play setting in the school.

Falk and Dierking (2000, p.136) argue that:

> *Learning is a dialogue between the individual and his or her environment through time.*

From the premise of a cultural-historical perspective on the CML model, the interactions between child and child or child and teacher within the context of science are usually dialogical processes (Fleer, 2014). The CML has typically been used to collect questionnaire data. However, that was not appropriate in this study because it was important to find out what the children were doing and talking about during their scientific play sessions. The CML was therefore complemented with an analytical framework for understanding talk in science lessons.

(a) Simon et al.'s (2008) Discourse Analysis (See Chapter 4)

Simon et al.'s (2008) Discourse Analysis framework is a tool for understanding the conversations of primary school children. It was used by Simon et al. (2008) with children (aged 4–11 years) and 16 teachers in the UK in a study in which a puppet was used to encourage conversations during science lessons. Simon et al.'s (2008) study was carried out to investigate how the nature of the whole class discourse would differ when puppets were used in a dialogical way to enhance children's talk and engagement in science.

Simon et al. (2008) collected data to study the nature of discourse via the frequency of certain types of talk in each lesson. Therefore, even though the present study was not centred on dialogical teaching, Simon et al.'s (2008) framework was appropriate because the coding scheme was devised to study teachers' and children's conversations during a science lesson. Simon et al. (2008) used the framework to identify types of talk that are desirable in a science context, including asking questions, making observations and giving explanations to argue about and justify the problem-centred focus of the lesson using puppets. The present study integrates Simon et al.'s analytical framework with the CML and presents a new, adapted framework, combining two theoretical frameworks: Falk and Dierking's (2000) Contextual Model of Learning (CML) and Simon et al.'s (2008) Discourse Analysis.

2.5 Children's talk and primary science

According to Alexander (2005), talk that promotes reasoning in a science class is often missing and normal talk is rarely observed or heard (Lemke, 1990; Newton, Driver, & Osborne, 1999). In science education, talk that promotes reasoning is essential and a key contributor to science learning because this talk is what will foreground the children's ability to build scientific arguments (Kuhn, 1993; Snow, 2010; Wellington & Osborne, 2001) and to help them learn science. Children need opportunities to articulate their ideas as talk, writing and discussion, and peer collaboration has been shown to contribute positively to children's conceptual understanding of science (Howe, McWilliam, & Cross, 2005; Howe, Tolmie, Duchak-Tanner, & Rattray, 2000; Mercer, Dawes, Wegerif & Sams, 2004; Snow, 2010). Children are only able to retain the words that they have been taught if these words were embodied with meaning or with experiences attached to them (Snow, 2010).

'Exploratory talk' (Mercer et al., 1999) is a type of talk that is commonly found in science settings in which children engage with each other and build on each other's ideas in a group setting (Simon et al., 2008). The children work in a group and counter-challenge with evidence and can offer alternative hypotheses (Simon et al., 2008). This active exchange of utterances within the group can provide a strong stimulus to learning (Dawes, 2004). Exploratory talk has been demonstrated to have benefits for both reasoning and scientific understanding (Mercer et al., 2004). Talking and thinking together in spoken language is a powerful tool for building children's understanding of science and they can benefit from this approach (Olusoga & Keen, 2019). Talk also allows teachers and/or children to identify their misconceptions and partial understandings, which will result in children's development in science (Gibbons 2001).

In school science, children's development of scientific concepts in classrooms is typically undertaken through structured activities and mediated through oral language (Fleer, 2013) – often in the form of the teacher telling the children. Even in museums, which are places for free-choice learning, there are few different kinds of interaction and conversations (Braund, 2004). Apart from the teacher in teacher-led interaction, Mercer et al. (2004) argue that children's peer-group interaction and teacher-led interaction are the two main contexts in which spoken language can relate to the learning of science in schools. Stevenson (1991) carried out a study at a science museum in the UK and found that there were differences between three groups of visitors (See Figure 2.2). Figure 2.2 shows that conversations between the teacher and the children were the least frequent and the teacher had appeared to discourage sustained interaction or conversation with the children. In the present study, children participated in free play and teachers were asked not to interrupt too much in the children's play, but rather to act in responsive mode, supporting children who asked for it.

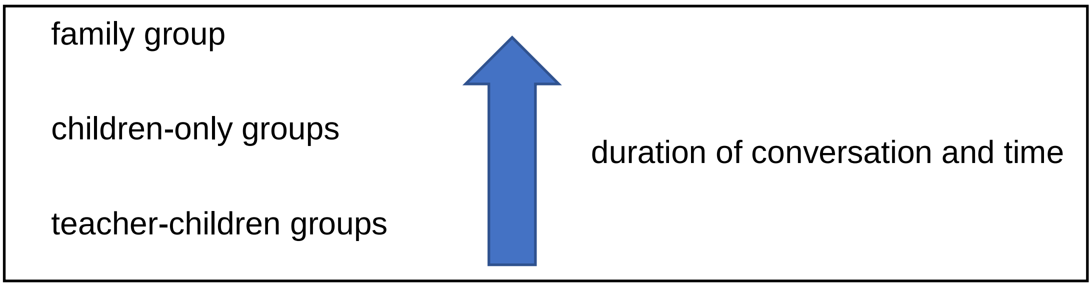


Figure 2.2: A figure showing the duration and time of conversations for different groups of museum visitors

Through talk, children can develop in their use of specialised vocabulary and their understanding of current scientific explanations, models and ideas (Fleer, 2013). However, Galton and Rudduck (1999) argued that there is limited opportunity for children to explore their ideas or raise questions in a typical science class.

2.51 The historical and cultural heritage of the country

The location where a study takes place is important in terms of its influence and impact on how children participate in talk. For example, in Chin's (2007) study, she argues that the historical and cultural heritage of the country where the research on talk is carried out does matter. Chin (2007) raises the issue of how students in East Asian countries and Asian countries such as Singapore will react if a Confucian view of teaching and learning prevails. She explained that, in the Confucian view, the teacher is regarded as the master of knowledge, "virtuoso performer and coach" (Ko & Marton, 2004; Paine, 1990; Pratt, Kelly, & Wong, 1998). It is perceived as rude and disrespectful to interrupt the teacher or dominate the discourse in the classroom (Chin, 2007). Speaking up in class is like challenging the authority of the teacher, and most children will avoid doing so (Chin, 2007). This is very unlike their western counterparts, where children speak more freely and without inhibition.

Chin's (2007) opinion on the impact of historical and cultural context on how children speak was supported by another empirical study carried out by Iyengar and Lepper (1999). In their study, 52 Asian Americans and 53 Anglo Americans from the second to fourth grade with ages ranging from 7 to 9, were assigned into three groups based on who was making the decision, such as their own choice, the experimenter's choice or their mother's choice, to solve anagrams given to them. Their findings showed that Asian-American children were the most intrinsically motivated when choices were made for them by "trusted authority figures or peers", such as their mothers (Iyengar & Lepper, 1999, p.349). This is a challenge to free-choice learning due to the historical and cultural background of Asian Americans. However, evidence from psychological research has shown that freedom of choice leads to increased intrinsic motivation, which leads to increased persistence, resulting in better performance and higher satisfaction' (Iyengar & Lepper, 1999, p.349) within the same cultural group. However, if the study is conducted across different cultural groups, it can be seen from Iyengar and Lepper's study (1999) that certain cultural groups may still perform or be motivated more if the choice is made by a trusted person with authority.

Another empirical study, by Stevenson and Lee (1997), also contributes to the notion that the historical and cultural heritage of a context will have an influence on children's talk. In their study, which was carried out in an East Asian country, Stevenson and Lee (1997) argued that the whole-class instructional method has its own merits and that learners can benefit from the teachers by focusing on the teacher's talk instead of students' talk. Biggs (1996) and Cortazzi and Jin (2001) reported that, although the passive-looking students did not appear to be engaged on the surface, they were still participating actively in the tasks. The focus on the teacher's talk did enhance most of the children's conceptual understanding in that context.

Although Asian American and Singaporean Asian children may appear to be similar due to their common Asian roots, they may still be very different due to the historical and cultural differences that exist. Thus, Iyengar and Lepper's study (1999) may not be entirely appropriate for inferring how Singaporean children will react. Special consideration must be taken when drawing inferences from these studies. The three studies mentioned above reflect how the influence of local culture (East Asian culture) and context, such as Confucianism (which also includes respecting the authority of people like their parents), can result in typical behaviours exhibited by children in some contexts in some countries. These could be deeply seated in their mindsets within the cultural groups to which they belong and could have a different impact on children's talk. More research needs to be done in this area to study how different children in different cultures react in order to gain a better understanding of the type of children's talk that can take place.

2.52 Factors limiting talk from the teacher's perspective

According to Roth (2005), as well as writing science, talking science is another aspect that encompasses a wider part of achieving the various skills that distinguish science. Talking science is the medium in which science is done (Roth, 2005). However, in school science, as many resources are focused on the doing of the activity and not on talking, it is not easy for the teachers to manage talk. There are many factors that limit talk in school science and they will be discussed below.

In school, the people who often do the talking are the teachers, and they perform the role of talking very well. However, some teachers find it challenging to set up a context or setting for children's conversations to take place, and to manage the talk that results (Simon et al., 2008). Teachers can be uncomfortable with free talk situations and may restrict their repertoire of teaching practices by using a questioning style of initiation, response and feedback (Simon et al., 2008). This way of teaching is not engaging and will not stimulate much thinking among the children (Lemke, 1990). Moreover, factors like teachers' insecurity in their subject knowledge will make science talking even harder (Osborne & Simon, 1996). Furthermore, other factors such as the pressure they face to complete the syllabus and the weight of the science curriculum are examples of compelling factors that compound the problems, resulting in teachers providing few and limited opportunities for science talk for children. However, teachers who view science talk as an essential feature of learning will factor in more time and contexts for such talk to take place, compared to teachers who place more emphasis on written work and view science talk as secondary in nature and only use it as an optional approach (Alexander, 2005).

Therefore, to ensure that children get to engage in science talk during their classes, the perspectives of both the children and teachers are important. Learning via talk can be optimised when the talk is mediated and supported by others through social interactions (Vygotsky, 1978).

2.6 Children's perceptions of play in formal settings

According to Pyle and Alaca (2018, pp. 1063), even today, play and learning are still "predominantly conceptualised from an adult perspective" even though there has been a shift in recent years towards including children's views. Pyle and Alaca (2018) argued that, since children are the 'key agents' in classroom play contexts, it is vital to understand their views on play and learning. In addition, in the many studies conducted so far, the ways in which children define their perceptions of play have also been found to vary from how an adult would define it (Fisher, Hirsh-Pasek, Golinkoff, & Gryfe, 2008; Karrby,1989; Keating, Fabian, Jordan, Mavers, & Roberts, 2000; Robson, 1993; Rothlein & Brett, 1987; Sommer, Samuelsson, & Hundeide, 2010). Examples include cases in which a study was carried out with a group of adults who tried to recall their own play experiences from when they were young many years ago and offer their perspectives of play, and another case where play was seen through the parents' interpretations (Howard et al., 2017). Although these two studies mentioned children's views on play, those involved in the studies were adults who were recalling their childhood and parents' interpretations of play; they were not directly considering children's accounts of what play is (Howard et al., 2017). On the other hand, King (1979, 1982a, 1982b) designed her research differently and invited children to code their school experiences into categories such as either work or play, instead of using the usual approach where the researchers make their observations and code what they observe. This demonstrated the types of activities that children considered to be play.

Furthermore, Richards' (2011) study shows that the difference in children's ages is also important to note because their perspectives may vary with age. In Richards' (2011) study, he examined three seven-year-old children and some older children and found that the younger children spoke about play differently than the older children: younger children spoke about play using “a different social relation” while the older children were “somewhat serious, commonsensical and dispassionate” when reflecting on play rules (Richards, 2011, p.316). Younger children tended to engage in play which they labelled as silly, while the older children expressed more serious perspectives about their learning through play.

Therefore, studies need to be designed from a child’s perspective so that we can gain access and insights into how children think about and view play (Fleer, 2017). This is especially so if the study is an observational study on children at play or any play-based programme. As children are the key participants, ‘users’ or the ‘target audience’ and for the data to be ecologically valid (Barnett, 2013), children’s perspectives should only be collected from the children themselves. Hearing children’s views is essential because it can help to establish an important channel of communication between adults and children, by consulting them (DfE, 2012). Moreover, listening to children’s perspectives also help to foster more active participation in their play activities (Miller & Kuhaneck, 2008).

According to McInnes et al. (2013), play may be most beneficial when it is considered as an approach to a task and is based on a definition of play from the child’s perspective. The spaces where children frequently play are usually supervised and governed by regulatory bodies in most countries (Ailwood, 2002). Therefore, if more could be done to understand children, the play spaces can be better used to support learning. Understanding more about children can help to guide policy and enhance practice, enabling adults who work with children to be in a better position to support their health, care and development (Waldman-Levi & Bundy, 2016). However, research is only beginning to be carried out on children’s perspectives on play and learning during play-based interactions (Nicholson, Shimpi, Kurnik, Carducci & Jevgjovikj, 2014; Theobald, Danby, Einarsdóttir, Bourne, Jones, Ross, Knaggs & Carter-Jones, 2015). Nevertheless, studies that include children’s perspectives have already influenced teaching practices (Skamp, 2012).

When researching play, instruments such as observational studies, interview studies, surveys, formal and informal assessments, video-stimulated recall (e.g. Morgan, 2007) and the photographic categorisation method (e.g. Howard, 2002) are often used. This is not an exhaustive list, but observational studies (some of them), interview studies (such as focus groups and group interviews), video-stimulated recall and photographic stimuli methods are examples of instruments that are linked to children's perspectives. In interviews, there may be power relationship issues between the child and the teacher. This could be overcome by using group interviews but, in hindsight, there is a high possibility that the talk will be dominated by the more vocal children (Brooker, 2001; Westcott & Littleton, 2005). For observational studies, non-participatory observations in the form of video or audio recordings of what children do and say during their play are ways to obtain more ecological data about them. As for the rest of the tools, which are more based on adults' perspectives, they will be discussed below, in Section 2.7.

2.7 Teachers' perceptions of play in formal settings

For play to be implemented in educational settings, it is often viewed through an educational lens with an increase in outcomes predetermined by adults (Rogers, 2013) and based on the teachers' perceptions of play. This type of play is often termed school play or education play. The perspectives are from the practitioners' points of view but not from those of the 'players' – the children – who should be considered as important (e.g. Einarsdottir, 2005; Nothard, Irvine, Theobald, Staton, Pattinson, & Thorpe, 2015). Saracho and Spodek (1994) argued that, from the teachers' perspective, the difference between play and non-play is often linked to the objectives or the expected outcomes to which the teachers had assigned play. The difference does not take into what or how the children think and feel; instead, it is more obsessed and dominated by a strong desire to achieve the target outcomes. An extensive survey carried out by Powell, Graham, Taylor, Newell, and Fitzgerald (2011) across 46 countries around the world showed that policymakers attribute little or no value to children's perspectives, a view confirmed by other research (Ailwood, 2003; Wood, 2014). When teachers compared their thinking with that of children, children's voices were deemed to be inferior and often ignored or dismissed (Colliver & Fleer, 2016).

> *We support children to play in particular ways because we value these ways. We analyse children in terms of their capacity to play in these ways. However, we rarely reflect on play and its overall purposes.*
>
> Fasoli, Wunungmurra, Ecenarro, & Fleet (2010, p.218)

In the above quote, Fasoli et al. (2010) spoke about a real situation where, in the name of education, the teachers planned and allowed play. However, when they did that, it did not occur to them that their views may be already obscured by their own beliefs and what they treasure, above the original perspectives of the children. Examples of such studies are McInnes et al.'s study (2013) and Rogers and Evans' study (2008). McInnes et al.'s (2013) study was conducted in two English early-years settings. The study's findings showed that there was a difference in how children and adults classified what play and non-play were, and it is the understanding of what children perceive as play that can inform practice. Some ways in which teachers can disrupt play include overriding children's decisions and changing the original course that the children intended, consequently limiting children's talk and play (See Section 2.5). An in-depth understanding of children's choices in play is needed to equip teachers with the relevant skills to enter children's play without removing control from them (Singer, Golinkoff, & Hirsh-Pasek, 2006).

However, research continues to perpetuate the same problem and little research has been done to investigate children's perspectives. Powell et al. (2011), for example, argued that there was an issue with a child's competence to make their own decisions from the teacher's point of view. It was found that many researchers still have the preconceptions that children are not competent to make their own decisions and they do know what is right for them (Powell et al., 2011). However, Colliver and Fleer (2016) challenged this assumption. They studied the perspectives of 28 two to five-year-old children who were interviewed about their learning through play. The findings of their study showed that the children did understand after all, and they had learnt all the rules they believed were associated with the imaginary situation, focusing on the central rule of the play. It was also in this study that the researchers realised a change of methodology was what they needed in order to understand what the children were trying to say. Not being able to understand what the children were saying does not imply that younger children do not make sense or fail to understand. In Colliver and

Fleer's (2016) study, it was apparent that, ultimately, it was not the competence of the child that was the problem but a mismatch in the methodology that rendered the researchers unable to understand what the children were saying. In this study, children's comments were incomprehensible when researchers used an acquisition model of learning (Sfard, 1998) and a developmental view of play. However, when Hedegaard's (2009) holistic model of perspectives was used to analyse the children's responses, along with a cultural-historical conception of play, the data painted a different picture and started to show a clearer picture of children who did know what they were doing. Despite the knowledge that there is a gap in the research from children's perspective, the progress in research has been slow to indicate many changes.

Teachers' jobs are challenging, and they need to be adequately trained to equip them with the right sets of skills to develop appropriate practices while trying to meet the demanding curriculum standards (Pyle & Alaca, 2018). Teachers are advised to make time to listen, observe, reflect, and analyse children's play in order to gain a better understanding of the perspectives of children (Chesworth, 2015). Play allows the teacher to take a step back and have a chance to observe their pupils and get to know more about them.

Brock (2009, p.132) conducted a study with a group of student teachers in the UK and drew up a list of trainee teachers' perceptions of the value of play (refer to Table 2.6).

1. Play promotes creativity through self-directed learning.
2. Planning for free-flow play is important.
3. Children develop self-esteem through play.
4. Children learn more if activities are self-chosen.
5. Children learn through making mistakes in play.
6. Play promotes visual, aural, kinaesthetic and active learning.
7. Children sustain play in one activity quite substantially.
8. Play makes learning relevant for children.
9. Play is fun!

Table 2.6: Trainee teachers' perceptions of the value of play (Brock, 2009, p.132)

Brock (2009) argued that it is essential to understand the perceptions of student teachers because they are the ones who are going into schools to teach. To have an idea of what these student teachers think will be useful to fill the gap when they fall short and build on strengths that enable play to take off. This is important as Diamond et al. (2019) argue that, when teachers enjoy their teaching, it will reduce teacher burnout.

Teachers' understanding of play is important because any decisions made by the teacher will have an impact upon the children they are teaching. There have been concerns among early-years educators because there has been some movement in the past few years to adopt more formal ways of teaching; being more teacher-directed and didactic and increasingly coupled with worksheets (Ceglowski, 1997). Hyson, Hirsch-Pasek and Rescorla (1991) found that children who had attended more academic pre-schools were less creative and less positive about their school experiences. The children also showed more test anxiety. In contrast to the original intentions of the parents who had sent their children to these schools, to help them prepare for primary school, the findings of the research showed otherwise and revealed a detrimental impact on the children, who expressed displeasure with their school experiences.

To study play, instruments such as observation (e.g. McInnes et al., 2009), interview studies, surveys, and both formal and informal assessments are often used, taken from the teachers' perspectives. Through observation studies, teachers can make use of video and audio recordings to see what was happening during play in a participative or non-participative mode. However, observation studies can be open to subjective interpretation (McInnes et al., 2009) when they are laden with teachers' perspectives, because the teachers can choose what they want to see and follow the subjects. In addition, the teachers may only film or record what they want to see or hear. Moreover, the presence of the observer may influence how the children play (McInnes et al., 2009). Using structured observation schedules also poses problems, as teachers may look at the selected behaviours but overlook other important behaviours (Rolfe, 2001; Tudge & Hogan, 2005). As for interview studies, these can be teacher-centred too, where structured interviews with fixed questions that the teachers are interested in and focused on will be asked, with their perspectives in mind. All the other three instruments – surveys, formal and informal assessments – are often designed and used in formal school settings. Therefore, these instruments are built mainly from adult perspectives and based on them.

For the benefit of teachers, the perspectives of both groups, including the children, need to be heard and seen because they are essential to bring about a better learning experience for both parties during a science lesson. This understanding will directly or indirectly help to determine the effectiveness to our students' learning (Fesseha & Pyle, 2016). When teachers understand the children's perspectives, they can develop a common understanding with the children and forge a good relationship with them (McInnes et al., 2011). This is supported by Hattie's (2009) study where, in a meta-analysis of 800 studies of class lessons, the findings suggest that the student-teacher relationship has a high effect size of 0.72 on learning. That is to say that, in terms of the contribution to the achievement of the students, a good student-teacher relationship has a high impact on children's learning.

In conclusion, by consulting both teachers and children – the two primary stakeholders in a class – which is fundamentally essential to give varied angles on what works well in a class and what needs to be done to improve a lesson, this study aims to arrive at an understanding of the role of play in science classes.

2.8 Scientific play in this study

Before the understanding of the role of play in science classes could be investigated in this research study, it was essential to establish a clear definition of the nature of play. The play in this study is informed by the literature review in this chapter and is termed 'scientific play' because it is carried out by two groups of participants: children and their teachers, during their science lessons.

Children:

The nature of scientific play is mainly based on Meckley's (2002) definitions [Section 2.15], supported by Fleer's (2017) cultural-historical view [Section 2.13], and is part of purposeful play (MOE, 2012). Scientific play is free play (Lim, 2010) and has been especially designed with children's perspectives in mind (Pyle & Alaca, 2018). In scientific play, children have the freedom to decide what they want to play with or what they want to learn from their own perspectives (Pyle & Alaca, 2018). The children are given their rightful play space and time in class, with rules set by themselves. They are not restricted to play in groups at their table but can play with anyone in the room. They are allowed to move around freely. However, as explained in Section 2.17, in reality, 'scientific play' cannot be totally free in school settings. Instead, it is quasi-free in nature due to the restrictions set by the physical locations, health and safety guidelines and the availability of materials. During their scientific play, children are given the time, space and opportunities to talk, voice what is on their minds, express their opinions, and be heard rather than suppressed, unlike in Asian culture in general (Chin, 2007).

Teachers:

The teachers are also engaged in the free play. However, their role changes during the scientific play. There is a diminished power relationship between the teacher and the children; the researcher reminds the teacher not to interrupt unnecessarily and will intervene if a child is seen to be struggling or needs some help from the teacher. Teachers are told to observe the children first to assess whether they actually need help, and to allow them to try, at least for a while, before intervening. The teacher's intervention is put in place so that the children who cannot get into the play can ask for help from an adult through the scaffolding available to them (Weisberg, Hirsh-Pasek, & Golinkoff, 2013), allowing a Zone of Proximal Development (Vygotsky, 1978) to take place. This enables the children to enter play, and allows them access to play. Scientific play is used as pedagogy, and empowers the children to have a voice in their learning and space to experiment or try things out in whatever way they wish, as long as it is safe. The teachers are free to enter the children's play without removing their control (Singer, Golinkoff, & Hirsh-Pasek, 2006), joining in as participants or observers. The teachers can do what they usually do, except that they are instructed not to over-dominate the conversation or steer the children's conversation towards what the teachers want [see Section 2.5]. Teachers are advised to take time to listen, observe, reflect and analyse the children's play in order to gain a better understanding of their perspectives (Chesworth, 2015). Worksheets are not needed to record what they learn during the scientific play sessions.

With the nature of the scientific play that has been presented in this section for the two groups of participants in this study, informed by the literature, 'scientific play session' will be the term to be used in this thesis to refer to all play sessions during the science lessons.

2.9 Conclusion

This chapter has reviewed and identified the gaps in the literature investigating where free play is used in primary science from a presentation and critical analysis of the relevant literature. Various definitions of play were examined, and the ones that fit this study and were adapted to come up with the scientific play are Meckley's (2002) definitions of play, supported by Fleer's (2017) cultural-historical view and part of purposeful play, i.e. play that is free and where children are given a safe space to choose, take risks and decide what they want to do. They can play with materials associated with the topic they are learning in class, make mistakes and talk freely with others in an informal situation. As free play was used in this study, the advantages of such play were examined and matched against the theoretical framework of this thesis – Falk and Dierking's (2000) Contextual Model of Learning (CML), which has previously been used to understand informal learning in free-choice situations, but not to understand play as a free-choice situation. Various of the studies discussed in this review have suggested that play can motivate children to like the subject and improve their learning and understanding in playful conditions.

The definition of scientific play used throughout this study is:

> *Scientific play is quasi-free play in a science learning context. It is a child-chosen and child-centred activity, shaped by the materials provided and the science classroom context. Whilst the intention of scientific play is to stimulate play on the theme of the science learning taking place, children have free choice, so their play may include investigation, play purely for enjoyment, the construction of things and pretend play.*

The critical review of the literature on what is known, presented in this chapter, has paved the way for the premise of this study and the choice of relevant methodology described in the next chapter. This chapter also forms the theoretical background against which the discussions of the findings and results will be referred, analysed and synthesised in Chapter 8.

Chapter 3 Methodology

3.0 Introduction

This chapter presents and describes the research's justification and a critique of its scope, linking them to the research questions, research strategy, design, population, instruments, and data collections. Sections 3.1–3.3 start with the scope of the study and its link to the research questions, followed by the research strategy and the rationale as to why a mixed-methods multiple case study design was chosen. Sections 3.4–3.6 elaborate on how the participants in the pilot study and the actual study were selected, together with the instrument designs (observation framework for the study, individual interviews for the teachers and group interviews for the children) and the timeline of the data collected. Sections 3.7–3.8 discuss the main study, how data were collected and the researcher's role. Then, Sections 3.9–3.10 proceed to ethical considerations, data quality, validation, triangulation of data, data storage and limitations of this research study. Lastly, the chapter concludes with a summary of this chapter and signposts the readers to the next four chapters: Chapter 4: The 'Primary Science Talk Framework with Play' (PSTFP), the new adapted framework chapter, followed by Chapters 5–7, the three findings chapters.

3.1 Research scope

This research study aims to investigate children's and teachers' experiences of and perspectives on play in primary science in Singapore. These aims arose due to the absence of empirical data on classroom talk during play. The researcher's interest in giving voice to children and their teachers on their perspectives on play was another reason for conducting this research to explore the role of play in primary science.

This research study answers four research questions, namely:

Q1. What are the nature and dominant types of talk among (a) children and (b) teachers during the scientific play sessions?

Q2. To what extent do children and teachers talk about science during the scientific play sessions play?

Q3. What are children's perspectives on play in primary science?

Q4. What are teachers' perspectives on play in primary science?

A mixed-methods strategy combining quantitative and qualitative methods was used to answer these research questions and provide depth to the study. The rationale for this mixed-methods strategy will be elaborated in the next section, Section 3.2. To answer Research Questions 1 and 2, a predominantly quantitative method was employed, using a new observation schedule developed by the researcher called the 'Primary Science Talk Framework with Play' (PSTFP) (explored in Chapter 4).

This new framework was adapted from a combination of Simon et al.'s (2008) discourse analysis framework and Falk and Dierking's (2000) Contextual Model of Learning (CML). It was used to carry out frequency counts on the types of talk used by the participants and supplemented with qualitative verbatim quotes from the children and teachers, to paint a picture of the play sessions and give depth to the different case studies in this research. To answer Questions 3 and 4, qualitative methods (in-depth group interviews and individual interviews before and after the scientific play sessions) were used. From these different methods, the findings were collected, analysed and merged to enable triangulation of the data.

3.2 Research strategy – Why mixed methods?

According to Cohen et al. (2011, p.22), the world has changed and varies in complexity; it is no longer exclusively qualitative or quantitative, but a mixture of both. Hence, both types of data are needed to capture the essence and richness of the data. Moreover, Mercer (2010) argued that both qualitative and quantitative methods are available to study classroom talk. Scrutiny in the context of this research study and the intended research questions, together with the literature read, had suggested the usage of a mixed-methods approach.

A mixed-methods approach offers more flexibility and reliability than a single-method approach can provide (Bryman, 2016; Denscombe, 2014; Newby, 2010). Additionally, the different aspects of a mixed-methods approach can complement each other, overcoming the limitations brought about by a sole method, and providing a more comprehensive set of data that best answers the research questions (McMillan & Schumacher, 2010). A mixed-methods approach can help paint a complete picture of the play phenomenon under study, giving the research its breadth and depth (Cohen et al., 2011, p.22). Moreover, it can also overcome the weaknesses and biases that each method will bring along, resulting in a better representation of the data, and improving accuracy (Mercer, 2010; Denscombe, 2008, p.272). Furthermore, Wood and Bennett (1997, p.23) argue that a mixed-methods approach can "capture the complex, multi-faceted aspects of teaching" that were revealed in the classroom observations.

In this research study, a convergent mixed-methods design with a single-phase design (Creswell & Creswell, 2018) was used. This mixed-methods study addresses the nature and dominant types of talk used by children and teachers during play and the extent to which they talked about science during play, as well as providing insight into the children's and teachers' perspectives on play in learning primary science. This method is considered an efficient design because in Phase 1, both qualitative (the children's and teachers' perspectives on play in learning primary science) and quantitative (the frequency count of all talk and science talk for both the children and teachers) data were collected by the researcher and analysed separately (Creswell & Creswell, 2018). Then, both results were compared, merged and integrated with the main findings (Creswell & Creswell, 2018) obtained from the frequency count of the talk (all talk and science talk) with the children's and teachers' perspectives on play in learning primary science. Only then could one see if the findings confirm or disagree with each other in the end through the triangulation of data from two different sources (Creswell & Creswell, 2018). This mixed-methods design is advantageous because the researcher was able to report the quantitative frequency counts and statistical findings as well as the participants' voices being heard through the perspectives shared in the qualitative part of the interviews (Creswell & Plano Clark, 2017). These methods help to build up the multiple cases in the chosen research design – the case-study method.

3.3 Research design – Why case study design?

According to Robert Yin, a leading American social scientist in the area of case studies:

> A case study is defined as an empirical inquiry that investigates a contemporary phenomenon (the "case") in depth and within its real-world context; especially when the boundaries between phenomenon and context may not be clearly evident.
>
> (Yin, 2014, p.16)

The rationale for the inclination towards this research design was the multifaceted nature of play. Play, a contemporary social phenomenon within this world, has for many decades appeared to be nebulous and difficult for scholars and researchers to define. Play, which is observed in the subjects' behaviours, is not standardised or definitive, often resulting in a researcher having minimum or absolutely no control over the behaviours exhibited. This points to the suitability of a case study design (Yin, 2014, p.2). Moreover, a case study can also address the depth and breadth of play, revealing more insights into what might have occurred. The researcher can delve deeper into the subject, focus on the case as an argument, and take a more varied perspective, looking at things from different levels and angles, creating rich empirical data sources (Thomas, 2016). This build-up of data gives play a richer form and creates a more three-dimensional picture, embodying what is known as "Foucault's polyhedron of intelligibility" (Thomas, 2016, p.4). Thus, an empirical inquiry into play would no longer be perceived as one-dimensional because evidence could be drawn from the research study and could connect the observational elements to create a line of argument in the study, encompassing the complex nature of play.

As argued by Yin (2014), a case study is often used to answer research questions that consist of 'why' and 'how'. In this study, although the research questions are all 'what' questions, it is argued that the 'what' questions in this study do mimic 'why' questions in some ways. For the first two research questions (see Section 3.1), the way this research was approached was, firstly, to discover the nature and dominant types of all talk (Research Question 1) and science talk (Research Question 2). There were quotes of children's and teachers' utterances, which were included to act as evidence to support the type of talk and answer the 'how' questions. Similarly, for Research Questions 3 and 4, the children's and teachers' perspectives are on play and primary science, also answered in a 'why' manner, accounting for their perspectives in the interviews and observational behaviours. Therefore, a case study approach is an appropriate method in this research study.

3.31 Robustness of the case study

Although the case study is perceived as a controversial approach to collecting data, it is widely accepted in the social sciences (Zainal, 2007). A case study is about the concept of whole and depth; it is about the particular and not the general (Thomas, 2016). It is what Flyvbjerg (2001, p.132) calls “getting close to reality”. Hence, with the methodological eclecticism present in this research method, the best possible theories or paradigms coupled with mixed methods (qualitatively and quantitatively) were used to synthesise what could be best understood and most representative of the data collected. An interpretation follows this to triangulate the research findings and contribute to a better understanding of the topic’s universal knowledge. This will be covered in Chapter 8. The robustness of the data can be enhanced, and with the broad range of methods used here, a case study approach is deemed a suitable and rightful research method to encompass methodological eclecticism.

3.32 Methodological eclecticism

Methodological eclecticism, a conceptual approach, means that one does not restrict oneself to relying rigidly on any single ideology (paradigm) or theory (Vergés Gifra, 2013). Various forms of paradigm are present for the case study (Thomas, 2016) and the flexibility provided by the case study design has allowed multiple theories to be drawn upon in order to produce the best possible outcomes. Thus, this research study’s premise is based on a combination of two paradigms: (a) the Constructivist Paradigm and (b) the Interpretive Paradigm, both of which will be used to discuss this research study.

(a) A constructivist paradigm

As proposed by two famous case study researchers: Robert Stake (1995) and Robert Yin (2003), play fits into the constructivist paradigm. In constructivism, the assumption made is that truth is relative, and hinges upon one’s interpretation of things (Searle, 1995). Constructivism is about how a person’s relative actions in the environment in real life have created and contributed meaning to the social world they live in (Searle, 1995). Through the close interactions between the researcher and their participants, rich data such as observations, interviews, and participants recounting their stories were obtained and analysed. A better understanding can be achieved to interpret and support the participants’ perspectives and actions (Lather, 1992; Robottom & Hart, 1993) using a constructivist approach. Therefore, research questions 3 and 4 on the children's and teachers' perspectives on play can be constructed using this premise of the constructivist paradigm to give them the desired richness and depth.

(b) An interpretive paradigm

Similarly, in line with the constructivist paradigm, Stake's approach to an interpretive paradigm (Bassey, 1999) was also preferred. Interpretivism "respects the difference between people and the objects of the natural sciences" as well as "the subjective meaning of social action" (Bryman, 2016, p.26). This paradigm primarily contrasts with Yin's approach of the positivist paradigm which is more scientific (Bassey, 1999) and relates to objective reality. Play, a complex phenomenon, cannot be easily quantified into neat categories because it is subjective to different people, and the relationship or perspective one has is relative and could vary from person to person. An interpretive paradigm is a better fit for qualifying a subjective relationship and giving meaning by interpreting the data found in interviews and observations, with the intention of understanding "the world of human experience" (Cohen & Manion, 1994, p.36) and how "reality is socially constructed" (Mertens, 2005, p.12). Therefore, a case study combining both the Constructivist Paradigm and an Interpretive Paradigm will be a good fit for the type of data and the context found in this research study.

3.33 Multiple case studies

According to Baxter and Jack (2008, p.544), a case study is a form of qualitative research which "can inform professional practice or evidence-informed decision making in both clinical and policy realms". In this research study, where an exploratory approach was taken, multiple case studies – a study of several cases studied jointly – were used to investigate the play phenomenon. Through multiple case studies, Yin (2003) argues that either similar (a literal replication) or contrasting (a theoretical replication) results can be obtained. Although one cannot generalise from a case study (Thomas, 2016), multiple case studies are believed to aid in theory building. Theory building is possible through the various cases where the researcher could make a better and informed decision to establish circumstances in which the theory will be valid or invalid (Eisenhardt 1989; Yin 2009), thus shedding more light on the children's and teachers' perspectives on play from the various cases studied in this research study.

(a) Selection of cases

In primary education in Singapore, children only start to learn science as a formal and additional subject in their third year of primary school, at Primary 3 (P3), from the age of 8–9 years. Based on anecdotal evidence of feedback from teachers and the experience of the researcher, who has been a middle primary teacher for more than 16 years, P3 children struggle to adjust to the transitional phase during the first half of their P3 year when they come from the lower primary in Primary 2 (see Table 3.1). This is due to various reasons, such as the difference in teaching styles, moving from a more hands-on and play-based curriculum to a more formal curriculum and having an additional subject, science, to learn.

The targeted level of students[3] in this study is the P3 level. In my experience as a P3 teacher, I had witnessed the transition that the students experienced when less play was used at this level, with a move to more formal, didactic and teacher-led approaches in most subjects. In P3, Science is introduced as an additional subject alongside English, Mathematics and Mother Tongue, which are taught from Primary 1. It may be that in P3, children could be missing an opportunity to use something that is developmentally associated with this age group – play. Science is an appropriate subject to investigate the role of play, particularly where it involves empirical investigation.

[3] The term “students” was used instead of “pupils” here as it is a preferred term used in Singapore.

Singapore's Education System (MOE, 2016)			
Age	**Level**	**Level**	**Assessment**
3–4	Nursery 1	Nursery	No examination
4–5	Nursery 2		No examination
5	Kindergarten 1	Kindergarten	No examination
6	Kindergarten 2		No examination
7	Primary 1	Lower Primary	No examination
8	Primary 2		P2 End of Year's Semestral Examination
9	Primary 3	Middle Primary	P3 End of Year's Semestral Examination
10	Primary 4		P4 End of Year's Streaming Examination*
11	Primary 5	Upper Primary	P5 End of Year's Semestral Examination
12	Primary 6		Primary School Leaving Examinations (PSLE)**

Key:

⇨ Level of Transition, of interest in this study

Table 3.1: A table showing the educational levels in Singapore.

* P4 End of Year's Streaming Examination is a school-based examination with at least 20% controlled test items provided by the Ministry of Education in a data bank form.
** PSLE is a national examination which Primary 6 pupils take in order to move on to secondary school.

From empirical studies by Walsh et al. (2010) on implementing a play-based curriculum in primary schools in Northern Ireland, it was noted that both children and teachers faced difficulties in the transition. The teachers receiving the children after the transition had observed anxiety in both the children and the teachers and had experienced incongruence in expectations as they came from P2 to P3. Mirkhil (2012) argued that this transition in school is crucial because it affects children socially and can also contribute significantly to their academic success, impacting upon them significantly in their future. Therefore, the ease of transition does have some relevance to the children's success in fitting into the school's system. Understanding what this transition is like for both the children and teachers may help to ease the transition, which could be better and less stressful. With the above context in mind, a decision was made to select cases in Primary 3 and look at how play could help ease children's learning and teachers' teaching of science at this level.

(b) Selection of schools

The researcher aimed to explore children's and teachers' perspectives on play in primary science in the transitional age group from Primary 2 and Primary 3, using the topic of magnetism as taught in Singapore. These prerequisites set by the researcher limited the number of schools that could be considered. Moreover, the original plan includes choosing a sample that includes a range of typical representative schools (a co-educational government school, a co-educational mission-aided school, an all-girls and an all-boys school), and this intention further reduced the number of participating schools to three when the researcher failed to recruit an all-boys school for this study. Convenience or opportunistic sampling was used (Cohen et al., 2011). Through contact with two ex-colleagues and a close friend who were all either the Head of the Department of Science or a vice-principal, three schools were recruited to participate in this study. The topic, magnets, was taught in Primary 3 in these schools during Terms 3 and 4 (June to September 2017). This fact helped to narrow down and identify the cases in this research study. Even though the schools were recruited through convenience sampling, they were purposively selected (Cohen et al., 2011). Although the researcher knew the gatekeepers of this study very well, neither she nor the gatekeepers were involved in the actual teaching because five other teachers were assigned to participate in the study to avoid conflicts of interest.

Two co-educational schools were selected because they are representative of schools in Singapore, which are either the usual secular government schools (which make up the majority of primary schools in Singapore), government-aided mission schools (customarily supported by Christian or Catholic Missionaries) or, lastly, government-aided schools supported by various Chinese Clans. There are two mission schools in the cases selected due to how these schools were set up; most of the all-boys and all-girls schools are mission-aided schools started by Christian or Catholic missionaries in the country. The researcher was unable to recruit an all-boys school in the end because there are only nine all-boys schools in Singapore and not all schools teach the topic "Magnetism" in Primary 3. The researcher contacted all the possible schools with numerous corresponding emails for months but could not find a school that would consent to take part in this research. One school, in particular, wanted a promised and 'guaranteed' gain in learning from playing as a result of this research due to the pressure from parents and the school's prestige. It was not possible to meet this request, and the sample of an all-boys school was not obtained, limiting the initial target for this study.

When the last all-boys school declined to participate in this research after months of communications at the final hour, a decision was made to increase the number of cases in the all-girls school from one to three. This decision was made because the school had kindly given its consent to participate and was willing to allow more teachers to participate and look at how their girls learn science in school. There is constant interest in the decreasing number of girls interested in science, and without any all-boys school recruited, stratified purposive sampling (Bryman, 2016) was carried out, with subgroup interests such as the gender of the teacher and the way in which the classes were streamed according to the children’s Primary 2 academic results. A male teacher (the only adult male participant in this study) was recruited from the all-girls school and the three classes chosen to participate had children of varied academic abilities. Moreover, the tight timeline within which different schools covered the topic and the lower feasibility and logistics of moving between schools in different locations on the same day were contributing factors that informed the decision. Finally, after a few meetings, the three cases in the last school were confirmed, bringing the total number of cases to five, across three schools.

(c) Selection of participants

The targeted groups of participants in this research were drawn from the five classes (one each from the two co-educational schools and three classes from the all-girls school) and included five teachers, who were assigned by the three participating schools in Singapore. There were 183 Primary 3 students, aged 8–9 years. Five teachers (four female and one male teacher) were involved and were interviewed twice; one 30-minute interview about their perspectives on play in learning primary science before the scientific play sessions and one 30–60 minute interview about the differences in the teachers’ perspectives on play in learning primary science after the two scientific play sessions. All five teachers involved had 4–6 years of teaching experience. The topic of “Magnets” was taught in all the participating schools for an approximate duration of two weeks, and two sessions of a one-hour science lesson on magnets were observed in each class. An observation of a usual science lesson for all five teachers was also carried out. The topic of “Magnets” was chosen because the topic’s nature lent itself nicely to the research and was more play-inclined, whereby pupils could interact with the materials provided to explore and learn more about the subject. More details on the schools and the teachers will be presented in in the next section, on participants.

3.4 Participants

3.41 Participating schools

Three schools participated in this study, including the school used for the pilot research. A pilot study was first conducted before the actual study. The schools were recruited through the contacts of the researcher, who was previously also a primary school teacher in Singapore. Although the pilot and the actual study were both conducted in one of these three schools, the children’s classes were at different levels and in different year groups. There was no duplication of children involved in the study. The first two schools provided one class of children each and the third school provided three classes. All schools in Singapore have rooms or laboratories provided with laboratory equipment and curriculum materials supplied or funded by the Ministry of Education (Lee, 2018). Below, a brief summary description of the participating schools is presented.

(a) School 1

This is a government-aided, Christian mission, co-educational school located in a mature estate near Singapore’s northernmost central. The school has an above-average social economic status (SES). It is a popular school that holds a ballot for school places in the Primary 1 registration exercises for most years. There were seven classes at Primary 3 level and the school did not have a laboratory technician. This school was also used for the pilot study.

(b) School 2

This is a government-funded, co-educational school. The school is situated in an area where the old and new housing estate were side by side, in the northeast part of Singapore. The school’s student catchment is from the neighbouring 1–2-room rental units and some new condominiums around it, with a significant mixture of lower SES group and some average SES. The school is equipped with two science laboratories and has a laboratory technician. There were six classes at Primary 3 level and the school was open to educational research.

(c) School 3

This is a government-aided mission Catholic girls school situated in the southern part of Singapore's central region. The school has a low to high SES due to its catchment area in a mature estate and the school's history. The school is equipped with two science laboratories and has a laboratory technician. There were six classes at Primary 3 level and the school was open to educational research. This school provided three of the five cases in this study.

3.42 Participating teachers

Ten teachers were interviewed for this study. Five teachers from five different schools were recruited and interviewed for the pilot study (see Table 3.5), while five teachers were recruited from the three participating schools and interviewed for the actual study (see Table 3.2). The participating teachers for both studies had a similar number of years of teaching experience in their respective groups (pilot study and actual study): the pilot group of teachers had 16–23 years of teaching experiences while the teachers assigned by the schools in the actual study had 4–6 years of teaching experience. The teachers for the pilot study were recruited by convenience sampling and gave consent to be interviewed while the teachers for the actual study were all nominated by either the school leader or Head of Department for Science (HOD), who had matched the teacher's personality to the theme on play, or by convenience as they were science level representatives (LR) for the level and had given consent to participate in this study.

No.	Teacher’s Name	Teaching Qualifications	No. of Years of Service	No. of Years Teaching Science
1.	Madam Lee	PGDE*	6	6
2.	Madam Bhavani	PGDE*	5	5
3.	Mr Wong	Dip. Ed. (Pri.) **	6	6
4.	Ms Koh	BA*** (Ed.)	4	4
5.	Ms Geetha	PGDE*	6	0.5

*PGDE: Postgraduate Diploma in Education (Primary)
** Dip. Ed. (Pri.): Diploma in Education (Primary)
*** BA (Ed.): Bachelor of Arts (Education)

Table 3.2: A table showing information about teachers participating in the actual study.

(a) Teacher 1: Madam Lee (School 1)

Madam Lee had a degree in chemistry and was the science level representative of the level. She had experience of play with her young child at home and used it in her teaching in school.

(b) Teacher 2: Madam Bhavani (School 2)

Madam Bhavani had a degree in English and up to ‘advanced (A) level’ Science. She was also the science level representative of the level. She had experience of play with children both at the kindergarten level and at home.

(c) Teacher 3: Mr Wong (School 3)

Mr Wong was the only male teacher who participated in this research. He had a diploma in electronics. He had experience of play at the kindergarten and primary level in schools and with his children at home.

(d) Teacher 4: Ms Koh (School 3)

Ms Koh had a degree in linguistics and advanced level (‘A’ Level) science, with a special paper in biology. She was a science level representative for two levels; Primary 3 and 4. Ms Koh had spent her early years overseas and had then lived in Singapore from the primary level. She had experience with children before she joined teaching and had experience of using play in her teaching in school.

(e) Teacher 5: Ms Geetha (School 3)

Ms Geetha had a science degree, majoring in chemistry and biological chemistry. She had some experience with children before joining teaching.

Next, this chapter will proceed to a section describing the instruments that were used in this research study.

3.5 Instruments

A mixed-methods approach was used to capture the essence, depth and breadth of the data in order to build the multiple case studies to answer the research questions comprehensively. The instruments used in this research were carefully chosen and developed over time. Both qualitative and quantitative tools were used to answer the research questions, as indicated below in Table 3.3.

No.	Research Question	Methods of Data Collection
(1).	What are the nature and dominant types of talk used by children and teachers during play?	• Audio recordings of all groups' utterances by the children and the teachers during Scientific Play Session 1 (PS1) and Scientific Play Session 2 (PS2). • Video recordings with audio for the two scientific play sessions in classes. • Onsite field notes taken by the researcher as an observer during the two scientific play sessions.
(2).	To what extent do children and teachers talk about science during play?	• Audio recordings of all groups' utterances by the children and the teachers during the two scientific play sessions. • Video recordings with audio for the two scientific play sessions in classes. • Onsite field notes taken by the researcher as an observer during the two scientific play sessions.
(3).	What are the children's perspectives on play in primary science?	• Children's group interviews.
(4).	What are the teachers' perspectives on play in primary science?	• Individual teacher's interviews before and after the first scientific play session and the second scientific play session.

Table 3.3: A table showing the methods of data collections, matching the research questions.

3.51 Classroom observations

In this research study, classroom observation was essential to supplement the children's and teachers' audio recordings. Classroom observations are not strictly either quantitative or qualitative. They can be used to act as a triangulation source and primer to inform the interview questions or to follow up in the semi-structured group interviews. Classroom observations are observational data that can help to validate and increase the reliability of data, such as the group or individual interviews, on the ‘truthfulness’ of the interviewees.

For classroom observation, there are varying degrees of participation (LeCompte, Preissle & Tesch, 1993: pp.93–94). In this research, the researcher assumed an ‘observer-as-participant’ or ‘participant-as-observer’ role (Cohen, Manion & Morrison, 2000: p.310). The researcher was known to the children as a researcher for this project (Cohen, Manion & Morrison, 2000: p.310). The researcher stayed with the children for a substantial period (at least two weeks) in their classes during their science lessons. According to Cohen, Manion and Morrison (2000: p.311), this action helps to reduce reactivity effects, ‘reducing the effects on the researched’. This observation allowed the researcher to gain first-hand experience of how the children interacted with their teacher and peers during a typical science lesson, both with and without play.

As the scientific play sessions were set to take place within the science lesson (the last 15 minutes of a one-hour lesson), the classroom observations would be one of the best and most naturalistic ways (Cohen, Manion & Morrison, 2000) to understand what happens during them. During this time, the researcher could observe how events changed over time, the dynamics of the groups, the personalities of the children, their interactions with peers and teachers and the contexts where the children would play during these sessions (Cohen, Manion & Morrison, 2000). A more holistic view of the essential features of the contexts where the participants got involved would be revealed, allowing the researcher to gain easier access to understanding the intricate interrelationships of factors (Morrison, 1993: p.88), ‘thickening’ the descriptions of the observations. A more accurate explanation and interpretation of events would be grounded and generated based on evidence-informed observations, rather than the researcher’s inferences (Cohen, Manion & Morrison, 2000).

These ‘thick descriptions’ can involve recording the participants’ utterances in verbal forms, looking at what happened physically in non-verbal forms in class and detailed contextual data from the field notes (Carspecken, 1996: p.47). As one of the aims of this study was to find out about the children's and teachers' perspectives on play in learning primary science, their utterances were collected in order to understand more about their perspectives. Their discourse is often referred to as the classroom talk during a lesson. Dependent on a researcher's epistemological theories, research paradigms and disciplinary traditions, the ways in which one studies classroom talk can vary, and the chosen methods will differ (Mercer, 2010). The study of classroom talk has been well-researched, well-documented and peer-reviewed for many years (Mercer, 2010). Mercer (2010) proposes that amateur researchers (such as the researcher in this study) can tap into the rich resources built up over the years and make good use of them, rather than creating new frameworks. The researcher considered and scrutinised the research questions repeatedly and finally decided what accounts for the methods discussed in the following few sections. This research's premise is based on the types of talk and the children's and teachers' perspectives on play in primary science, during their scientific play sessions in science classes. As the settings were located in schools, the children were observed during their scientific play sessions, which often took place in groups, and classroom talk was observed between the teacher and the children and children with their peers.

In the context of play, both qualitative and quantitative methods have been used in research. As found in most empirical studies on play, largely qualitative instruments such as observational studies of a class session or following the children playing were often recorded in video and audio forms, followed by interviews. As well as qualitatively, play can also be studied using quantitative methods using systematic observation schedules such as Broadhead's (2006) 'Social Play Continuum' or Simon et al.'s (2008) 'discourse analysis framework'. However, as in any research study, the observation schedule's suitability is critical and depends on the research questions. For example, in this study, it was not an exact match, and some adaptations had to be made. These will be discussed in the following section. The next section will explore the instruments used, first the quantitative methods and then the qualitative methods.

(a) Quantitative methods

In this study, quantitative methods such as systematic observation using video recordings were used to gather field notes, which enhanced the data gathered.

Quantitative methods were used as part of the framework to collect data. Systematic observation is a well-established research type for investigating classroom interactions (Mercer, 2010). It has been used as a class observations tool, in groups or pairs (Bennett & Cass, 1989). Researchers can use their research questions and initial observations of class interactions to develop their categorising system and create codes, or they can use one that is already peer-reviewed (Mercer, 2010). Codes can be allocated to observed talk, and or to even non-verbal gestures (Mercer, 2010). The researchers can sit in the classroom and do this in real-time, or they can work from video recordings (Mercer, 2010). Video recording of these observations during the research is helpful because it helps to provide many opportunities to understand the research target (Rantalaa & Määttä, 2012), more than can be achieved during real-time. More time could thus be spent in making field notes and observing the participants in areas that the video did not cover. In this study, the choice to work from the video recordings was made using the proposed framework: the 'Primary Science Talk Framework with Play' (PSTFP), which will be discussed in more detail in Chapter 4. Using the recorded group utterances, the researcher assigned what she had observed and heard (Mercer, 2010) from the two sources accordingly and coded them using the PSTFP, a new framework which the researcher created from the adaptation of two existing frameworks and models: Simon et al.'s (2008) discourse analysis framework and Falk and Dierking's Contextual Model of Learning. The PSTFP was created due to the gaps identified in the two frameworks and models. Simon et al.'s (2008) discourse analysis framework and Falk and Dierking's Contextual Model of Learning could not be used to answer the research questions in their existing formats. PSTFP was designed as a best fit for this research to study the nature and dominant types of talk used by both the children and their teachers during their scientific play.

Thirty recordings of the classroom interactions were collected for this study. For this amount of data, systematic observations conducted quantitatively have the advantage of allowing a large sample of classroom interactions to be sampled without analysing verbatim. This allowed the researcher to move quite quickly from observations to analysis, reducing the enormous quantity of data in the transcribed talks to counts of a specific set or a manageable number of emergent themes which surfaced from the observation schedules used (Mercer, 2010). This method was assisted by technology, with computer software like *Nvivo* (QSR International Pty Ltd, 2011) and "Statistical

Package for the Social Sciences" (*SPSS*) Version 25 (in this study) being used to analyse the data captured by the new observation schedules (see Chapter 4).

For this research study on play, two relevant observation schedules: (a) Simon et al.'s (2008) discourse analysis framework and (b) Broadhead's (2006) Social Play Continuum, which can be used to study play and dialogical exchanges, will be discussed. Through a careful analysis of both observation schemes, only Simon et al.'s (2008) discourse analysis framework was found to be relevant and suitable to be used in this study. The third framework, (c) Falk and Dierking's (2000) Contextual Model of Learning, which does not have an observation schedule, was adapted and used in this study. The complementary similarity that it has with Simon et al.'s (2008) discourse analysis framework, in a sociocultural setting, allows this framework to be the fundamental backbone of this research. It was further adapted to form the final framework used, the 'Primary Science Talk Framework with Play' (PSTFP), which will be discussed in Chapter 4.

(i) Simon et al.'s (2008) discourse analysis framework

Simon et al.'s study was a mixed-methods study carried out in primary schools in England with 16 teachers and their pupils aged 7–11, focusing on the learning of science. In the study, the researchers used large puppets to determine whether they would help teachers to change the nature of their whole-class discourse to enhance children's talk and engagement in science. However, in this section, only the quantitative methods of their study will be discussed. During their study, Simon et al.'s (2008) discourse analysis framework was created and used as part of their strategy. The framework had a coding scheme in which codes were created and used in the time-related (30s) observation schedule. They were used to study the frequency of certain kinds of talk in each lesson. As this framework is one of the ones used in this study to create the PSTFP, more details about it will be discussed in Chapter 4.

(ii) The Social Play Continuum – Broadhead (2006)

The Social Play Continuum is an observation-interpretation tool used as a formative tool to observe children during play, detailing the child's progression in learning and illustrating factors that impact upon progression (Broadhead, 2006).

The Social Play Continuum, as the name implies, is a continuum, which spans four domains, starting with the associative domain, then the social domain, the highly social domain and, lastly, the cooperative domain. This observation schedule focuses primarily on the social domains of children in their early years, but as the research for this thesis was not solely about the social domains of older children, but also about what they would discuss and do when given free play during the scientific play sessions, this framework was not suitable. Although a few categories seemed to fit this research, tracing how the students would have behaved, such as watching play for the associative domain, to laughing in the social domain, sporadic dialogues developing roleplay themes in a highly social context, offering and accepting verbal help in the cooperative domain were less frequently observed in older children. These were all very fine-grained details that this research could not capture sufficiently due to the sample size and available manpower, which led to some limitations.

Some examples of limitations are the details of observations (the large class sizes in Singapore schools of up to 43 students per class has made it difficult to capture every facial expression of every student) and the limited funding as a single postgraduate student to buy or borrow a sufficient number of video cameras to record the scientific play sessions or the lesson. The limited timeframe for completing this research and the lack of manpower for carrying it out were also contributing factors that made this framework not practical or feasible to use. Moreover, this framework is designed for an individual child, tracking when she or he enters and leaves play, which is also not feasible as there were183 students involved in this study. Therefore, due to these limiting factors, this framework was deemed unsuitable to be used for this study.

(iii) Falk and Dierking's (2000) Contextual Model of Learning

Falk and Dierking's (2000) Contextual Model of Learning (CML) (see Section 2.4) has been used to understand how learning takes place in an informal setting, such as a museum. As there were many problems with the term 'informal', which is often tagged by external agencies or institutes, to differentiate it from learning in school, Falk (2005, p.272) argued that this term should be replaced by the term 'free choice' learning, which is more apt and can withstand "the positive and negative biases that currently surround schooling". This model presents a scenario in which an individual's personal, sociocultural context and the physical contexts of the learning environment interact to result in a unique learner's contextual learning experience, determining the degree of engagement (Falk & Storksdieck, 2005).

In this study, Falk and Dierking's (2000) CML, is used as the primary framework to form the basis of the newly adapted PSTFP, along with Simon et al.'s (2008) discourse analysis framework. The latter informs the coding schemes, being nested and subsumed into the personal and sociocultural contexts of Falk and Dierking's (2000) CML. More about how PSTFP came about will be presented in Chapter 4.

Next, this section moves on to the qualitative methods, part of the mixed methods of this research study.

(b) Qualitative methods

Classroom talk is the centre of this study. Talk, here termed utterances, cannot be used or taken at face value alone. Utterances themselves can be temporal and ambiguous because their surface forms may have different meanings and functions linked to them, with multiple layering (Mercer, 2010). In the field, complex factors such as the context and location can be complicated by the institutional, historical and cultural aspects (Mercer, 2010). Crook (1999) argued that the interactions observed were not one single isolated or standalone session each but a session that could have brought along with itself the myriad of factors compounded by previously established happenings. How the children or teachers reacted in the sessions could be influenced by events that occurred before the sessions. Utterances are not one dimensional and can be associated with many different implications. A qualitative method can embrace such a varied and open-source dataset and be a better fit to present the data that encapsulates all these factors and their deserved depth.

This study considered several models of qualitative analysis, including: (i) ethnographic analysis, (ii) sociolinguistic analysis, (iii) conversation analysis and (iv) sociocultural discourse analysis, which are linked to classroom talk. Sociocultural discourse analysis was chosen as the main mode of qualitative analysis for this study because the context of the study – play, a social activity – takes place within a sociocultural setting and is best explained and analysed using this approach.

(i) Types of analysis to study talk during scientific play sessions

- **Ethnographic analysis**

This method adapts social anthropologists' and sociologists' methods in non-educational fields (Hammersley, 1982; Woods, 1983). In ethnography, the researchers are closely involved with their research environment, observing events, going into depth and obtaining rich and detailed data about the participants (Mercer, 2010).

Although the researcher stayed in each school for at least two weeks to carry out this study, she was not a school staff member. Although she was seen in all the sessions, she was considered an outsider during the study. Thus, this form of analysis could not be used entirely. What could result would be the field notes accumulated while carrying out a naturalistic observation at several levels (Spradley, 1980; Bogdan & Biklen, 1992; LeCompte & Preissle, 1993), such as jotting down descriptions of events, behaviour and activities, taking some quick and brief notes of keywords and painting the characteristics of participants using words.

- **Sociolinguistic analysis**

Sociolinguistic analysis has its roots in sociolinguistics (Mercer, 2010). It is concerned with different forms and structures of languages and their uses in society (Swann, Mesthrie, Deumert & Leap, 2000). Here, discourse analysis, used in a general manner, is used in different ways to analyse the language used, both spoken and written (Mercer, 2010.) Educational research on classroom talk uses this approach, and students' contributions were observed using the popular and famous initiation-response-feedback (IRF) structure (Sinclair & Coulthard, 1975).

Although the adaptation of The Play Continuum with the addition of peer codes from Mortimer and Scott's work (2000) does fall under the IRF structure, the subject itself – science – and not language, was studied. The focus was on the utterances spoken, with the content and not the language structure of their conversations being examined.

- **Conversation analysis**

Conversation analysis (commonly abbreviated to CA) is a methodology with roots in ethnomethodology (Mercer, 2010). Ethnomethodology focuses on how social interaction is achieved through one's actions, and narrates how the social world works (Mercer, 2010, p.8):

> […] minute by minute, through everyday talk and non-verbal communication, and how people 'account for' their social experiences

Although this mode of analysis was quite close to what was intended in this research: to study social settings in play situations, the account for every participant's social experiences, a total of 188 people (183 students and 5 teachers), was not possible and raised ethical issues around encroaching their privacy. The scale of the study does not allow this form of analysis to be carried out.

- **Sociocultural discourse analysis**

Sociocultural discourse analysis is focused on the social context observed over time, on content and function, and the ways in which a shared understanding is developed, rather than the language components (Mercer, 2005, 2008). Unlike research in linguistics, in educational research, discourse analysis refers to the analysis of talk within a social context (Mercer, 2010). Sociocultural discourse analysis is the tool by which groups of people involved in a social context interact with one another, constructing knowledge and understanding shaped by their culture (Mercer, 2004). Although it is a methodology for analysing classroom talk which focuses on using language (the talk in the class) as a social mode of thinking (Mercer, 2004), which seems to be more qualitative, it is often perceived as a whole methodology comprising both quantitative and qualitative aspects (Mercer, 2004), i.e. a mixed-methods approach (Mercer, 2010). Sociocultural discourse analysis is versatile and flexible; it can be combined with quantitative methods to be tested systematically and generate hypotheses for specific interactions (Mercer, 2010). Thus, this particular feature fits the criteria to be used as one of the methods in this study.

Moreover, this study took place in a social setting – the science classrooms – which makes sociocultural discourse analysis even more relevant. In addition, this research study reviews all the classroom talk, whereby both the teachers' and the children's utterances were scrutinised and analysed in a sociocultural context. With its multi-layered analytical framework (Black, 2007), this method allows the utterances collected to be broken down in many various ways to derive meaning, building up the case. The findings from such an analysis are helpful for future pedagogical suggestions and implications. Thus, the data could advance educational research and contribute to the build-up of empirical data with the wealth of current frameworks available (Mercer, 2010), which is one of the aims of this research. Therefore, sociocultural discourse analysis fitted this study the best and was used in this research.

(ii) Semi-structured interviews

In addition to sociocultural discourse analysis, semi-structured interviews were used in this research. According to Braun and Clarke (2013), the semi-structured interview is the most typical kind of interview used in qualitative research and the dominant form for qualitative interviews. In this type of interview, the researcher prepares a list of questions or an interview guide before the actual interview (Braun & Clarke, 2013). However, the interviewer needs to be flexible and not follow the guide word by word or the exact sequence of questions as planned. Instead, the researcher should be responsive to the participants' developing account and co-construct meaning with them (Braun & Clarke, 2013). Question wording and order are contextual, and participants are given opportunities and spaces to voice and raise any concerns or issues that are important to them but not anticipated by the researcher during the interview (Braun & Clarke, 2013). In this research, interviews with both the teachers and the children were semi-structured in order to answer Research Questions 3 and 4 and capture their perspectives in their own words (Braun & Clarke, 2013).

- **Individual Interviews with teachers before and after the scientific play session**

The teachers were interviewed both before and after the scientific play sessions and the interviews were transcribed. During the transcription, besides listening to the utterances carefully, the researcher also tried to incorporate the comments in the field notes about the interviewees' non-verbal expressions, body language and level of comfort while answering in the interviews to generate responsible knowledge (Song & Parker, 1995). The researcher also allowed the interviewees to choose the venue where the interview would take place to put them at ease by being in a familiar environment (Braun & Clarke, 2013). Pseudonyms were used to protect participants' anonymity (Braun & Clarke, 2013). Member checking of the final transcripts was also carried out and the interviewees got to see the full transcripts to check if what had been transcribed was what they had meant during the interview (Guba & Lincoln 1989; Miles & Huberman 1994). Two interviews were conducted with each teacher: before and after the scientific play sessions, to see the difference in perceptions and perspectives after they had immersed themselves in the two scientific play sessions.

- **Group interviews with children**

As one of the aims of this research study was to discover the children's perspectives on play, it is vital that the information comes from the children themselves as they are the best sources to ensure authenticity (Deatrick & Faux, 1989). In order to grasp how the children understand and interpret their world, there is a need to get into their unique childhood culture (Yamamoto, Soliman, Parsons & Davies, 1987). Research has shown that even very young children (ages 3–6) can express their perspectives well (Clark & Statham, 2005; Dayan & Ziv, 2012), and they are credible 'experts' on their own lives (Clark, 2004). The children in this study were 8–9 years old, so they could convey their valuable inputs about the context proposed.

According to Einarsdottir (2007), interviews are the most common form of data collection in children's research. Group interviews for children, as used in this research, are less disruptive, less intimidating and much faster than individual interviews (Cohen, Manion & Morrison, 2000). The advantage of group interviews is that they include the potential for discussions to develop, thus yielding a wide range of responses (Watts & Ebbutt, 1987), capturing the diversity of the children's responses in their own words (Braun & Clarke, 2013). Like adults' interviews, Arksey and Knight (1999) argue that developing trust or rapport with the children, using appropriate language and the lingo they use themselves, and listening to them attentively, are all relevant guidelines for conducting qualitative interviews with them. The researcher spent at least two weeks in the schools and had already been present in each class for at least one lesson before the actual scientific play session, and remained for two lessons after the second scientific play session. The researcher was also present during the two recorded scientific play sessions. Therefore, when the group interviews were carried out, the children were already quite comfortable with the researcher and willing to disclose personal information and provide a rich and detailed account to answer the research questions (Braun & Clarke, 2013).

Although interviews can be a complex and challenging task (Clark, 2010), there are ways to interview children. As recommended by prior research with children by Einarsdottir (2005) and Graue and Walsh (1998), the interviews were conducted in small groups of between two and four as a comfortable group size. During the group interviews, video-stimulated recall of the lessons was used at the beginning to jog the children's memories of the scientific play sessions (Campbell, 2008). This "stepping back and analysing practice" (Simons & Campbell, 2012, p.319) served as a powerful technique, with video recall snippets being played back to help the children refresh their memories. This practice established a common point for communication to occur among the children, easing them into the interviews.

Then when the questions moved on to their play experiences, emojis (see Appendix 3.1) were shown to them. From Kaye, Wall and Malone's (2016) research, emojis were effective for children, including helping them to express and relax their mood. For the interview schedule with children in this research, a set of emojis was used to allow them to indicate their scale of liking the scientific play sessions. The emojis acted like contextualisation cues (Al Rashdi, 2018) and immediately helped the children to open up communication channels more readily to promote interaction (Gibson, Huang & Yu, 2018). A researcher's diary was kept, with observational field notes captured by her during all the interview sessions and later followed up to analyse the data.

3.6 Data Collection

3.61 Timeline of the data collection

The data for this study were collected in two phases. The first phase was the pilot stage in 2016 to 2017 (December to April), while the actual data was collected between July and October 2017 (see Table 3.4 below). The first phase was important because it informed the actual data phase. This is elaborated in the next section.

No.	Year	Term	Month	Type of session			
				1	2	3	4
1.	2016–2017	Autumn–Spring term	December–April	-Pilot teachers' interviews before scientific play sessions, scientific play session and a group interview with the P4 students.			
2.	2016–2017	Autumn–Spring–Autumn term	December 2016–September 2017	-Recruitment of schools for the study in Singapore.			
3.	2017	Summer–Autumn term	July–September	**Observational Scientific Play Session**			
				1	**2**	**3**	**4**
				✓	✓	✓	✓
4.	2017	Summer–Autumn term	June–September	-Pre-Scientific-Play and Post-Scientific-Play Interviews about Perspective on Play with Teachers.			
5.	2017	Summer–Autumn term	June–September	-Children's group interviews after the completion of both scientific play sessions.			

Table 3.4: A table showing the timeline for data collection in this research study.

3.62 Pilot study

The pilot study was the first phase, carried out between December 2016 and April 2017 in Singapore. Here, the materials used for the scientific play session, the observation schedule for group play, and the teachers' individual and children's group interview schedules were piloted.

(a) Teachers

Five Singaporean teachers were recruited in the pilot study by convenience sampling and interviewed using the researcher's interview schedule about their perspectives on play in primary science. The interviews had a semi-structured format and these teachers were interviewed using the pre-scientific-play-session interview schedule. Only one of these five teachers went on to pilot the post-scientific-play-session interview for teachers because she was the only teacher who carried out the children's scientific play session with her students. These five teachers were a representative sample (Bryman, 2016) (teaching at co-educational government and government-aided schools and girls' schools) as the targeted schools in the actual data collection sessions would be similar. Table 3.5 depicts the backgrounds of the teachers participating in the pilot study.

Teacher's Code	Subject Specialisation	Number of Years Teaching	School	Demographics of the school	Gender
A	Maths & English	16	1	Girls' school, Catholic[4] school	F
B	English & Maths	20	2	Co-educational school, Neighbourhood school	F
C	Physical Education & Maths	23	3	Girls' school, Catholic school	F
D	Science & Social Studies	20	4	Co-educational school, Christian[1] school	F
E	Science & Gifted Education	22	5	Teachers' training college, Boys' school, Catholic[1] school	F

Table 3.5: A table showing the backgrounds of the teachers interviewed for the pilot study.

A duration of 30 minutes was appropriate, and all the interviews were completed within this planned duration. Some changes were then made to the interview schedules to better fit the questions asked because some periods of awkward silence were experienced if the teachers did not have much prior play experience or were asked about their educational background. Braun and Clarke (2013, p.84) recommend to "funnel questions" and think of them as being like "an inverted triangle", meaning that the early questions should be less sensitive and direct. Hence, these questions could be shifted to the later part of the interview, moving from the general to specific. These suggestions were taken, and the interview guide was amended a few times before finalising.

[4] Catholic and Christian are the usual terms used in Singapore to classify schools started by missionaries in the past.

(b) Children

A group of Primary 4 (P4) children was chosen to study the scientific play session. Two girls and one boy who had volunteered with the consent of their parents and themselves (assent from the children) were chosen to simulate the actual scientific play session. P4 children were chosen instead of P3 children for the pilot study because the researcher intended to see how the children would respond in a group interview after learning the topic. P3 had not yet studied the topic of magnetism when the pilot study was carried out. Therefore, to avoid having the same batch of children doing the research twice, P4 children were the closest match for this pilot. As P3 was the targeted population, the researcher requested that the children participating in the pilot be 9 years old, not 10 years old yet, so that the selected children in the pilot would think like children at that age.

In the pilot study, the children were observed to pick up some materials more frequently than others, to copy one another in the scientific play and negotiate for materials. The synergy and interactions observed also served as primers to sensitise the researcher for future codes. The materials provided for the scientific play sessions were sufficiently stocked with different materials and some "loose parts" (Casey & Robertson, 2017, p.6), which provided a rich environment for the children to allow free play to take place, extending their play. "Loose parts" are natural or synthetic materials that allow children to play in an open-ended manner, exploring them in various manners (Department for Education Australia, n.d.).

3.7 Main study

3.71 Context of the data collected

Altogether, 183 P3 children and five teachers from five classes in three schools participated in this study. In total, there were 45 groups of children. As the class size of a typical Singaporean class is 38–40, when the children were grouped into fours, there would be about 10 groups of children per class. As there were two classes with 43 children, there were three groups in these two classes with five children each. There was also one class with a lower enrolment of only 18 children, so here there were three groups of four children and two groups of three. Thus, the number of groups in this class was five, half the number of a fully enrolled class. The unit of analysis (Yin,

2009) was set at the level of the groups within a class. The teachers were asked to select three groups based on how the group had played during the scientific play sessions, to avoid researcher bias. Teachers were asked to choose one group they perceived to have 'played well' (Group A), one group which had 'played averagely well' (Group B), and one group which 'did not play so well' (Group C). This was intended to form a focus for the analysis and to discover whether the groups that the teachers thought had played well used more scientific talk than those they were less happy with. It was important for the teachers to understand talk for the full behavioural range of the children in this study because they were less likely to use play if they were not happy with student behaviour, so it was important for them to know what was going on in these groups.

For the group interviews, 15 groups of children were selected from the five classes, and formed the 15 cases in this study. In order to arrive at this grouping, three groups of children from each class were selected by the teachers. A multiple case study design (Yin 2003), called a collective case study (Stake, 1995), was used in this research. Through the descriptions and comparison of these 15 cases, a cross-case analysis was first carried out to provide insight into the nature and dominant types of talk used during play. The researcher was particularly interested in what the children talked about during play and the extent to which they discussed science during such lessons. As there were 15 cases in this research, the cross-case analysis helped to increase the data's validity and credibility. Multiple cases provided the data and evidence by which the whole analysis would become more robust and convincing to provide a fuller picture of what happened (Herriott & Firestone, 1983). All these data are closely associated with the 'Play Protocol', which will be discussed in the following section.

3.72 The Play Protocol

The play protocols (see Appendices 1.1 and 1.2) is a two-page document that was specially written for the teachers. It contained a set of instructions for the teachers about the essential learning points from the science lesson before the session, the types of materials provided and the procedural instructions for the logistics of the scientific play session. A play protocol was given to all the teachers before the sessions to allow them to become familiar with every scientific play session. They were asked by the researcher to preferably carry out the scientific play session towards the end of a one-hour science lesson. Each scientific play session was targeted to be 15 minutes long and be held after the first 45 minutes of a standard one-hour science lesson. Teachers were asked to follow the play protocol to ensure the study's fidelity.

The play protocols were specially designed for this research study by the researcher, an experienced primary school teacher. She had considered the tight schedule of Singapore science lessons and merged the local syllabus and the activities in the prescribed activity book used in most schools with some space for playfulness. She was able to identify which teacher behaviours to promote: responsiveness over instruction. For example, the play protocol was given to all teachers a week before the scheduled scientific play session so that they could gain an idea of what kind of questions they could ask, or how to scaffold the children's learning, without 'interrupting' their play. A great deal of care was taken to ensure that the children's health and safety were taken care of and that the materials linked to the children's daily lives, such as providing some 'loose parts' which could provide a richer environment for the children's play (Casey & Robertson, 2017, p.6). Moreover, she had checked to ensure that the materials were available in the science laboratory and gender neutral if possible.

Headings from the play protocol	**Purpose of the play protocol**
-Essential Learning Points from the Lesson	• To act as a guide for the teachers to ask guiding questions related to what the children had learnt so far in their prior science class during their scientific play.
-Materials	• To inform teachers of the type of materials given to the children during their scientific play session.
-Procedure	• To inform the teacher of what they needed to do before (such as organising the children into groups), during (what it is recommended for the teacher to do) and after the scientific play session.

Table 3.6: A table detailing the different parts of the play protocol used in this study.

Two pilot studies with a total of five children were conducted and these helped to shape this protocol beforehand. Special notes were taken of what children loved to play with. These play protocols also took into consideration children's misconceptions in primary science, such as the idea that the bigger a magnet's size, the stronger its magnetic strength, and that all metals are magnetic. These play protocols helped to give the teachers some ideas about what would be issued for that particular scientific play session so that they would be able to ask relevant and supportive questions or support the children's play. It was while the scientific play sessions were taking place that data from the children's and teachers' utterances were collected for analysis.

3.73 Data analysis

In this research, a mixed-methods approach was used. Data collected were analysed both quantitatively and qualitatively. There are four key sources of data used for this research:

(a) audio recordings of the children's group interactions during the scientific play sessions,

(b) audio recordings of the children's group interviews after both scientific play sessions,

(c) audio recordings of the teachers' interview before and after both scientific play sessions, and

(d) field notes taken from the researcher's observations during both scientific play sessions and video recordings.

The primary data source was the audio recordings of the participants (children and teachers) from the research fields and the researcher's field notes taken during the scientific play sessions and while watching the video recordings. These audio recordings were transcribed verbatim, and the transcripts were analysed in both quantitative and qualitative manners. Above, (a) is mainly quantitative with some qualitative elements while (b) to (d) are solely qualitative. The nature of the data, the rationale of the researcher's steps, and how these data analyses were carried out will be explained and discussed in the following few sections.

In this research, two scientific play sessions were recorded, and the children's and teachers' dialogical utterances were analysed. Management software like *NVivo* (QSR

International Pty Ltd, 2011) was used to manage the data to set aside where the researcher could use their own codes and analyse the transcripts, measuring the relative occurrence of the types of talk. The frequencies of the different types of talk during the scientific play sessions were quantified, and SPSS was used to analyse the data (see Chapter 5 and Appendix 5.3) statistically.

This research study is a convergent design variant, where the parallel-databases variant was used to collect two parallel sets of data that were analysed independently. Only after the analysis was the data brought together and interpreted in the discussion section (Creswell & Plano Clark, 2017). The two databases containing the quantitative and qualitative data were merged to examine and compare multiple cases in a cross-case comparison.

(a) Preparing the data

Before the transcripts were analysed, a 'unit of meaning' (Gan & Hill, 2014) was identified; this was to be an utterance spoken by a child in a group or a teacher. According to Kempa and Ayob (1991, p.345), an utterance is defined as "any verbal unit which possesses a recognisable and interpretable element of communicated information". Thus, in this research, an utterance could be some voiced or spoken syllables, word(s), phrases or sentences. What defines a 'unit of meaning' is the precise and clear boundaries of its thematic content (Gan & Hill, 2014). An utterance should only contain one theme to minimise the possibility of overlapping codes (Gan & Hill, 2014).

With the 'unit of meaning' determined, the audio recordings were then transcribed verbatim and formatted utterance by utterance. Then, the proofreading of the transcripts was conducted, and Punch's (2005) suggestion of data cleaning was followed. Data cleaning was carried out and the data was prepared and cleaned (Punch, 2005). Any unclear or ambiguous transcripts of utterances were rectified to make sense of them before the frequencies of the types of talk were counted, using *NVivo* (QSR International Pty Ltd, 2011) to code.

(b) Analysing data

According to Mercer (2004), 'sociocultural discourse analysis' does not refer to one particular method but to the methodology as a whole. It involves several methods, both qualitative and quantitative. In this research, sociocultural discourse analysis was used as a methodology to present the analysis of classroom talk and the perspectives of the children and teachers. The framework used to analyse the data is described in Chapter 4. Using a multilayered analysis framework (Black, 2007), a few analysis methods were used to analyse the children's and the teachers' data using sociocultural discourse analysis.

(i) Quantitative data

- **Children's and teachers' utterances**

With the transcripts cleaned up and presented utterance by utterance, *NVivo* (QSR International Pty Ltd, 2011) software was used to code all the utterances, line by line using the 'Primary Science Talk Framework with Play' (PSTFP) (see Chapter 4). This framework contains 17 nodes for the children's talk and 13 nodes for the teachers' talk. Each utterance was coded deductively using the framework. At the end of the coding process, the number of utterances under each node was summed and a total calculated. Totals were presented in tables to give a quantitative view of the frequency of occurrences and show how much science was being discussed during the scientific play sessions. With the total number of utterances accounted for, the nature and dominant types of group talk during the scientific play were determined by dividing the individual frequency count by the total number of utterances and expressing the answer as a percentage (see Table 5.1 for All Talk and Table 5.3 for Science Talk). The information obtained then served as the 'database' for subsequent analyses, during which the 15 cases would be reorganised into the three groupings mentioned earlier (see Section 3.71) and analysed from a different angle to provide insights into whether the groupings of the children had on the data. Lastly, the researcher zoomed in on the quotes of utterances classified within the ranked targeted nodes. Quotes of utterances were listed as evidence for the most dominant to the least dominant types of talk in all talk and science talk in order to add the qualitative part to the quantitative part of this study in Chapter 5. This combination of both kinds of data helped to build up the findings' richness, giving better and more complete depth to the case studies in this research.

(ii) Qualitative data

Within the sociocultural discourse analysis in this study, a multi-layered framework was used (Black, 2007) whereby the data went through at least two layers of analysis, with thematic analysis (TA) being one of the methods utilised in this study. Software like *NVivo* was used as a systematic organising tool to code and organise the data. Using *NVivo*, the researcher went through "each unit of meaning" (Gan & Hill, 2014) in the prepared transcripts and coded them inductively into themes. Themes are phrases of words that sum up what the participants were trying to convey during the interviews (Rubin & Rubin, 2012).

- **Children's group interviews and teachers' individual interviews**

Firstly, the recordings collected during all the interviews were carefully listened to and transcribed verbatim, utterance by utterance, by the researcher. Transcribing is the process in which audio recordings of the interviews are played, and the researcher listens and creates a reliable written account of the interview in textual form (Gillham, 2005). These were then verified by listening once again after transcription to check the field notes and the transcript.

Before analysing the data, a collaborative approach with the teachers was carried out using member checking (Guba & Lincoln 1989; Miles & Huberman 1994). This step helped to give the teachers a voice and increased the reliability of the analysis. All the data were transcribed and returned to the teachers. They were asked to acknowledge and comment (if they wished) on what had been transcribed. This step was carried out to ensure that the transcripts tallied accurately with what the interviewees had meant to say. This step allowed the researcher to refine the central concepts as they emerged, and the teachers commented on the emerging interpretations. After this, the data was ready for coding to take place.

Coding is analysis (Miles, Huberman & Saldana, 2020). Firstly, an inductive method was used to analyse the utterances in the transcripts and code them into themes. The codes were generated by the researcher where the 'unit of meaning' (Gan & Hill, 2014) was 'translated' (Vogt, Gardner, Haeffele & Vogt, 2014, p.13) and interpreted, attaching meaning for later pattern detection, capturing the essence of each datum. This first round of coding was a data-driven, 'bottom-up' approach based on the data (Braun & Clarke, 2013, p.178), where theming of the data took place (Miles, Huberman & Saldana, 2020) with the emergent themes being identified. The analysis of the data from these interviews was exploratory and descriptive.

Next, the second cycle of coding took place, where the pattern codes, inferential codes or explanatory codes were pulled from the first cycle into more meaningful 'units of meaning'. Here, meta-coding took place (Miles, Huberman & Saldana, 2020), where the emergent themes generated in the first cycle were reorganised into the personal and sociocultural contexts of Falk and Dierking's (2000) Contextual Model of Learning (CML). During this second cycle, the approach was top down, where each pre-coded 'unit of meaning' (Gan & Hill, 2014) was distributed into the CML model's personal and sociocultural contexts for children and its personal, sociocultural and physical contexts for teachers.

With multiple instruments like the teachers' and children's semi-structured group interviews, observational data, field notes, and audio and video recordings of the scientific play sessions, with sociocultural discourse analysis as the backbone, the themes were organised using Falk and Dierking's (2000) CML. The findings were mapped onto the personal and sociocultural contexts, the two contexts in the CML model, and presented in two narrative reports, in Chapter 6 (for children's perspectives) and Chapter 7 (for teachers' perspectives).

3.8 The role of the researcher

In this mixed-methods research, the role of the researcher was vital because, even in the quantitative part, she was the primary data collection instrument (Creswell & Creswell, 2018). The interpretivist or constructivist researcher had to base her data on the participants' views (Creswell, 2003, p.8) – the children's and teachers' perspectives on play and primary science being studied. It is essential to note that the way in which the researcher interpreted the data would be linked to her own background and experiences (Creswell & Creswell, 2018). Therefore, the researcher needed to be aware and identify her personal values, assumptions and biases before starting the study (Creswell & Creswell, 2018). It is inevitable in qualitative research that the researchers will influence the research process and the knowledge produced (Yardley, 2008, p.237). The researcher will be deeply involved with the data in one way or another via their perceptions once they start coding. Despite this, Locke, Spirduso and Silverman (1987) argue that the researcher's contribution to the research setting can be supportive and constructive, rather than harmful.

With this in mind, the researcher was conscious of the possible biases that she may bring to the research and decided to opt for a non-participating observer role in the field; she was not involved in the actual teaching or in conducting the scientific play sessions. The researcher's role was mainly one of logistics, where she sourced and packed the materials needed and set up the recording devices for the scientific play sessions. She had arranged to meet the teachers to brief them on what they needed to do in order to carry out the scientific play sessions. The two play protocols were sent to them in advance of their teaching sessions to familiarise them with the materials. As an observer in the study, the researcher took field notes to indicate interesting observations that would be helpful later in analysing the data. There is also the issue of ethics, which is discussed in the next section.

3.9 Ethical considerations

In this study, before the data collection started, a research proposal, the three different consent forms (for children, parents and teachers), the play protocols, the interview schedules for the teachers and the children, together with the Ethical Issues Audit Form, were submitted and approved by the University of York's Education Ethics Committee. Samples of these documents are attached in Appendices 3.2, 3.3 and 3.4. A separate application containing the research proposal and supporting documents, as well as the university's confirmation of ethical approval, was also submitted to the Ministry of Education (MOE) in Singapore to seek approval to collect data in Singapore schools.

After the first two layers of ethical approvals from the university and the MOE in Singapore, the researcher then approached the schools to gain another round of approval from them. Consent was sought from the schools' various stakeholders and gatekeepers, including the principals, the heads of department (science) and the science teachers, via a consent form given to each of them (see Appendix 3.5). The research aims (Hall, Hume & Tazzyman, 2016) were communicated and made known to all gatekeepers and participants on these consent forms.

In an interesting anecdote recalled during the interviews, the children pointed to the researcher and said that the research aims were written on the consent form when she tried to explain the research aims to them before starting one of the interviews. Trust and good rapport with the participants will be increased if they are notified about the study (Crow, Wile, Health & Charles, 2006) and the details were communicated to the participants accordingly. Although informed consent via the written consent forms had already been sought before the interviews, special care was taken before every interview with the teachers and children; the researcher would still ask politely and obtain verbal consent from the participants again before proceeding with the interviews. Children's assent was also sought before the start of every scientific play session and interview. The children whose parents had not given consent were highlighted to the researcher to ensure that the child would not be filmed in the video or interviewed. After the interviews and member-checking process, the interviewees were asked again if their data could be used to gain their consent (Hall, Hume & Tazzyman, 2016). Positive informed consent was vital, because weak consent usually leads to poor data as participants might try to hide or protect themselves (Miles, Huberman & Saldana, 2020).

The study was also specially planned to blend into the usual science lesson and be less disruptive. Minimised risk and harm were ensured in light of all participants' welfare and well-being in this study. All materials provided in the case studies were carefully selected and it was ensured that they were safe, non-poisonous and child-friendly to manipulate and play with. The lesson venues were kept to the usual rooms that the teachers used so that teaching could be carried out in such a way as to minimise changes and disruption. Furthermore, the researcher, who is still employed by the MOE in Singapore, is a trained and experienced primary school teacher and has experience working with children aged 8–9 years.

Confidentiality and anonymity of the data were ensured, with the names of the schools, teachers and children being coded and given pseudonyms when referred to in the transcripts or field notes. Pictures taken or used would only show the children's hands or work without identifying them (for example, by their uniforms). All data collected were recorded and transcribed following the university's ethical procedures and anonymity. One usual science lesson, two recorded scientific play sessions and the group interviews were all carried out within the school's normal hours, carried out in the designated school compound arranged by the participating teacher for the researcher, in an open venue, with the school's teacher and lab technicians (if any) present at the venues. All possible ethical considerations to be taken in school were abided by.

(a) Data storage

Raw data and other materials, such as instruments and details of the procedures, were stored under lock and key, as required by the university's policy. Any data that could identify the participants were given identifier codes on data files to ensure confidentiality, and the list of participants and their identifier codes were stored separately in a locked cabinet (Holmes, 2012). It was also important that the groups' interactions and interview transcripts did not include the participants' names and were anonymised and stored on the university's password-protected Google drive, encrypted with two layers of passwords, protecting against any avoidable accidental data leakage. Backup information and data were also encrypted with passwords and placed in different locations and drives.

3.10 Quality of data, validation and triangulation

In this research study, the quality of the data is enhanced by the mixed-methods approach used. As argued by Bryman (2016) and Denscombe (2014), the mixed-methods approach is versatile and has a high degree of reliability, whereby the different methods could complement each other and not compromise the data. Reliability refers to the consistency of getting the same results when the same measures are repeated by another researcher with a different group (Yardley, 2008), while validity is defined as a piece of research claiming what it is capable of doing (Goodman, 2008). The findings of this study have enhanced reliability and validity because they came from many varied sources. These sources were: teachers' and children's group interactions with utterances during the scientific play sessions, the children's group interviews, the teachers' individual interviews, and field notes from the researcher’s observations and video recordings. All the data were collected using the mixed-methods methodology, and embedded in a sociocultural context. These varied sources allow data triangulation, ensuring the quality and validity of the data. Triangulation is defined as using two or more data-collection methods (using the mixed-methods approach, this includes both quantitative and qualitative data) to study some aspects of the richness and complexity of human behaviour from more than one standpoint (Cohen, Manion & Morrison, 2000).

Moreover, the data collection instruments, such as frequency counts (see Chapter 4) and interview schedules, underwent a few rounds of piloting with participants before the actual study and this made the tools more credible and reliable. For example, the ‘Primary Science Talk Framework with Play’ (PSTFP) nodes were fine-tuned and adjusted until the nodes were stable, mutually exclusive, and improved based on the pilot findings. All the children and all the teachers used the same tools: the Play Protocols with the same play materials, PSTFP and the exact interview schedules for all scientific play sessions and interviews. Fidelity to the procedures and materials was ensured for a fair test in the study.

Next, inter-rater reliability was carried out to validate the analysis process of this study (Braun & Clarke, 2013) and compare the reliability of the new framework’s coding schemes. Another coder was given the exhaustive list and codes and asked to carry out coding independently, then their codes were compared (Vulliamy & Webb, 1992). The level of agreement between the codes was calculated using Cohen’s Kappa, where a Kappa of >.80 indicates a very good level of agreement and supposedly ‘reliable’ coding (Yardley, 2008). In this research, a .64 inter-rater reliability was established with a third-party coder using the list given, which was substantial on the strength of agreement (Salkind, 2010). Therefore, if we think of reliability more broadly as ‘trustworthiness’ or ‘dependability’, some version of reliability is still applicable here (McLeod, 2001).

Next, this section proceeds to the issue of limitations of this research.

(a) Limitations

Although the researcher did start by trying to recruit any random schools within the criteria set out in Section 3.33 (b), in the end the schools that consented with strong support were schools with which the researcher had a good working relationship or friendship with the Head of Department (HOD) of Science in the school or the school leader. Although, in the end, the samples were obtained via convenience sampling (Bryman, 2016), which Cohen, Manion and Morrison (2007) argue has low ecological validity, the participating classes were assigned by the schools. The HODs or school leader whom the researcher knew were not directly involved in the research or in teaching the assigned classes, making the data less biased. As discussed earlier, it is probable that the absence of an all-boys school participating was limiting for this research.

Another limitation observed was that play tends to lend itself more to physical science topics (such as magnets in this study), rather than biological science topics. There was also a newly emerging issue that caused a limitation observed in the field. Although this research talked about being free and the children being able to venture in the way they wanted or wished for, the reality was, sometimes, that we (the researcher and teachers) were not ready when resources were damaged during the act of play (for example, because they were not waterproof) and play was also limited by the number of sets of equipment that the school had to start with.

Lastly, the concept of relatability, whereby the degree of relatedness as to whether knowledge gained from one context is relevant or applies to other contexts, or the same context in another time frame (Dzakiria, 2012), was also looked into in this study. It assumes a role similar to generalisation (Dzakiria, 2012). For this research study, whether it is generalisable depends on the reader and how they would like to apply the theory elsewhere than the original study (Dzakiria, 2012).

3.11 Conclusion

This chapter has outlined the careful deliberations and choices made in relation to the methodology in order to answer the research questions that the study set out to answer.

Research Questions:

Q1. What are the nature and dominant types of talk among (a) children and (b) teachers during the scientific play sessions?

Q2. To what extent do children and teachers talk about science during the scientific play sessions?

Q3. What are the children's perspectives on play in primary science?

Q4. What are the teachers' perspectives on play in primary science?

With sociocultural discourse analysis as the framework for the research, mixed-methods research was selected. A multiple-case study design was chosen as the research design to present this study in a sociocultural context in classrooms or science laboratories where the spaces, depth and richness of the different cases could be studied. Instruments such as audio recordings, observations and interviews collected many rich data, which were made sense of by interpretation and analysis using many methods; coding and generating themes using a computer-assisted programme, *NVivo*, and analysed using *SPSS*. It was the work of an ethical researcher who was a non-participatory observer, and aware of her biases as far as possible. The findings are presented in the next few chapters.

Chapter 4 presents the new 'Primary Science Talk Framework with Play' (PSTFP), which was created by the researcher in this study, adapted from both Simon et al.'s (2008) Discourse Analysis Framework and Falk and Dierking's (2000) Contextual Model of Learning. The chapter includes an explanation of how this new framework was developed from the two above-mentioned frameworks and modelled as a result of the gaps present in the original frameworks in order to answer the research questions in this study more fully and adequately. As this research study had a mixed-methods research design, the findings from the methods used are discussed in the following few chapters. Chapter 5, which is mainly quantitative, reports the findings on the nature and dominance of the different types of talk for all talk and science talk by the children and teachers during the scientific play sessions. The findings in this chapter are also further illustrated with examples of qualitative quotes to support the narratives presented. Chapter 6 is primarily qualitative and reports the findings in a narrative way, describing the children's perspectives on play, while Chapter 7 is also qualitative and reports the findings on the teachers' perspectives on play.

Chapter 4 The Primary Science Talk Framework with Play (PSTFP)

4.0 Introduction

The researcher developed the Primary Science Talk Framework with Play (PSTFP) for data analysis to explore the nature of talk that children and teachers engage in while playing in science. Initially, the researcher was attracted to Simon et al.'s (2008) discourse analysis framework (DAF), in which puppets were used as a medium to encourage children to talk. The framework was then used to study the nature of children's discourse and the frequency of their utterances in a science class. For this study, however, the children used free play as a medium to encourage talk instead of puppets. Therefore, drawing parallels between the two designs in terms of the research aims, the PSTFP framework allows the researcher to study the nature and frequency of classroom talk during the scientific play sessions. Moreover, Simon et al.'s (2008) DAF was a relevant and close match to this study because it had a coding scheme that could classify classroom talk and analyse the data.

Although Simon et al.'s framework was quite a close match to this study, the researcher identified a gap in it. The researcher realised that it was unable to determine the extent of scientific and non-scientific talk that children engaged in during their scientific play. This was also the case for the other model chosen for data analysis, Falk and Dierking's (2000) CML, which has no coding scheme but only key factors grouped within three contexts. This gap in Falk and Dierking's (2000) CML makes it inadequate to answer the research questions in this study. However, when both framework and model were combined, they complimented each other well and, with some adaptations made by the researcher, the PSTFP framework was created as a better fit to answer this study's research questions. The PSTFP was adapted from the pre-existing framework and model. The researcher in this study thus created the Primary Science Talk Framework with Play (PSTFP) by combining Simon et al.'s (2008) discourse analysis framework and Falk and Dierking's (2000) Contextual Model of Learning.

This chapter highlights the step-by-step development of this new framework; where it originally came from, how it progressed and what the researcher went through to finally come up with the new design of the PSTFP to answer the research questions set in this study.

4.1 Simon et al.'s (2008) discourse analysis framework

Simon et al.'s (2008) study [see Section 2.44 (a)] was a mixed-methods study undertaken to investigate children's talk and engagement in science in primary classrooms in the UK. Simon et al.'s study focused on children's talk that promotes reasoning in science. Likewise, for this study, during the scientific play sessions, children had some opportunities to question and reason through talk. Simon et al. (2008) argue that these opportunities for children to talk are essential and can help to promote their reasoning and improve their understanding and learning in science. To understand Simon et al.'s (2008) DAF better, it is imperative to look at the list of original codes used in their coding scheme. Attached below, Table 4.1, shows how the codes are represented by a single letter, with some examples given as illustrations. The children in the class are assigned 'C' and teacher 'T'. The teachers' and children's utterances were recorded and coded accordingly in an observation schedule table shown in Tables 4.2 and 4.3.

Code	Meaning	Illustration
Q	Reasoned questions	Open questions that present a problem. Questions that require reasoned answers.
N	Non-reasoned questions	Questions that do not require a reasoned answer. Closed, theoretical or non-science questions.
L	Language	Features of language: focus on the use of words rather than ideas and concepts, e.g. correcting grammar or introducing vocabulary.
A	Argumentation	Use of ideas to challenge or justify a point of view.
F	Feedback	Offers a superficial response that does not promote thinking or challenge for further explanation.
E	Encourages	Offers praise or positive endorsement.
R	Recall	Recalls information from memory or accesses previously learned knowledge.
O	Observation	Describes something in the classroom. Reads from a worksheet or the board.
P	Procedure	Gives information or instruction, or discusses things that relate to the procedure to be followed.
S	Story and character	Creates a contextualising narrative in which scientific concepts can be applied to give the lesson a sense of purpose.

Table 4.1: A table showing the codes used in analysing the nature of discourse in a science lesson (Simon et al., 2008).

Children's Code (Class Lesson)

Code	Tally Table of Frequency (𝍸)		Total
	S1	S2	
CQ			
CN			
CL			
CA			
CF			
CE			
CR			
CO			
CP			
CS			

Table 4.2: A tally table for scoring the frequency of different types of children's talk during the usual science lesson, adapted from Simon et al. (2008).

Teacher's Code (Class Lesson)

Code	Tally Table of Frequency (𝍸)		Total
	S1	S2	
TQ			
TN			
TL			
TA			
TF			
TE			
TR			
TO			
TP			
TS			

Table 4.3: A tally table for scoring the frequency of different types of teacher's talk during the usual science lesson, adapted from Simon et al. (2008).

4.11 Strengths and limitations of Simon et al.'s (2008) DAF

Before the decision was made to use Simon et al.'s (2008) DAF in this study, its strengths and limitations were compared and weighed. In this section, the strengths and limitations of Simon et al.'s (2008) DAF will be presented and discussed.

There was a high congruency in the research aims for Simon et al.'s (2008) study and this study. Simon et al.'s (2008) DAF was chosen as one of the frameworks to be used in this study due to the similarities and matching aims of both Simon et al.'s (2008) study and this study. Firstly, both studies were investigating classroom talk. Classroom talk was important in this study because, in a typical Asian classroom, children's talk is usually suppressed and the lesson is dominated by the teacher. The inclusion of a scientific play session as part of the science lesson aimed to provide contexts where classroom talk could take place to allow children to articulate their ideas in a safe environment. Besides stimulating and increasing the students' motivation to learn, classroom talk also helps to increase engagement (Alexander, 2015). Likewise, there was also an interest to see if, like the puppets, the scientific play sessions could help to increase the motivation of learners. The code schemes in Simon et al.'s (2008) DAF could account for the frequency of the types of talk uttered by the children in the scientific play sessions. The code schemes also gave some valuable insights for the researcher into what the children said and did when they played in science. Moreover, the targeted age group is also similar. Both Simon et al.’s (2008) study and this study were designed for primary school-aged children. Simon et al.’s (2008) study involved children aged 7–11 years, while this research focused on children aged 8–9 years. The subject studied in both cases was primary science and this increased the compatibility of Simon et al.’s (2008) DAF to be used for this study.

In terms of limitations, Simon et al.’s (2008) study differed in a few ways when both studies were compared. For example, Simon et al.’s (2008) study was more dialogical in nature, with an emphasis on the teacher steering the conversation, the pre-puppet and introduction to the lessons. In contrast, this study’s emphasis was more on the children’s utterances and not the teachers’ dialogic talk. The children had more ownership in their conversations with both their peers and teachers, and they could speak freely. Additionally, there was also no emphasis on any particular part of the scientific play session, but rather on the whole lesson in this study. According to Simon et al. (2008), this difference would result in a difference in the utterances collected, unless specific measures were taken to correct it. Moreover, in Simon et al.’s (2008) study, a time-related observation schedule of 30-second time intervals was used. This differed from this study, where the intended observation schedule was used for the entire scientific play sessions.

Although there were limitations to Simon et al.’s (2008) study, its strengths outweighed those limitations. Furthermore, there are no frameworks researched so far that come close to what Simon et al.’s (2008) DAF could offer in terms of understanding talk in a primary science context. The DAF needed a few adaptations to fit into this study and answer the research questions. Therefore, it was deemed suitable to be used as one of the two antecedents to this study. However, as discussed earlier, it was not sufficient on its own but would combine well with Falk and Dierking’s (2000) contextual model of learning (CML), which does not focus on talk. The CML contributed by filling a gap in Simon et al.’s (2008) study and focusing on the missing contexts that support learning in a classroom, while Simon et al.’s (2008) complemented Falk and Dierking’s (2000) CML with the missing part on talk. In the next section, the discussion moves on to the second of the two selected models – Falk and Dierking’s (2000) Contextual Model of Learning.

4.2 Falk and Dierking's (2000) Contextual Model of Learning

Falk and Dierking's (2000) Contextual Model of Learning is a model that has been used to understand how learning takes place in informal settings such as museums, away from the formal setting of school [see Section 2.4]. As there were many problems with the term 'informal', which is often tagged with external agencies or institutes, Falk (2005, p.272) argued that it should be replaced by the term 'free choice' learning, which is more apt and is able to withstand "the positive and negative biases that currently surround schooling". This describes contexts where learners have freedom over what and how they learn, as is the case in the scientific play sessions in this study. This model presents a scenario where an individual's personal, sociocultural context and the physical contexts of their learning environment interact and result in the unique learner's contextual learning experience, determining the degree of engagement (Falk & Storksdieck, 2005).

4.21 Strengths and limitations of Falk and Dierking's (2000) Contextual Model of Learning

Like Simon's et al.'s DAF, the strengths and limitations of Falk and Dierking's (2000) Contextual Model of Learning (CML) were compared and weighed before a decision was made to use it. In this section, these strengths and limitations will be presented and discussed.

In terms of strengths, Falk and Dierking's (2000) CML fits well with this study because play is a social activity in which children and teachers are involved in the classroom. The research for this thesis emphasises the learners' experiences; trying to look at how children interacted with their peers and teachers and their perspectives on the relationship of play with the learning of science when play was introduced. The free-choice setting in this study allowed children to set the pace for themselves and voluntarily participate during the scientific play sessions. This free-choice aspect offered to the children coincided with the informal learning context offered in Falk and Dierking's (2000) CML and thus matched in both studies. Moreover, although this study was conducted in schools, the nature of the scientific play sessions allowed the children to make choices that fulfilled the criteria of 'free-choice learning'. Furthermore, Falk and Dierking's (2000) CML has overlapping similarities with Simon et al.'s (2008) DAF. This enabled Simon et al.'s (2008) DAF to be subsumed into Falk and Dierking's

(2000) CML, which is a bigger model, to create the new 'Primary Science Talk Framework with Play' (PSTFP).

As to its limitations, Falk and Dierking's (2000) CML differs in a few ways from this study. For instance, the CML emphasises three contexts: personal, sociocultural and physical contexts, which support learning. It has no coding scheme and does not focus on talk. In addition, because this study mainly took place in classrooms or science laboratories, the CML's physical context could not be used because the children and teachers did not have much choice about entering these venues. The venues were all restricted and assigned to them in this study. The children and teachers were not given a choice to refuse to enter because the scientific play sessions were part of the science lessons in school.

Despite having limitations, Falk and Dierking's (2000) CML fitted in very well with this study because the play took place within a sociocultural context, influenced by the personal context of the participating parties. The CML was also very flexible, so this study could be mapped onto it and could be used a tool to triangulate the sets of data in this study. Thus, it was decided that Falk and Dierking's (2000) CML was a good fit for this study and could be used in the collection and analysis of the data. Now, with the two antecedents having been scrutinised and the decision made to use them, this chapter proceeds to the next section, where a stage-by-stage account of what happened to help shape the final creation of the PSTPF, an important observation schedule designed to answer the research questions of this study.

4.3 Creation of a new framework based on Simon et al.'s (2008) discourse analysis framework and Falk and Dierking's (2000) contextual model of learning

This section describes the stages that the researcher went through in this study with Simon et al.'s (2008) discourse analysis framework (DAF), before it was finally adapted and used in combination with Falk and Dierking's (2000) Contextual Model of Learning (CML) to create a new framework for classifying talk in free-choice science learning settings. It is essential to state that there was an emphasis on the teachers' dialogical teaching and control in Simon et al.'s (2008) original discourse analysis framework. This section also shows how the researcher navigated through the iterative processes of fine-tuning the coding scheme of the original framework to finally arrive at the finalised coding scheme used in this study.

<u>Stage 1</u>:

Simon et al.'s (2008) discourse analysis framework was first used in its original form to analyse the play transcripts (see Tables 4.2 and 4.3). However, when coding using this framework, the code 'language' did not fit well into this research study as it was not the focus of the research. A decision was made to remove that code, and the total number of codes was thus reduced from 10 to 9. Next, there was also one part of Simon et al.'s (2008; p.1236) framework where the code CN is defined as:

1. Reasoned Question (Q)
2. Non-Reasoned Question (N)
3. Language (L)
4. Argumentation (A)
5. Feedback (F)
6. Encourages (E)
7. Recall (R)
8. Observation (O)
9. Procedure (P)
10. Story and Character (S)

→

1. Reasoned Question (Q)
2. Non-Reasoned Question (N)
3. Argumentation (A)
4. Feedback (F)
5. Encourages (E)
6. Recall (R)
7. Observation (O)
8. Procedure (P)
9. Story and Character (S)

Non-reasoned questions: Questions that do not require a reasoned answer. Closed, rhetorical or non-science questions.

Figure 4.1: A diagrammatical representation of how 10 codes were reduced to 9 codes

In stage 1, the researcher disagreed with the way in which the authors had coded CN. A non-science question can still be a reasoned question, just without the scientific content, and a closed science question that used to be coded as CQ (reasoned) which the children sometimes answered with a 'yes' or 'no' without much reasoning, thinking and most importantly direction, was moved to this category. Hence, the researcher modified this category for non-reasoned questions.

<u>Stage 2</u>:

When Simon et al.'s (2008) DAF was used to run the audio recordings of the children's group utterances, it was noticed that this framework has some similarities with Falk and Dierking's (2000) CML. A decision was thus made to put both frameworks side by side and compare them. An attempt was made to reorganise all nine remaining codes into the two contexts in the CML framework: the ‘Personal Context’ and ‘Sociocultural Context’ (see Figure 4.2).

As seen in Figure 4.2, it was possible to match all nine codes with the key factors in the personal context of the CML framework very well. As for the sociocultural context, all nine nodes could be comfortably placed in that context as well because play is a social activity and the whole scientific play session fits very well into this context. Although play is very similar to the idea of informal learning proposed in the CML, the venue of this research study was restricted to classrooms or science laboratories, so the ‘Physical Context’ of the CML was removed. With ‘Physical Context’ removed, it was seen that the whole of Simon et al.’s (2008) DAF could very well be situated within the CML, as the CML is the bigger framework and encompasses the DAF. These two frameworks were found to be complementary to each other.

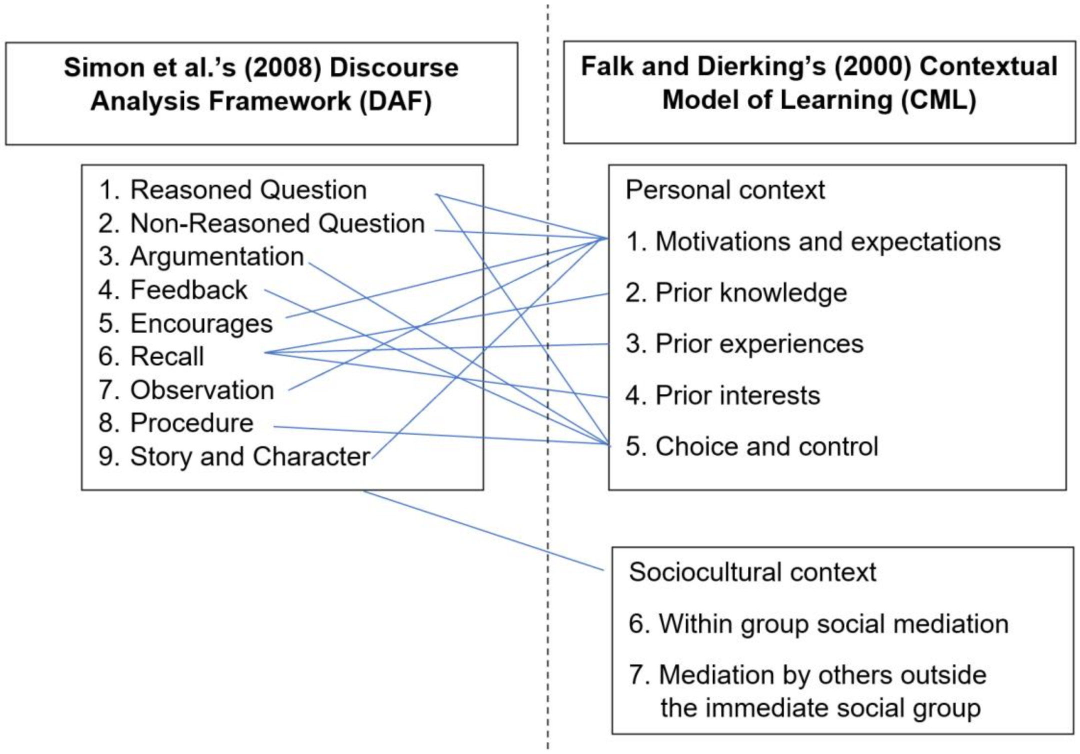


Figure 4.2: A comparison table where Simon et al.’s (2008) Discourse Analysis Framework (DAF) (shown on the left above) was compared with the Falk and Dierking’s (2000) Contextual Model of Learning (CML) (shown on the right above).

Stage 3:

With the newly found relationship established, the audio recordings were repeatedly listened by the researcher again and analysed. She noticed certain features of how the children played, such as advising peers on what was the right thing to do, and the rules they needed to abide by in class, and children explaining to their peers how to do certain things. A decision to create a whole new set of three-letter codes was made, in order to capture what was observed and informed by the scientific play sessions in the pilot study, as well as in the actual scientific play sessions, placed under 'Sociocultural Context' (see Table 4.4). Six new three-letter codes were especially created to differentiate the source of the codes (i.e., that they were not from Simon et al.'s original framework) and were created to fit into Falk and Dierking's (2000) CML under the sociocultural context, which was prominent in this study.

The Sociocultural Context (proposed new three-letter codes)	
CMG (Children Mediating Group)	
CMO (Children Mediating Others)	
OMC (Others Mediating Children)	
CPA (Children Playing Alone)	
CPG (Children Playing in Group)	
CSN (Children Advising Social Norms)	

Table 4.4: A proposed adapted framework with the new three-letter codes for sociocultural context.

Stage 4:

After the addition of the three-letter codes to the original coding scheme found in Simon et al.'s (2008) study, the adapted framework was used to analyse the audio recordings. However, looking further at the newly adapted framework, there was also interest in investigating how much the children carried out science talk during their interactions with other children in the scientific play sessions. After much consideration, a further demarcation was then made to all the codes to classify them into 'science' and 'non-science' to differentiate and identify the utterances (see Table 4.5).

<table>
<tr><th colspan="5">The Sociocultural Context (Proposed New 3 letter codes)</th></tr>
<tr><td></td><th colspan="2">Science</th><th colspan="2">Non-Science</th></tr>
<tr><td>CMG (Child Mediating Group)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>CMO (Child Mediating Others)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3">OMC (Others Mediating Children)</td><th colspan="2">Child</th><th colspan="2">Teacher</th></tr>
<tr><th>Science</th><th>Non-Science</th><th>Science</th><th>Non-Science</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><th colspan="2">Science</th><th colspan="2">Non-Science</th></tr>
<tr><td>CPA (Child Playing Alone)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>CPG (Child Playing in Group)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>CSN (Child Advising Social Norms)</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Table 4.5: An adapted framework with utterances classified under ‘Science’ and ‘Non-science’.

Stage 5:

Using this adapted framework of science and non-science categories, the audio recordings were examined again. However, some overlapping codes were noticed (CMG with CPG, CMO with CPA and CPG), which were not mutually exclusive. These codes posed some problems and even though the three-letter codes did match the audio recordings, it was decided that this whole section of sociocultural context would be dropped as they overlapped and related more to observations that were visible rather than audible. This then brought the researcher back to Stage 4.

Stage 6:

Restarting from Stage 4, the audio recordings were analysed again. This time, the code for ‘procedural’ talk was coded many times and became a very large category where many nodes could find themselves. Some of the nodes were subsets of both codes in the adapted framework and posed some problems. The framework was once again modified to allow ‘procedural’ talk to be part of the relevant node subcategories, instead of a node on its own. The number of nodes for the sociocultural context was increased to include a finer grain for the whole section, expanding the categories where ‘procedure’ can be coded in a more specific manner.

Looking back, the data enabled the researcher to see the rise in the children's freedom because they had taken more “choice and control”, which is visible in the increased frequency count. This differs from a usual classroom interaction, where the teacher is the one in control. This was also unlike the case in Simon’s framework, where the teacher was the main person talking in the contexts set up by the teachers, taking a more dialogical approach. Many utterances communicating this point were surfacing and, looking back at the CML, a decision was made to introduce another new code into the nodes for personal context: ‘Choice and Control’.

<u>Stage 7</u>:

The iterative process of developing the framework was similar to piloting the data, as Bryman (2016, p.298) argues, and helped to identify which code attracted “a substantial percentage of items”. The node ‘Choice and Control’ was too general, and the utterances coded under this node overlapped with the original nodes. Some more overlapping codes were found when coding with the audio recordings, and the number of utterances under the node of ‘Choice and Control’ was found to be very high. The researcher followed Bryman’s (2016) suggestion, and broke this node into more categories to allow greater discrimination between utterances as they were coded and analysed, decreasing the chances of codes overlapping.

A decision was made to use *NVivo* as the data management software, and the transcripts of the audio recordings were analysed in *NVivo* in order to keep track of and account for what was being coded. Before the transcripts were analysed in the software, a ‘unit of meaning’ with clear boundaries in terms of its thematic content (Gan & Hill, 2014) with only a single theme was clarified and identified in the scripts to minimise the possibility of overlapping codes [refer to Section 3.73 (a)]. Clear boundaries and instructions were set up to ensure that mutually exclusive categories of nodes with no overlap were enforced and all that possible categories of nodes were exhaustive, i.e. the code will be mutually exclusive and will only code one utterance. With that in place, the audio recordings’ transcripts were used to code using *NVivo. NVivo* was used to recode all the utterances coded to the contexts: Personal Context and Sociocultural Context. *NVivo* is a good tool and allows a more systematic way of coding.

The node on ‘choice and control’ was becoming clearer and the frequency count of the utterances was more consistent than before. The recordings were analysed again using the new framework, which was then used to analyse the remaining recordings with different groups of children and different schools. The codes were stable, and the data shows saturation of the codes. The units of meaning were no longer overlapping and each one coded exclusively to only one node. This was an indication that the framework was robust enough to be used as the final framework. Eight evidence-informed sub-nodes (see Table 4.6) from the children’s utterances were uncovered and created.

The new set of sub-nodes for ‘choice and control’ was now a better fit and was able to reflect what the research was about: informal learning using play. With play as the medium used for this research study, the final version of the framework was a more appropriate fit to study the nature and frequency of the children’s utterances in science talk during their science lessons.

1.2 Child’s Choice and Control
1.21 Child Instructing Peers
1.22 Child’s Own Choice of Action
1.23 Child Teaching Peers
1.24 Child Negotiating Materials
1.25 Child Getting Help
1.26 Child Seeking Reassurance
1.27 Child Abiding by the Science Routine Rules
1.28 Child Interacting with a Peer from Another Group

Table 4.6: A list of eight new sub-nodes that were coded under child’s choice and control.

The freedom and the children’s choice and control over the scientific play sessions in this research study blended well with the features of Simon et al.’s (2008) framework and Falk and Dierking’s (2000) CML, to become the fundamental structures of this final version of the new adapted framework. The final framework (Tables 4.7 and 4.8) was specially tailored to cater to ‘play’ and can be used to quantify classroom talk in science, indicating the amount of ‘science-related or non-science related types of talk’ that were exchanged or present in this study.

Stage 8:

Following Simon et al.’s (2008) DAF, each utterance was coded to a primary node (there are eight of them, Table 4.7), which consists of two letters. The original two-letter coding system from Simon et al.’s (2008) model was used, and a three-letter coding system was created for the codes associated with the CML model. This difference in the number of letters helps to differentiate the two sources and also to show whether what was coded was the main node or a sub-node. A three-letter code was created for each of the eight sub-nodes, similarly to the two-letter codes, where the second and third letters indicated the types of utterance.

Many rounds of iterative coding, recoding and fine tuning of the nodes were completed until saturation was reached (Bowen, 2008). When additional data (with at least seven sets of the groups’ utterances) from the field were used, saturation took place and did not generate any more new information (Morse, 1995; Sandelowski, 1995). The nodes were stable and were used to code all remaining audio recordings of the groups’ utterances collected from the field during their scientific play sessions. The final new framework to be used for this study was finalised and was named the ‘Primary Science Talk Framework with Play’ (PSTFP). It codes for 17 types of talk for children and 13 types of talk for teachers, as shown in Tables 4.7 and 4.8.

Simon et al.'s (2008) Discourse Analysis Framework (DAF)	1.1 Children's Questions (QN) 1.11 Child's Reasoned Questions (CQ) 1.12 Child's Non-Reasoned Questions (CN)
Falk and Dierking's (2000) Contextual Model of Learning (CML)	1.21 Child Instructing Peers (CIP) 1.22 Child's Own Choice (COC) 1.23 Child Teaching Peers (CTP) 1.24 Child Negotiating Materials (CNM) 1.25 Child Getting Help (CGH) 1.26 Child Seeking Reassurances (CSR) 1.27 Child Abiding By the Science Class Routine Rules (CAR) 1.28 Child's Interacting with Peer from Another Group (CIA)
Simon et al.'s (2008) Discourse Analysis Framework (DAF)	1.3 Child's Encouragements (CE) 1.4 Child's Observations (CO) 1.5 Child's Recalls (CR) 1.6 Child's Stories and Characters (CS) 1.7 Child's Argumentations (CA) 1.8 Child's Feedbacks (CF) 1.81 Reasoned Feedbacks (R) 1.82 Non-Reasoned Feedbacks (NR)

Table 4.7: The Primary Science Talk Framework with Play (PSTFP) for children.

Simon et al.'s (2008) Discourse Analysis Framework (DAF)	2.1 Teacher's Questions 2.11 Teacher's Reasoned Questions (TQ) 2.12 Teacher's Non-Reasoned Questions (TN)
Falk and Dierking's (2000) Contextual Model of Learning (CML)	2.21 Teacher Instructing Children (TIC) 2.22 Teacher Teaching Children (TTC) 2.23 Teacher Offering Help (TOH) 2.24 Teacher Giving Reassurances (TGR)
Simon et al.'s (2008) Discourse Analysis Framework (DFA)	2.3 Teacher's Encouragements (TE) 2.4 Teacher's Observations (TO) 2.5 Teacher's Recalls (TR) 2.6 Teacher's Stories and Characters (TS) 2.7 Teacher's Argumentations (TA) 2.8 Teacher's Feedback (TF) 2.81 Reasoned Feedbacks (R) 2.82 Non-Reasoned Feedbacks (NR)

Table 4.8: The Primary Science Talk Framework with Play (PSTFP) for teachers.

Using the PSTFP (Tables 4.7 and 4.8), the nature and dominant types of talk used by the children and teachers were analysed from the utterances collected during the scientific play session 1 (S1) and the scientific play session 2 (S2) over two science lessons. The final framework was of an emergent design and it was through countless rounds of iterative moving backwards and forwards that the final framework was created and established (Creswell & Creswell 2018) to be used for this research study. *NVivo* was used as an important piece of software to help classify all the utterances in the group play in the classes accordingly, accounting for the quantitative frequency count of the types of talk described in the next chapter, Chapter 5.

4.4 Conclusion

The Primary Science Talk Framework with Play (PSTFP) is a new framework created especially and specifically for this study by merging Simon et al.'s (2008) DAF and Falk and Dierking's (2000) CML. With the personal and sociocultural contexts of Falk and Dierking's (2000) CML model as the base, and Simon et al.'s (2008) types of talk from their DAF included, the new model adds the dimensions of choice and control and further distinguishes all talk into science and non-science talk.

With the establishment of this new framework through the iterative process of adjustment in coding and testing it, the PSTFP for both the children and teachers took shape and 'stabilised' as the data used to classify it became saturated. It was then robust enough to be used in this study to answer the research questions. With the PSTFP ready as an appropriate instrument for this study, the findings from the data could be collected and discussed. The next chapter, Chapter 5, examines the nature and type of all talk and science talk used by the children and teachers.

Chapter 5: Reporting Results – Children's Group Talk and Teachers' Talk during the Scientific Play Sessions

5.0 Introduction

This chapter addresses the first two research questions of this study:

Q1. What are the nature and dominant types of talk among (a) children and (b) teachers during scientific play?

Q2. To what extent do children and teachers talk about science during scientific play?

The results presented in this chapter are based on the recordings of 15 groups of children (three groups per class) (n = 62) in five different classes during two scientific play sessions where new content on magnetism was taught: first recorded session (S1) and second recorded session (S2), which both lasted 15 minutes[5] All children were aged 8 to 9, were in Primary 3 level and were observed during their scientific play sessions. The scientific play sessions were conducted according to the designed play protocols (Appendices 1.1 and 1.2). Audio recordings were transcribed verbatim and analysed using *NVivo*. For all sections (5.1–5.4), the quantitative data comes from frequency counts of the utterances transcribed and coded into the types of talk employed by the children and teachers, using the 'Primary Science Talk Framework with Play' (PSTFP, see Chapter 4) during the scientific play sessions. Frequency counts are expressed as percentages based on the total number of utterances in the session to compare groups of children and teachers. Qualitative data (in the form of transcripts from the audio recordings) is used to illustrate the quantitative results. Pseudonyms are given to the children in this chapter. Field notes recorded by the researcher were also used to provide context for claims made based on the qualitative and quantitative results.

This chapter aims to answer the first two research questions.

[5] All the classes had sessions which lasted about 15 minutes, apart from two classes in S2, where they were reduced to 5 minutes due to other school activities, such as school assembly.

Section 5.1 discusses the ‘nature and dominant types of talk’, and addresses parts (a) and (b) of research question 1. It explores the nature and dominant types of all talk by both children and teachers during the scientific play sessions. In this study, all talk refers to the total of science and non-science talk uttered by the children and teachers. Based on the data, 17 types of talk for children and 13 types of talk for teachers were identified. This section answers research question 1 above.

Section 5.2 covers ‘the extent of the discussion of science in scientific play’. In this section, the findings on the amount and type of science talk engaged in by both the children and teachers during the scientific play sessions is presented. This section answers research question 2 above.

Section 5.1 and 5.2 concludes with an overview of the primarily quantitative findings (Sections 5.1–5.2), supported by qualitative findings (presented as bold text in Sections 5.1– 5.2), answering the first and second research questions.

Section 5.3 presents the results of the Kruskal-Wallis test, a non-parametric statistical test on the 17 types of children’s talk and 13 types of teacher’s talk. This section presents the differences in talk between the children’s groups described by teachers as having ‘played well’ (Group A), ‘played averagely well’ (Group B), and ‘did not play so well’ (Group C) (refer to Section 3.71) as well as the five different teachers. Pairwise comparisons were performed on the significant means after the Kruskal-Wallis test to determine and pinpoint the differences resulting from the children’s grouping (Group A-C) and types of teachers (Teacher 1-5). This section is quantitative and indirectly answers research questions 1 and 2.

Whilst Section 5.3 does not directly answer the research questions 1 and 2, it provides some insights that are likely to be important for practioners such as the teachers, which is why the results are reported here. More details are further discussed in Section 5.3.

5.1 What are the nature and dominant types of talk among (a) children and (b) teachers during scientific play?

In this study, ‘all talk’ is defined as the total of all the scientific and non-scientific utterances by both the children and teachers during the study. The PSTFP presented in Chapter 4 was specifically created to code all talk during the scientific play sessions.

5.11 Nature and dominant types of talk by children

	First Recorded Session 1 (S1)			Second Recorded Session 2 (S2)		Total (Sessions 1 and 2)	
Code	No. of Utterances		%	No. of Utterances	%	No. of Utterances	%
CQ	346		4.4	363	4.7	709	4.5
CN	534		6.8	504	6.5	1038	6.6
QN*	880		11.1	867	11.2	1747	11.2
CE	338		4.3	267	3.4	605	3.9
CO	649		8.2	792	10.2	1441	9.2
CR	194		2.5	187	2.4	381	2.4
CS	358		4.5	391	5.0	749	4.8
CA	186		2.4	83	1.1	269	1.7
CF	R	1163	14.7	1147	14.8	2310	14.8
	NR	1673	21.2	1519	19.6	3192	20.4
CIP	600		7.6	718	9.3	1318	8.4
COC	584		7.4	523	6.7	1107	7.1
CTP	238		3.0	299	3.9	537	3.4
CNM	186		2.4	85	1.1	271	1.7
CGH	48		0.6	33	0.4	81	0.5
CSR	652		8.3	629	8.1	1281	8.2
CAR	104		1.3	91	1.2	195	1.3
CIA	41		0.5	128	1.6	169	1.1
Total	7894		100.0	7759	100.0	15653	100.0

*QN is not a new type of talk. It is the total of both CQ and CN.

Table 5.1: A table showing the nature of the children's talk (All Talk: S1, S2 and Total).

Key:

Child's Reasoned Question (CQ)
Child's Non-reasoned Question (CN)
Child Instructing Peer (CIP)
Child's Own Choice of Action (COC)
Child Teaching Peers (CTP)
Child Getting Help (CGH)
Child Seeking Reassurance (CSR)
Child Abiding By the Science Routine Rules (CAR)
Child Negotiating Materials (CNM)
Child Interacting with Peer from Another Group (CIA)
Child's Encouragement (CE)
Child's Observation (CO)
Child's Recall (CR)
Child's Story and Character (CS)
Child's Argumentation (CA)
Child's Reasoned Feedback [CF(R)]
Child's Non-Reasoned Feedback [CF(NR)]

Table 5.1 shows that, in the two scientific play sessions, the dominant (most frequent) types of talk observed were Child's Feedback (CF) (non-reasoned [NR] then reasoned [R]), Child's Questions (CQ), Child's Observations (CO), Child Instructing Peers (CIP), Child Seeking Reassurance (CSR) and Child's Own Choice (COC), in decreasing manner of dominance. These six dominant types of talk are discussed in detail below. There was little difference between the two lessons in terms of the dominant types of talk.

Child's Feedback (Non-Reasoned) [CF (NR)]

From Table 5.1, the most dominant type of talk is Child's Feedback (Non-Reasoned) [CF (NR)]. Child's Feedback consists of a broad spectrum of utterances, such as common verbal lingo used by children, short words to continue conversations or sound effects or singing to accompany the play. Utterances were coded as non-reasoned feedback when they did not clearly indicate what the children were trying to convey or the lines of action which might come next.

For example, Sam asked a question: 'This is magnetic?' In response to this question, Nick took a bar magnet and pretended it was a flying plane. He flew the magnet and tried attracting the spoon found in the basket. The 'plane' collided with the spoon and Nick made a 'bang' sound to accompany his play, with the 'plane' attracting the spoon. Then, Nick went on to use another bar magnet to cause it to repel, with like poles facing each other, causing both bar magnets to move apart and accompanied with a 'bouncing' off sound, 'bom'. Sam's responded to Nick, but the response Sam used was dubious and not definitive about what he was trying to say. These words were thus coded as non-reasoned feedback.

Sam: This is magnetic?
Lydia: Spoon….. I didn't know that this …..
Nick: **Bang, *bom*!**
Sam: **And *yah*.**

Child's Non-Reasoned Feedback [CF (NR)], T1G8S1

Child's Feedback (Reasoned) [CF (R)]

The second most dominant type of talk is Child's Feedback (Reasoned) [CF (R)]. Reasoned feedback comprises of a sentence, some phrases, words or a word such as "yes", "no" or "ok". These examples were classified as reasoned feedback because they can indicate the speaker's viewpoint or the direction they were coming from in response to what their peers had said.

In the following example, the children expressed their views on a rod magnet that they were playing with. Hafiz claimed that, by using a rod magnet's repulsion force, he was able to push open a structure that they were building. Adeline disagreed. Then, Gabriel remarked that it was the magnet that he was looking for and he needed it. Adeline responded to Gabriel's reply and commented that the rod magnet was her 'favourite thing'.

Hafiz: I just, I just push [sic] open it.
Adeline: **Haven't *lah*[6]**.
Gabriel: Not, I need!
Hafiz: Oh, ah……..!
Adeline: **Favourite thing**.

Reasoned feedback [CF (R)], T2G9S1

Child's Questions (QN- A summation of CN amd CQ altogether)

The third dominant type of talk is Child's Questions (QN), which consist of Child's Non-Reasoned Questions (CN) and Child's Reasoned Questions (CQ). For CN, the type of questions the children asked was usually short and closed.

In this context, Shimin tried to correct her peers that the material they were playing were magnetic and not non-magnetic ('de-magnetic' as Abigail incorrectly described it). These questions relate to whether specific materials are magnetic and how they know this:

Abigail: Put that non-magnetic thing here.
Joanne: Non-magnetic
Abigail: De-magnetic [sic]
Joanne: No…….!
Shimin: It is!
Li May: It is!
Shimin: I told you one. [sic]
Shimin: **These both magnetic?**
Li May: **It attract [sic] with any magnet, is it?**

Child's Non-Reasoned Questions (CN), T2G9S2

On the other hand, Child's Reasoned Questions (CQ), were open-ended and were used less frequently.

Yi Lin: **What are you building?**
Siu Hwee **You *leh*[7]?** (This is in Singlish. It means 'How about you?')
Francesca: *Aeh*, all of them made into like this.
Seraphina: **What?**
Seraphina: Repeat that.

[6] A typical Singlish particle placed at the end of a sentence or phrase for reassurance or emphasis

[7] *Leh*: is in Singlish and is often used in spoken form to soften a command, request, claim, or complaint that may be brusque otherwise.

Shalini: **What do you mean like this?**
Siu Hwee Do this.
Seraphina: Siu Hwee
Yi Lin: **What is this?**
Yi Lin: A wrist band.

Child's Reasoned Questions (CQ), T3G2S1

In this exchange, the children asked five open-ended questions. These questions were based on what they had observed during the scientific play sessions, about what their peers were doing and how to do the thing that Francesca had suggested. As the children went into this cycle of asking questions one after another, they were able to generate more questions than usual and some, like Yi Lin, asked a question about what she saw and answered it herself.

Child's Observation (CO)

Child's Observation is the fourth most dominant type of talk. In the example below, the girls compared two bar magnets (one in their hands, the other tied by a string to a retort stand). They found that they were the same type of magnet, by comparing different physical characteristics (appearance and weight). The girls made some observations by interacting with the materials.

Maya: **They look the same yah[8].**
Clara: Eurem…. going to say again?
Maya: Oh!
Clara: Again fun.
Maya: This one, huh?
Clara: **This one so heavy!**
Clara: **You saved it.**
Maya: Look!
Maya: **There are [sic] water.**

Child's Observations (CO), T4G5S2

Child Instructing Peers (CIP)

Child Instructing Peers (CIP) is the fifth most dominant type of talk. Here, the group was a larger one, consisting of five girls. There were a few more dominant girls, such as Yu Huan and Emma, who instructed their peers on what to do and gave directions bout what the whole group should engage in. They instructed peers not to touch the

[8] *Yah*: an interjection usually written at the end of the sentence to mean 'yes'.

items with words such as ‘don’t’ and used imperatives such as ‘put’ and hoped that they would move together.

Yu Huan: **Don’t touch it……!**
Siti Hahaha…..
Catherine: Er hahha……
Divya: Hello!
Siti: K[9]!
Siti K!
Catherine: Ok, let’s leh, the all see it.
Emma: **Put the cup.**
Siti: Ah, her…….!
Emma: **Put the bowl over here!**

Child Instructing Peers (CIP), T4G4S2

Child Seeking Reassurance (CSR)

Child Seeking Reassurance (CSR) is the sixth most dominant type of talk. It was observed that the children loved to repeat what they had seen, what they were going to do and other things, in order to get reassurance.

In this example, a group of girls made a small school flag using paper and pasted it onto a bar magnet. They then used a gigantic horseshoe magnet to hoist this magnet and sang their school song while standing to attention. Mandy was trying to get June’s attention by calling her name repeatedly and excitedly, trying to show June what she was doing. Although children like Mandy did not include much content in what they were talking about, this talk did result in the peer looking at her, making observations.

Mandy: **June….!**
Mandy: **June, look.**
Mandy: **June.**

Child Seeking Reassurance (CSR), T5G9S2

Child’s Own Choice (COC)

In the seventh most dominant form of children’s talk, children were observed to talk about what they wished or wanted to do by using the personal pronoun ‘I’.

[9] *K*: a shortened version of the response “Okay”, which means alright.

In this situation, the group forcefully dropped their magnets into the plastic basin of water, which cracked as a result, causing it to leak. Carmen used the personal pronoun 'I' to indicate the action which she had taken to help salvage the situation.

Sophia:	There is a hole.
Mia:	The hole!
Amutha:	Aeh ah the they …
Sophia:	They got hole in their ….
Sophia:	Cover the hole.
Carmen:	Aiyoh!
Carmen:	**I'm using my finger to cover**.

Child's Own Choice (COC), T3G1S2

Conclusions about the dominant types of talk

The most frequent types of talk used by children were Child's Feedback (Non-Reasoned) [CF (NR)], Child's Feedback (Reasoned) [CF (R)], Child's Question (QN), Child's Observation (CO), Child Instructing Peers (CIP), Child Seeking Reassurance (CSR) and Child's Own Choice (COC).

Although some of the examples above were not made in grammatically correct or complete sentences, these were actual utterances captured during the sessions in the natural classroom settings. Next, the report moves on to the other end of the spectrum of the data in Table 5.1, the least dominant kinds of talk engaged in by the children, covering the three least dominant types of talk.

Child Getting Help (CGH)

Child Getting Help (CGH) is the least dominant type of talk. Although the data for CGH may be the least extensive, the field notes showed that the children asked for help in different ways. They did not always verbalise their need for help and might start by trying to cope independently. If they could not solve the problem, they would quietly look around at their peers to see how others were doing it and copy them. If all of these strategies failed, they would get help from either the teacher or their peers.

In this context, two girls, Dione and Shena, got into a dispute about who some paperclips belonged to. They argued and resolved the situation by seeking help from their teacher, Ms Geetha.

Shena: I want a paperclip!
Dione: Give me back, my paperclip!
Shena: I didn't take any paperclip.
Shena: Your paperclip is right there!
Shena: **Ms Geetha.**
Mira: There, there, bishop so stu… [sic]
Mira: You show me can love each other.
Mira: Is it so far to do it?
Dione: **Ms Geetha.**
Dione: **Ms Geetha.**
Shena: **Aeh, can you call Ms Geetha?**

Child getting help (CGH), T5G4S1

Child Interacting with Peer from another Group (CIA)

The next least dominant type of talk is Child Interacting with Peer from another Group (CIA). CIA is probably infrequent due to how the children had been taught in school to focus on the members of their group while carrying out an activity. Although there was no mention of the rule that they could only play within their group, the children were used to the class routine and tended to abide by the usual classroom rules.

In the two contexts below, two groups were sitting together at one table in close proximity. In the first example, Evelyn was thrilled and excited to share with her peer from the other group, Samantha, when she discovered that the paperclips placed in a plastic petri dish were attracted by her bar magnet. In the second example, Clara from one group was happily interacting and exchanging comments with her peers in her group when she suddenly stopped and noticed that Evelyn from the other group was with her group. Clara questioned Evelyn's presence and told her that she should not be there. She spoke to Evelyn and interacted with her using only one utterance, avoiding any further conversation with peers from another group.

Example 1:

Evelyn: **Samantha, Samantha, I show you something.**
Zoey: The one which we need to ...
Evelyn: **Samantha, Samantha, see!**

Child Interacting with Peer from another Group (CIA), T3G1S1

Example 2:

Sarah: Why can't we pointing [sic] to north?
Clara: Huh?

Clara: **One sec people, what you doing here?**
Evelyn: **Copy, somebody said** (from another group)

Child Interacting with Peer from another Group (CIA), T4G5S2

Child Abiding by the Science Routine Rules (CAR)

Child Abiding by the Science Routine Rules (CAR) is the third least dominant type of talk. Children in Singapore are generally well behaved and follow the rules faithfully. Group work is undertaken quite often in class and the children are aware of the spoken or unspoken rules that they need to abide by.

In this example, the teacher was calling out the names of children who were not deemed to be behaving appropriately. Nurul could see that when the group members, Noah and Ashraff, were not agreeing with each other and getting heated in their arguments, she quickly intervened and said 'shez……' with a finger to her lips to remind her peers to keep quiet. This action was seen frequently in many groups for the class under this teacher when the group members became rowdy during the activity.

Madam Bhavani:	Patrick!
Noah:	I've gone down.
Ashraff:	Give me all if you!
Ashraff:	So ah.
Noah:	Whatever.
Ashraff:	No, no, no…..
Nurul:	**Shez…………**
Nurul:	**You guys keep watching it first.**
Aishah:	Maybe.
Nurul:	**Just voice.**

Child Abiding by the Science Routine Rules (CAR), T2G1S1

Conclusion

In this section, the nature and dominant types of talk in all the talk depicted by the data showed that the first four dominant types of talk were of two-letter code types and six out of ten types of talk covered were of the three-letter code from the 'choice and control' (see Table 4.7) section of the PSTFP. The children engaged in more general talk (two-letter code) before getting involved in talk which required them to exercise more choice and control.

In the next section, 5.12, the results of the ‘Nature and Dominant Types of Talk for Teachers’ will be scrutinised and selectively presented, ranked from the most dominant to the least dominant.

5.12 Nature and dominant types of talk for eachers

Codes		Session 1 (S1) N1	Session 1 (S1) %1	Session 2 (S2) N2	Session 2 (S2) %2	Total [Session 1 (S1) & Session 2 (S2)] N3	Total [Session 1 (S1) & Session 2 (S2)] %3
QN^T	TQ	49	7.1	71	13.5	120	9.8
	TN	80	11.5	80	15.2	160	13.1
QN^{T*}		129	18.6	151	28.7	280	22.9
TE		30	4.3	16	3.0	46	3.8
TO		3	0.4	10	1.9	13	1.1
TR		4	0.6	6	1.1	10	0.8
TS		2	0.3	1	0.2	3	0.2
TA		15	2.2	9	1.7	24	2.0
TF	R	58	8.3	36	6.8	94	7.7
	NR	8	1.2	13	2.5	21	1.7
TIC		380	54.7	188	35.6	568	46.4
TTC		36	5.2	46	8.7	82	6.7
TOH		6	0.9	26	4.9	32	2.6
TGR		24	3.5	26	4.9	50	4.1
Total		695	8.1	528	6.4	1223	7.2

QN^{T*} is not a new type of talk but a total of reasoned and non-reasoned questions.

Note:
The calculation of % is based on the formula below:
$\%^1 = N_1/S1$ $\%^2 = N_2/S2$ $\%^3 = N_3/(S1+S2)$
The percentage calculated in this table is the percentage of all talk by teachers, expressed over the total of all talk by both children and the teachers added together.
$Total^4$ is the total of all science utterances and the % of all science utterances.
S1 = 8 589 S2 = 8 287 S1 + S2 = 16 876 (all talk obtained from Table 5.3)

Key:
Teacher's Question (QN^T)
Teacher's Reasoned Question (TQ) Teacher's Non-reasoned Question (TN)
Teacher's Encouragement (TE) Teacher's Observation (TO)
Teacher's Recall (TR) Teacher's Story and Character (TS)
Teacher's Argumentation (TA) Teacher's Reasoned Feedback [TF(R)]
Teacher's Non-Reasoned Feedback [TF(NR)]
Teacher Instructing Child (TIC) Teacher Teaching Child (TTC)
Teacher Offering Help (TOH) Teacher Giving Reassurance (TGR)
Table 5.2: A table showing the nature of teachers' talk (All Talk: S1, S2 and Total).

	Session 1 (C & T)	Session 2 (C & T)	Total (C & T)	Session 1 (T)	Session 2 (T)	Total (T)
N	8589	8287	16876	695	528	1223
%	100.0	100.0	100.0	8.1	6.4	7.2

Key: C- Children T- Teachers
Table 5.3: A summary of the teachers' talk in all talk (S1, S2 and Total).

Table 5.3 shows that the teachers talked much less than the children and that the first four most dominant types of talk observed (see Table 5.2) were: Teacher Instructing Child (TIC), Teacher's Question (QN^T), Teacher's Feedback (Reasoned) [TF(R)] and Teacher Teaching Child (TTC). As with the children, for the teachers, excerpts of qualitative utterances and the context in which the type of teacher's talk took place are used to illustrate the nature and dominant type of teacher's talk in each section discussing the teachers.

Teacher Instructing Child (TIC)

From Table 5.2, the most dominant type of talk is Teacher Instructing Child (TIC). In this study, Teacher Instructing Child (TIC) refers to the instructions that the teachers gave to the children to start and end the activity as well as managing behaviours.

TIC was also the only type of talk used by Teacher 5, Ms Geetha. She had to reduce the scientific play session because her science lesson was shortened in length in Session 2 due to a school event, and she only managed to speak three times.

In this example, Ms Geetha was instructing the children what to do when time ran out and she used two commands* to get their attention.

Ms Geetha:	**Two silent claps*.**
Joanne:	Bizz…..
Ms Geetha:	**Sit down and eyes on me!**
Abigail:	Aeh?
Joanne:	K!
Abigail:	K!
Ms Geetha:	**Eyes on me*!**

Teacher Instructing Child (TIC), T5G10S1

Teacher's Question (QN^T)

The second dominant teacher's talk is Teacher's Question (QN^T). As with the children's questioning, the teacher's questions comprise of both Teacher's Reasoned Question (TQ) and Teacher's Non-Reasoned Question (TN), with both science and non-science talk being taken into consideration for each code. The teachers questioned more and instructed less in the second session.

It was noted that both Mr Wong and Ms Geetha, who had their entire lessons reduced to about 30 minutes (and the scientific play session reduced to 5 minutes) due to school events, had greatly reduced the time they spent asking the children questions in S2. In contrast, the other teachers asked more questions in S2. Ms Koh asked the most questions while Ms Geetha asked the fewest questions. This was perhaps due to the fact that, from the researcher's observations, Ms Geetha had followed the protocol of the lessons more closely than the other teachers, thus retaining the fidelity of the play protocol.

In this example, Ms Koh was helping to guide a group of children who seemed to be lost because they could not read the compass very well. She intervened and guided the group with some carefully planned reasoned questions (TQ). She encouraged them and guided them step by step without giving them direct answers, instead getting the children to tell her the answers and point to the direction.

Ms Koh:	**So, may I know where's the north and where's the south of the …the classroom?**
Ms Koh:	**Correct?**
Ms Koh:	**The same?** (The children pointed to one corner of the classroom.)
Ms Koh:	Very good!
Yu Huan	This one is north
Emma:	Over there!
Catherine:	North is it?
Siti:	Who's ever goes there?
Emma:	Oh……..ok!

Teacher's Questions (QN^T), T4G4S2

Teacher's Feedback (Reasoned) [TF(R)]

The third most dominant type of talk is Teacher's Feedback (Reasoned) [TF(R)]. In contrast with the children (Table 5.1), the teacher's feedback consists more of reasoned than non-reasoned feedback.

In the example below, Madam Bhavani gave reasoned feedback: "suspended" to help scaffold Safiq's learning as he was able to use the science vocabulary 'freely'. Then, she tried to continue the conversation by introducing the word 'suspended' to complete Safiq's learning and get the desired science keyword – 'freely-suspended' magnet.

Madam Bhavani avoided dominating the conversation and instead tried to introduce the science vocabulary subtly to allow the children to pick up the relevant vocabulary in the appropriate context.

Madam Bhavani:	What can you do for this one to make it?
Gabriel:	Eruem…
Safiq:	Freely!
Madam Bhavani:	**Suspended!**
Adele:	Go Zinnia!
Hafiz:	I ['ve] at least try [sic]!

Teacher's Feedback (Reasoned) [TF(R)], T2G9S2

Teacher Teaching Child (TTC)

The fourth most dominant type of talk is Teacher Teaching Child (TTC). This consists of telling and teaching the children what to do for science and non-science types of talk, telling them what is right and what is wrong to do in the class.

Madam Bhavani had started the lesson but found the volume of the class too high. She stopped the activity and began teaching the children, reminding them of what was considered good and appropriate behaviour during the scientific play sessions before allowing them to resume.

Madam Bhavani:	**You look around, there are some students in every group who are standing because they are not showing responsibilities.**
Madam Bhavani:	**Responsible learning is firstly by not doing so loud, they are disturbing others and other class next door.**
Madam Bhavani:	**If you want to be part of this activity, show me you can be responsible.**
Madam Bhavani:	Right?

Teacher Teaching Child (TTC-Non-Science), T2G3S1

As an example of science talk, the quote below shows how Ms Koh advised and taught the group how to read the compass correctly.

Ms Koh: **You need to wait for that to stop moving first.**
Emily: It's fun!
Zoey: Each time.[10]

Teacher Teaching Child (TTC-Science), T4G1S2

Conclusions about dominant types of talk

The most frequent types of talk used by the teachers are Teacher Instructing Child (TIC), Teacher's Question (QN^T), Teacher's Feedback (Reasoned) [TF(R)] and Teacher Teaching Child (TTC).

Next, the report moves on to the other end of the spectrum of the data in Table 5.2 to examine the least dominant talk engaged in by the teachers. Here, three less dominant types of talk: Teacher's Story and Character (TS), Teacher's Recall (TR) and Teacher's Observation (RO) are covered.

Teacher's Story and Character (TS)

Among the teachers, Teacher's Story and Character (TS) is the least dominant type of talk.

In this case, Noah got into a situation with his peers from another group about whether he had thrown something or not. He claimed innocence and said that it was placed there by his peers. His teacher, Madam Bhavani, did not believe him and drew a parallel with a story by replying "Khamis the big ant".

Noah: They put me there.
Madam Bhavani **Khamis the big ant.**
Ashraff: Hehehe….! (Giggling)
Noah: I don't know!

Teacher's Story and Character (TS), T1G5S1

This story was not easy to come up with and needed the right timing and context to come up with the imaginary story and characters. Here, the teacher used something to draw a parallel and avoided being punitive towards the guilty or innocent child.

[10] Here, what Zoey meant was that they needed to wait for the compass to stop moving first before they were able to read the directions on it.

Teacher's Recall (TR)

The next least dominant type of talk is Teacher's Recall (TR). This section mainly contains recollection of the teachers' observations or a repetition of what the children had said previously.

In this example, Ms Koh recalled and reminded the children that she had already given them a clue where north was, and that they should be able to use that to work out the other directions in the science laboratory.

Ms Koh: **Just now, I tell you this is north.**

Teacher's Recall (TR), T4G5S2

Teacher's Observation (TO)

Teacher's Observation (TO) is the third least dominant type of teacher's talk. The teacher's observations were more science-related than non-science.

In the evidence below, Madam Bhavani may have observed that one of the children in the group dropped the magnet. She used the words which were tagged to an observation made and concluded that one of them did it, although Aminah joined in and said that the magnet was already broken when she picked it up from the floor.

Lucas:	Aeh, Madam Bhavani, who broke this?
Madam Bhavani:	**You broke it!**
Lucas:	I din…..
Madam Bhavani:	**You dropped it and broke it!** If you drop magnet, they break! You have to take care of it!
Lucas:	I din, I din drop……!
Madam Bhavani:	**One of you did!**
Benjamin:	Madam Bhavani, I did not!
Lucas:	I did not.
Aminah:	Just now, I got from the floor and I picked up, then I put it in.

Teacher's Observations (TO), T2G6S1

Conclusion

From section 5.12, the nature and dominant types of teachers' talk suggest that the types of talk were quite typical of what the teachers would do in a class, instructing and questioning the children. There are two significant differences noted in Table 5.2, which shows that the teachers questioned the children more during scientific play

Session 2 and instructed them less often in Session 2. The role of the teachers had probably resulted in Teacher Instructing Child (TIC), which is part of the 'choice and control' in Falk and Dierking's (2000) Contextual Model of Learning (CML), to overtake other types of talk to be ranked the highest and most dominant in Session 1.

However, as the teachers became used to the scientific play session, they were able to gauge what they wanted to do in the next lesson and adjust their types of talk accordingly. The teachers started questioning more and instructed the children less often. The high result for TIC could also be attributed to the teachers' fidelity to the play protocol. TIC in the first session may have been higher because the teachers had followed the play protocol closely and instructed the children to begin and end the scientific play sessions, avoiding other types of talk so as not to interrupt the children's play. However, when the teachers gained more knowledge about how play worked, their mode of talk changed and they would ask questions, as in Teacher's Question (QN^T). In the example above, Ms Koh intervened to help a group who appeared to be lost during their play by questioning and guiding the group towards their own learning.

Lastly, the least dominant type of talk being Teacher's Story and Character (TS) shows that this was something the teachers did not often do in class. The low number for TS was probably due to its low occurrence and unpredictable nature because it is difficult to find the right context to come up with a story. Another factor that could explain this small number is the personality of the teacher.

5.2 The extent of the discussion of science in play

In this section, the report proceeds to examine the extent of science used in play. The extent of the discussion of science is explored for both the children and the teachers, over the two scientific play sessions. Section 5.21 covers the children's discussion of science while Section 5.22 covers the teachers' discussion of science.

5.21 The extent of the discussion of science in play among children

From the data on the total number of children's utterances (Table 5.4), it was found that the total numbers were roughly similar for the two sessions. The majority of talk was non-science talk. However, the children were observed to have used 12.9% more science talk in Session 1 than in Session 2, with almost double the number of utterances spoken. Overall, close to one quarter (24.7%) of the total children's utterances for the two lessons was science talk (see Table 5.4).

The probable reason for the reduction in science talk during the second session is due to the shortening of the scientific play sessions by two teachers who had their lessons for Session 2 affected by school events. The scientific play session was shortened to 5 minutes instead of 15 in two classes, which did not allow the children the space and context to engage in science talk.

		Science	Non-Science	Total
Session 1 (S1)	N	2 442	5 452	7894
	%	(31.1%)	(69.1%)	(100.0%)
Session 2 (S2)	N	1 416	6 337	7753
	%	(18.2%)	(81.7%)	(100.0%)
Total (S1 & S2)	N	3 858	11 789	15 647
	%	(24.7%)	(75.3%)	(100.0%)

Table 5.4: A table showing the proportion of science and non-science talk for children.

	Session 1		Session 2		Total	
Codes	N_1	%[1]	N_2	%[2]	N_3	%[3]
CQ	113	1.5	46	0.6	159	1.0
CN	99	1.3	57	0.7	156	1.0
QN	212	2.8	103	1.3	315	2.0
CE	154	2.0	66	0.9	220	1.4
CO	535	6.8	409	5.3	944	6.0
CR	94	1.2	44	0.6	138	0.9
CS	122	1.5	67	0.9	189	1.2
CA	123	1.6	39	0.5	162	1.0
CF R	187	2.4	95	1.2	282	1.8
CF NR	0	0.0	0	0.0	0	0.0
CIP	129	1.6	120	1.5	249	1.6
COC	208	2.6	82	1.1	290	1.9
CTP	163	2.1	152	2.0	315	2.0
CNM	101	1.3	29	0.4	130	0.8
CGH	10	0.1	4	0.1	14	0.1
CSR	163	2.1	78	1.0	241	1.5
CAR	21	0.3	9	0.1	30	0.2
CIA	8	0.1	16	0.2	24	0.2
Total[4]	2442	31.1	1416	18.2	3858	24.7

Note:
The calculation of % is based on the formula below:
$\%^1 = N_1/S1$ $\%^2 = N_2/S2$ $\%^3 = N_3/(S1+S2)$
The percentages calculated in this table are the percentages of science talk, expressed over the total of all talk (science and non-science talk) that took place.
Total[4] is the total of all science utterances and the % of all science utterances.
S1 = 7 894 S2 = 7 753 S1 + S2 = 15 647 (all talk obtained from Table 5.4)

Key:
Child's Reasoned Question (CQ) Child's Non-reasoned Question (CN)
Child Instructing Peer (CIP) Child's Own Choice of Action (COC)
Child Teaching Peers (CTP) Child Getting Help (CGH)
Child Seeking Reassurance (CSR) Child Abiding by the Science Routine Rules (CAR)
Child Negotiating Materials (CNM) Child Interacting with Peer from another Group (CIA)
Child's Encouragement (CE) Child's Observation (CO)
Child's Recall (CR) Child's Story and Character (CS)
Child's Argumentation (CA) Child's Reasoned Feedback [CF(R)]
Child's Non-Reasoned Feedback [CF(NR)]

Table 5.5: A table showing the amount of children's science talk in S1, S2 and Total.

From Table 5.5, out of the 17 types of talk for science, besides CF (NR) which recorded 0% for both S1 and S2 and CGH recorded 0.1% for both S1 and S2, only CIA had an increase in value, from 0.1% in S1 to 0.2% in S2, with a 100% increase. This increase could be a result of the fact that the children had discovered that there were no restrictions on their movements during the scientific play session and they were free to talk to any of their peers. Therefore, they exercised some 'choice and control' from Falk and Dierking's CML and interacted with peers from other groups. However, most children still chose to stay and play within their groups. Those who interacted with others outside their group were the children who got excited and wanted to share what they were doing with peers from the nearby groups, those who walked around from group to group to search for materials to use, or chased peers who did not belong to their group.

Order of Dominance of Science Talk	Code	Total Sci. Utterances	% of Sci. talk[1]
1	CO	944	6.0
2	CTP	315	2.0
3	COC	290	1.9
4	CF (R)	282	1.8
5	CIP	249	1.6
6	CSR	241	1.5
7	CE	220	1.4
8	CS	189	1.2
9	CA	162	1.0
10	CQ	159	1.0
11	CN	156	1.0
12	CR	138	0.9
13	CNM	130	0.8
14	CAR	30	0.2
15	CIA	24	0.2
16	CGH	14	0.1
17	CF (NR)	0	0.0
	QN*	315	2.0

Key:
Child's Reasoned Question (CQ)
Child Instructing Peer (CIP)
Child Teaching Peers (CTP)
Child Seeking Reassurance (CSR)
Child Negotiating Materials (CNM)
Child's Encouragement (CE)
Child's Recall (CR)
Child's Argumentation (CA)
Child's Non-Reasoned Feedback [CF(NR)]
Child's Non-reasoned Question (CN)
Child's Own Choice of Action (COC)
Child Getting Help (CGH)
Child Abiding by the Science Routine Rules (CAR)
Child Interacting with Peer from Another Group (CIA)
Child's Observation (CO)
Child's Story and Character (CS)
Child's Reasoned Feedback [CF(R)]
Child's Question (QN) which includes CQ and CN

* This is not a new type of talk but a sum of two forms of talk (CQ and CN)
[1] - % of science talk is 24.7% of the total of all utterances (all talk) linked to Table 5.5

Table 5.6: A table showing the order of the dominance of the 17 types of science talk for children and the frequency count and percentages of the type of science talk for each code.

Child's Observation (CO)

The most dominant science talk observed is Child's Observation (CO). For example, Madam Lee was walking towards a group when Sam started with the first observation that he had made. His observation was confirmed by his peer, Lydia, who agreed with what he said. Lydia asked him a question to which Sam responded with another observation that he had made and his conclusion. Nick, another member of the same group who had seen and played with the ruler, answered 'aluminium' as the possible material that the ruler was made of.

Sam: One of the magnet…. **One of the metal ruler[s] can be attracted to a magnet but the other one can't.**
Lydia: **Yah, and this can't stick on this!**
Lydia: Can't even to do this.
Lydia: How to do this?
Sam: And the marble cannot, and **the marble cannot stick to the magnet**.
Sam: The **marble can't stick to a magnet**.
Nick: **Aluminium**

Child's Observations (CO), T1G8S1

Child's Question (QN) and Child Teaching Peers (CTP)

The second most dominant children's science talk is shared by Child's Questions (QN) and Child Teaching Peers (CTP). These were two different types of science talk that the children engaged in.

As inferred by the total percentage of CN (1.0%) and CQ (1.0%) in Table 5.6, the series of continuous questions looked as though they were taking place so that the children could impress their teacher. However, further scrutiny of the transcripts reveals that there were also instances when the children kept asking questions and making observations without the presence of the teacher. This helps to refute the suggestion that they were trying to impress the teacher. This series of asking questions in different situations suggests that it was the members of the group who actually loved asking questions.

In the context below, although Dora was asking a peer from another group to tell her if there was anything that was magnetic, her own group member answered her question with another question, asking what nickel, a magnetic metal, was doing (personifying the metal), indirectly telling her that nickel is magnetic. Emily pointed out to the group that she had noticed the material (which she had called ‘that one’) liked the magnet, and was attracted to the magnet, which implied that it was actually magnetic in nature. Zoey then asked the whole group why certain things did not work.

Dora:	**Anything magnetic?**
Evelyn:	**What happened, Nickel?**
Emily:	That one like magnet.
Emily:	And yesie [sic], yes and yes.
Zoey:	**Why this one cannot?**
Dora:	Try do this.
Emily:	Only the small one
Evelyn:	Ah, ah……
Zoey:	Aeh, it doesn’t work.

Child’s Questions (QN), T4G1S1

From this example, one can see that one question being asked, started by Dora, led to several more questions following up and being tried by different members of the group. This group went into a cyclic conversation, as shown below:

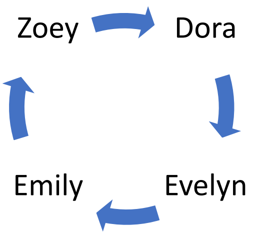


Figure 5.1: The cyclic conversation in a group

The group had four members and they took turns to give feedback or ask questions to keep the conversation going on the topic of ‘magnetic materials’. They made observations, which was the most dominant type of science talk, gave suggestions and corrected their peers if they were wrong. Moreover, they also provided some science content that their peers could learn and pick up, which leads us to another dominant type of science talk, Child Teaching Peers (CTP). Therefore, the first three dominant types of children’s science talk suggests that these three types of science talk could be related and linked in a manner such that the children talked to one another during play.

Child's Own Choice (COC)

The fourth most dominant form of children's science talk is Child's Own Choice (COC). There is a drop in percentage from S1 to S2 and the children's science talk involved less of their own choices in S2 due to the nature of the play in the second scientific play session. Here, Seraphina got the group excited by asking them to look at what she could do with the bar magnet and a petri dish filled with paperclips. Xiu Hui saw it and was interested. She responded by saying that she wanted to try and did so by using the bar magnet to attract some paperclips from the petri dish. Seeing what both of her peers were doing, Yi Lin stopped what she was doing and joined in the play with her peers. She took the bar magnet, copied and repeated what her peers had done. She managed to pick up the petri dish filled with paperclips without much effort and held onto the plate.

Seraphina:	Hey, look at this!
Xiu Hui:	**I tried ah….!**
Yi Lin	Oh my ….
Yi Lin:	**I'm lifting the whole plate up!**
Paola:	That's so strong!
Yi Lin:	Wendy!
Paola:	Get it down.
Xiu Hui:	Depends.
Yi Lin:	Oh my god!
Seraphina:	**I try first ha.**

Child's Own Choice (COC), T3G2S1

Here, the children used the 'I' pronoun, which they typically used to express their 'choice and control' from Falk and Dierking's CML and indicate their choice of actions. Besides using the representative 'I' pronoun, the children also made observations and gave feedback and encouragement for the group to continue.

Conclusions about dominant types of talk

The most dominant type of science talk observed is Child's Observation (CO), followed by Child Teaching Peers (CTP) and Child's Own Choice (COC). However, if we look at the highlighted portion of Table 5.6, the codes Child's Reasoned Question (CQ) and Child's Non-Reasoned Question (CN), when summed together as Child Asking Questions (QN), had a total percentage of utterances of 2.0% with 315 utterances, the same percentage as Child Teaching Peers (CTP). The total of the codes under asking questions will thus result in QN being ranked second with CTP in the dominant science talk, followed by Child's Own Choice of Action (COC).

The least dominant types of science talk are Children's Non-Reasoned Feedback [CF (NR)], Child Getting Help (CGH), Child Abiding by the Science Routine Rules (CAR) and Child Interacting with Peer from another Group (CIA). CAR and CIA are equal third least dominant science talk. The other types of science talk used by the children are illustrated in Table 5.6. The top three dominant and the least three dominant types of science talk, which are the ones that will help to answer the research questions, will be covered.

Child's Feedback (Non-Reasoned) [CF(NR)]

Child's Feedback [CF(NR)] is the least dominant type of talk. This was a result of the way in which the codes were developed; there were not any utterances that would be coded as this type of science talk. Any utterance, whether it is a long sentence or short phrase, uttered as feedback would be considered science talk as long as science vocabulary was used and coded as CF(R). Therefore, it was not possible to have utterances considered as a science talk and coded as non-reasoned. Non-reasoned feedback was for a superficial response like various sounds, words or phrases with no indication of direction by the speaker.

Child Getting Help (CGH)

Child Getting Help (CGH) is the second least dominant type of talk because it was observed that the children had developed other mechanisms to seek help in their own ways. They would not openly ask verbally for help unless they had exhausted all the ways to get help in a more subtle way, such as peering or watching how their peers were doing things or the convenient method of just copying what their peers were doing.

> Sam: One of the magnet…. One of the metal ruler can be attracted to a magnet but the other one can't.
> Lydia: Yah, and this can't stick on this!
> Lydia: Can't even to do this. **How to do this?**

Child Getting Help (CGH), T1G8S1

The context for this example is that Sam had told his group that he had discovered one of the rulers they had been given was non-magnetic. Lydia did not quite get what Sam meant even though she had replied “yah” to him, as one can see by her response “this can’t stick on this”. Lydia was still holding onto what she thought she knew – that most or all metal rulers should be attracted to a magnet. She decided to seek help from Sam and asked him why she was not able to use the magnet to attract the non-magnetic ruler. Lydia was adamant about using the magnet to attract the non-magnetic ruler.

Child Abiding by the Science Routine Rules (CAR) and Child Interacting with Peer from another Group (CIA)

Two types of children’s science talk are equally third least dominant: CAR and CIA. Although the final total looked the same, they were two different types of science talk. Both of these types of science talk were three-letter codes and were closely related to the ‘choice and control’ portion of the Contextual Model of Learning.

Child Abiding by the Science Routine Rules (CAR)

The context for Child Abiding by the Science Routine Rules (CAR) was when the group was trying to pack things away at the end of the scientific play session. Evelyn initiated the packing up by informing her peers that she would pack the non-magnetic things. Then, Zoey suggested putting the magnets together and she would help others do the packing. As Zoey had turned down packing the magnet, Dora volunteered to help Evelyn collect all the magnets. There were some instances of strained disagreement, but the whole episode ended when Emily volunteered and managed to end the possible dispute by saying that she could help Dora.

Evelyn:	**I will pack the non-magnetic thing.**
Zoey:	**Put the magnet.**
Evelyn:	**I pack the magnets back.**
Ms Koh	Very good, it attracted mask.
Zoey:	**No, I’ll help other[s] do**…….
Dora:	**I help you take all the magnets.**
Zoey:	Non-magnetic to you.
Dora:	No, you help me get one.
Emily:	**And I will help you …**

Child Abiding by the Science Routine Rules (CAR), T4G1S1

Although there were no rules about how they could play, the grouping of the children and arranging them to sit in groups, indirectly or directly conditioned many children to abide by the invisible rules of classroom routine. They seldom played alone, and the other peers in the same group would immediately pull their peers together or involve any peer who was seen playing alone into the group play within minutes. The group interviews revealed the children's point of view on how they viewed the scientific play sessions and that they felt more comfortable and had more fun if they played together. This phenomenon might be good or bad. Solo play was difficult and playing undisturbed and alone was less preferred.

Child Interacting with Peer from another Group (CIA)

Child Interacting with Peer from another Group (CIA) was different and was the only type of science talk that increased in S2. The number of utterances doubled in the second recorded session and some children slowly came to realise that they were allowed to move away from their group and talk to other peers. From the field notes, the children were observed to have interacted mostly with close friends from other groups. They usually shared with their other peers what they had discovered during their scientific play session.

Here, Audrey was building a structure called the spoon rocket which a few of her peers subsequently also constructed. Audrey was excited and wanted to share with Mei Zhen, another peer sitting near her group at a table next to hers. This behaviour was also seen in a few other groups where some children were seen turning and calling to specific peers from other groups to share their excitement during the scientific play session.

Natalie: Give me those I give you.
Audrey: There, still got some more.
Natalie: **Mei Zhen ah.**
Audrey: **Show you something.**
Audrey: **Zhen, look ah!**

Child Interacting with Peer from another Group (CIA), T5G9S1

As for CAR, in CIA most children had exercised their 'choice and control' and were more comfortable playing within their group. They made their choices, rarely moved out of their seats and controlled themselves not to call out to their peers in another group. What was observed was that the children who did interact with peers in other group(s) were usually the same children in the two sessions. These children joined their peers who were sitting nearby when encouraged by them and shared what they had discovered with them.

Conclusion

From Section 5.21, it can be seen that the discussions of science in play that were observed in science talk were mostly related to the science skills practised by the children in a class – observing and questioning. Unlike all talk, presented in Section 5.11, the nature of science talk gravitated more towards Child's Observation (CO) and Child's Questions (QN^T) as compared to Child's Feedback (CF) and Child's Question (QN) in all talk. For both types of talk (all talk and science talk), talk with three-letter codes classified under "choice and control" only surfaced as the third or fourth most dominant type of talk after the two-letter codes had dominated in the first three types of talk. Talk classified under the two-letter codes (such as CO and QN) were the more dominant types of science talk in this study.

By sharing their knowledge and teaching their peers (CTP), children engaged in science talk where ideas and scientific knowledge could be brainstormed together and exchanged. It was also noted in the table that the child's own choice (COC), expressing his or her actions in the scientific play sessions, could probably set the foundations for the children to carry out science talk. As the children may have been conditioned to the daily classroom routines and rules, most of them displayed expected group-work behaviour. They verbalised less about what they would do to follow class routines as they internalised the rules and felt more comfortable working together, within the same group.

In conclusion, Section 5.21 answers the second research question in this research:

Q2. To what extent do children and teachers talk about science during scientific play?

Although the children did talk about science during their scientific play sessions, the percentage of science talk was moderate (24.7%). Despite only about a quarter of their total talk being on science, the free play settings in their scientific play did allow the children to make observations using some of their science skills and to question the things that they were playing with in science. The extent of the discussion of science during play by the children will be further explored in Chapter 8.

Analysis: What does it mean?

Comparing Table 5.1 (all talk) and Table 5.5 (science talk) for the first five most dominant types of talk, Table 5.7 presents a comparison table between the dominant types of talk for all talk and science talk.

Order of Dominance of Talk	Code (All Talk)	Code (Sci. Talk)
1	CF (NR)	CO
2	CF (R)	QN
3	QN	CTP
4	CO	COC
5	CIP	CF (R)

Table 5.7: A table comparing the order of dominance of the first five types of all talk and science talk by the children.

For all talk, the communication the children had with their peers on the surface took the form of feedback: non-reasoned [CF (NR)] and reasoned [CF (R)] feedback that they needed to get the conversation going. However, if we look at the science talk that took place, the children did spend most of their time talking about their observations (CO). With these observations, the group of children then went on to ask questions to explore (QN), understand and make sense of what they were doing during the scientific play sessions. This is interesting, as seen in Tables 5.1 and 5.3, questions asked by the children ranked highly, being the third and second most dominant types of talk in all talk and science talk, respectively.

The children were seen to have played with the materials given to them by carrying out what they had learnt in the preceding lesson, such as using the magnets provided to demonstrate attraction and repulsion. With their observational science talk, they tried to experiment with what the lessons had taught them before moving on to the next stage and applying the scientific concepts. At this stage, the children were involved in questioning and would question their peers when they tried to come up with creative things such as a robot, a house, an imaginary flagpole, jewellery or even a game. When asked by the researcher, the children were able to explain their creations well and they pointed out the scientific concepts which had informed their play.

Play provided the children with a space to be observant, to question what they wanted to know and respond to one another. From the transcripts of the children's utterances, they were observed to have engaged in an average of 5–6 cycles of 'cyclic' conversations (see Figure 5.1). Cyclic conversations are conversations in which all the children in a group participated and took turns to give feedback (reasoned or non-reasoned) or talk about a topic. It was observed that the group would only move on to talk about a new topic when all members of the group had contributed. If the cycle was not completed, the conversation on the topic continued for quite a long time, when they were seen to be talking around the same subject repeatedly without success in completing the cycle, before they abandoned what they had been talking about to start a new group topic.

Moreover, probably due to the difference in the nature of scientific play session 2, Child Teaching Peers (CTP) ranked highly. This high percentage was perhaps a result of the design of the lesson, which had a component on reading a compass. Most of the children did not have much experience of using a compass and thus they spent a fair amount of talk during that lesson trying to teach their peers how to read it and the directions on the compass. The field notes record that some groups investigated further with the compasses, checking readings in different parts of the classroom.

Furthermore, the way the scientific play sessions had been planned and set up could have allowed the children to take better ownership of their learning, expressing his or her need (COC: child's own choice). The quasi-play settings (Chapter 3) afforded them opportunities to indicate to their peers what they wanted to do. It was through COC taking place that the Child's Feedback (CF) came into action, and they communicated with their peers. With feedback established, the children then moved on to a more comfortable level to instruct their peers on what they needed to do during the scientific play sessions. This was ranked the sixth most dominant type of science talk.

Order of Dominance of Talk	Code (All Talk)	Code (Sci. Talk)
17	CGH	CF (NR)
16	CIA	CGH
15	CAR	CAR/ CIA

Table 5.8: A table comparing the order of dominance of the five least dominant types of all talk and science talk for children.

From Table 5.8, it can be seen that the least dominant type of science talk was Children's Non-Reasoned Feedback [CF (NR)] because it was impossible to give non-reasoned science feedback. No matter what science feedback the child uttered, either in a monosyllabic response or phrases, it would always be classified as reasoned science feedback. Therefore, this code will always end up being zero due to the design of the framework.

As for the second least dominant type of science talk, Child Getting Help (CGH), it was observed that during the scientific play sessions the children would usually follow their peers in order to do something together. If they were unsure, it was noted by the researcher that they would look around and see how it was being done. They would not verbalise or ask for help unless they had tried the two above-mentioned strategies. The third least dominant type of science talk was Child Interacting with Peer from another Group (CIA). The children were accustomed to working in groups in class settings and were observed to have kept to their routine behaviours and avoided interacting with another group, even though this was not a requirement of the play protocol. As reported by the children in the group interviews, they were aware that such behaviour would be frowned upon by the teachers and would not be abiding by the class rules. During the scientific play sessions, most groups kept the play within their group and would chase away any peers who did not belong to the group. As the children in the five classes were already in their third year of school, they understood how group work is managed in class and were observed to abide by the class routines and rules (classroom norms), unless someone in the group had not abided by it and then members like Devi would intervene and remind her peers:

Devi: **Don’t let the compass touch the water.**
Devi: **The compass will not touch [the water].**

Child Abiding by the Science Routine Rules (CAR), T1G9S2

In conclusion, the nature and dominant types of talk in all talk and the extent to which the children discussed science have both similarities and differences. Both types started with utterances to get the conversation going. All talk begins with a mixture of reasoned and non-reasoned feedback, while science talk builds on observation, more skewed towards science. The children’s talk then proceeded to questioning in both all talk and science talk, before the ‘choice and control’ of Falk and Dierking’s CML moved in. The least dominant type of talk for all talk and science talk was also linked to the ‘choice and control’ of Falk and Dierking’s CML. Additionally, the adapted framework was designed to exclude Children’s Non-Reasoned Feedback in science. CGH was the second least dominant talk for science talk and the least dominant talk for all talk (see Table 5.8). This could mean that the likelihood of the children seeking help was really low. For both types of talk, the children did not often involve themselves in seeking help from others. As for the third least dominant type of science talk, CAR, it could be ranked as such due to the classroom practices and the ways in which the children usually behaved in class. In conclusion, the extent of the discussion of science during play for children is 24.7%, which is about a quarter of all their talk. This was comparatively low compared to all the talk that the children were engaged in, at 92.8%. Therefore, the findings answer research question 2(a) and show that the extent of discussion of science by the children was less for science talk because they were more engaged in non-science talk during play.

In the next section, Section 5.22, the results for the extent of the discussion of science during play by the teachers will be analysed and presented to answer research question 2(b), about teachers.

5.22 The extent of the discussion of science during play by teachers

This section analyses the results of the extent of the discussion of science during play by teachers, which answers the second part of research question 2.

Q2. To what extent do (a) children and (b) teachers talk about science during play?

		Session 1 (S1 = 695)		**Session 2 (S2 = 534)**		**Total (S1 & S2 = 1 229)**	
Codes		N_1	$\%^1$	N_2	$\%^2$	N_3	$\%^3$
QN^T	TQ	38	5.5	44	8.2	82	6.7
	TN	26	3.7	39	7.3	65	5.3
TE		20	2.9	7	1.3	27	2.2
TO		2	0.3	8	1.5	10	0.8
TR		1	0.1	4	0.7	5	0.4
TS		2	0.3	1	0.2	3	0.2
TA		6	0.9	8	1.5	14	1.1
TF	R	4	0.6	7	1.3	11	0.9
	NR	0	0.0	0	0.0	0	0.0
TIC		22	3.2	13	2.4	35	2.9
TTC		9	1.3	41	7.7	50	4.1
TOH		6	0.9	23	4.3	29	2.4
TGR		11	1.6	14	2.6	25	2.0
Total[4]		147	21.3	209	39.0	356	29.0

Key:
Teacher's Question (QN^T)
Teacher's Reasoned Question (TQ)
Teacher's Non-reasoned Question (TN)
Teacher's Encouragement (TE)
Teacher's Observation (TO)
Teacher's Recall (TR)
Teacher's Story and Character (TS)
Teacher's Argumentation (TA)
Teacher's Reasoned Feedback [TF(R)]
Teacher's Non-Reasoned Feedback [TF(NR)]
Teacher Instructing Child (TIC)
Teacher's Teaching Child (TTC)
Teacher's Offering Help (TOH)
Teacher's Giving Reassurance (TGR)

Note:
The calculation of % is based on the formula below:
$\%^1 = N_1/S1$ $\%^2 = N_2/S2$ $\%^3 = N_3/(S1+S2)$
The percentage calculated in this table is the percentage of the science talk, expressed over the total of all talk (science and non-science talk) that took place.
Total[4] is the total of all science utterances and the % of all science utterances.

Table 5.9: A table showing teachers' science talk in S1, S2 and Total.

		Science	Non-Science	Total
Session 1 (S1)	N	147	548	695
	%	(21.2%)	(78.8%)	(100.0%)
Session 2 (S2)	N	209	325	534
	%	(39.1%)	(60.9%)	(100.0%)
Total (S1 & S2)	N	356	873	1 229
	%	(29.0%)	(71.0%)	(100.0%)

Table 5.10: A table showing the proportion of science and non-science talk by teachers.

From Tables 5.9 and 5.10, it can be seen that 29.0% of all utterances made by the teachers were science talk, while 71.0% were non-science talk. The extent to which the teachers became involved in the science talk was different; 21.2% during Session 1 (S1) and 39.1% during Session 2 (S2), with an increase of 17.9% from S1 to S2. The percentage for the amount of science talk for both S1 and S2 was 29.0%. The teachers used more science talk in S2 compared to the children, who used less science talk in S2. This could be due to the teachers getting used to the scientific play session and asking more questions. From Table 5.10, only the first four most dominant types of science talk and the three least dominant types for the teachers will be discussed.

Teacher's Question (QN^T)

The most dominant type of science talk for the teacher is the Teacher's Question (QN^T). QN^T consists of Teacher's Reasoned Question (TQ) and Teacher's Non-Reasoned Question (TN).

In the example below, Ms Koh directed the group's attention to the different types of magnetic and non-magnetic materials given to the group. She questioned them and asked a reasoned question (TQ) about why some materials were attracted by the bar magnet while other materials were not. She then followed up with a closed, non-reasoned question (CN) which warranted a 'yes' or 'no' answer, before encouraging the children and inviting them to try it out. Through questioning, Ms Koh asked a few guiding questions to allow the children to try things out and find out for themselves.

Ms Koh: You see this.
Ms Koh: **Why does this happen to this and not happen to the rest?**
Ms Koh: **Does it happen to the rest?**
Ms Koh: Try it out.
Siti: Let's try the mine [sic]….
Ms Koh: Besides that, you see, there are so many different types of coins here.
Ms Koh: So many different types.
Catherine: This coin doesn't work!
Ms Koh: **Yah, why doesn't it work?**
Ms Koh: **Which one separate them into what?**

Teacher's Questions (QN^T), T4G4S1

Teacher Teaching Child (TTC)

The second most dominant type of science talk for the teacher is Teacher Teaching Child (TTC), and there was about a fivefold increase of this type in S2. In this example, Ms Koh asked the children why the compass moved when a bar magnet was placed near it. Emily answered correctly and Ms Koh went on to teach the children how the needle in the compass was magnetic and was attracted to the magnet.

In this science talk, the teachers exercised 'choice and control' from Falk and Dierking's CML and decided to teach the children much more in S2. After adhering to the play protocol in Session 1, the teachers became used to the scientific play sessions and knew how much support or guidance they could offer to their children. The role of teacher surfaced and with opportunities like the learning gap (on the usage of a compass) in Session 2, they went on to teach the children who were struggling to use the compass.

Ms Koh: Why do you think is moving?
Evelyn: Because ….
Dora: Because ….
Emily: Because …. magnetic.
Ms Koh: Yes!
Ms Koh: **So, this one is trying to**
Ms Koh: Try to be attract[ed]?
Ms Koh: **And that's how it works out to.**
Ms Koh: **So, basically, this thing is trying to get attracted to the north pole.**
Dora: North and south.

Teacher Teaching Child (TTC), T4G1S3

Teacher Instructing Child (TIC)

The third most dominant type of science talk observed is Teacher Instructing Child (TIC). The teachers instructed the children less often in S2.

In TIC, the instructions that the teacher gave to the children were usually rather non-science and not science based. The instructions were typically related to the process and science-based examples were quite limited.

Here, after seeing how some groups had damaged the recently purchased non-waterproof compasses by soaking them in the water, Madam Lee stopped the groups in the class and reminded them not to dip the compasses into water. In this group, she dominated the whole conversation and guided the students with instructions, one after the other, continuously.

Compared to Section 5.12, where the teachers scored highest in instructing the children for all talk, in science talk, opportunities for the teacher to instruct the children on science matters, using science vocabulary and phrases with science content were harder to identify in such a play situation. Contexts for such science talk were not easy for the teachers to find and they were very conscious and used many science terms to instruct the children.

Madam Lee: **The…. compass do not put into the water!**
Madam Lee: **Remember…. do not soak it in the water!**
Madam Lee: **On the plate, ok.**
Madam Lee: **Not in the water.**

Teacher Instructing Child (TIC), T1G9S3

Teacher Offering Help (TOH)

The fourth most dominant type of science talk observed was Teacher Offering Help (TOH). The teachers offered more help to the children during the second scientific play session. In this case, Ms Koh offered help to a group by asking a series of guiding questions and giving instructions to help them set some things up. Then she guided them by telling them which part of the magnet was north so that, with that piece of science information, the children could be guided and moved to the next step, inferring what the other part of the magnet would be.

With the help offered by the teachers in making that decision (choice), help was scaffolded and the children had their hands held to move along the line of learning the cardinal directions of a compass (control). This action helped to provide an opportunity for the children to have a small success and learn with the help offered by the teachers.

Ms Koh:	Then how about this one?
Ms Koh:	Can you set up this one?
Ms Koh:	K?
Ms Koh:	**I'm going to tell you which one is the north, ah!**
Ms Koh:	Hard to tell.
Ms Koh:	K, this is the north.
Ms Koh:	K!
Ms Koh:	So, see whether it….
Sarah:	North!
Clara:	North and south.

Teacher Offering Help (TOH), T4G5S3

Conclusions about dominant types of talk

The four most dominant types of science talk used by the teachers are Teacher's Question (QN^T), which consists of Teacher's Reasoned Question (TQ) and Teacher's Non-Reasoned Question (TN), Teacher Teaching Child (TTC), Teacher Instructing Child (TIC) and Teacher Offering Help (TOH).

Next, the report moves on to the other end of the spectrum of the data in Table 5.10, the three least dominant types of talk engaged in by the teachers: Teacher's Feedback (Non-reasoned) [CF(NR)], Teacher's Story and Character (TS) and Teacher's Recall (TR).

Teacher's Feedback (Non-reasoned) [TF(NR)]

The least dominant type of teacher's science talk is Teacher's Feedback (Non-reasoned) [CF(NR)]. As explained in Section 5.21, this was due to the design of the coding system where it was not possible to give any feedback that was both science-related and non-reasoned. That is why this was recorded as 0% for both the children and the teachers.

Teacher's Story and Character (TS)

The second least dominant type of science talk for teachers is the Teacher's Story and Character (TS). This was rather low and only two teachers used it, one in each session.

In this case, the children in the group were making a structure together. Madam Lee came along and asked the group what they were trying to make. James hesitated and then asked her if the metal ruler that he was using was made of stainless steel. He was interrupted by his peer, Li Min, who was trying to get the attention of Madam Lee at the same time. To reply to both, the teacher looked at them and said that the ruler was indeed made of stainless steel. She created a story on the spot that made fun of herself, and said that she was made of stainless steel.

Madam Lee: What are, what are you making?
Michael: Er…
James: Is this stainless steel?
Li Min: Madam Lee …
Madam Lee: Stainless steel, ok?
Madam Lee: **I'm made of stainless steel.**

Teacher's Story and Character (TS), T1G5S1

The response of CS was impromptu and created on the spot by the teacher. It was not planned or scripted. It was the context that set up the opportunity, and the teacher had to be creative and participating to come up with the story and characters, with some underlying content (steel is a magnetic material) that she aimed to build into the story she had created.

Teacher's Recall (TR)

The third least dominant type of science talk for teachers is Teacher's Recall (TR). In this example, Ms Koh guided the group step by step. She led them to see that, if you have assumed and set one end of the bar magnet as 'north', then the other end of the magnet must be 'south'. However, if one finds out that both sides are north, then the markings on the bar magnet could be wrong.

Ms Koh: This as you know, this is the north already.
Sarah: Do this!

Ms Koh: We attract to this?
Clara: North!
Ms Koh: This is the south.
Ms Koh: Very good!
Ms Koh: **Just now, I tell you this is north.**
Ms Koh: Right?
Maya: Yah!
Ms Koh: Therefore, they labelled wrongly.

Teacher's Recall (TR), T4G5S3

TR was somewhat rare in the collections of the teachers' utterances. Usually, one could locate this type of science talk by looking out for time determiners like 'yesterday' or 'just now'. These are a few examples of words that helped to indicate when the teachers were trying to recall what had happened and speaking about it.

Conclusion

For the teachers, the extent of the types of science talk was different in their dominance. Teacher's Question (QN^T), Teacher Teaching Child (TTC), Teacher Instructing Child (TIC) and Teacher Offering Help (TOH) were the four most dominant types of talk, while Teacher's Feedback (Non-Reasoned) [CF(NR)], Teacher's Story and Character (TS) and Teacher's Recall (TR) were the three least dominant types of talk. Section 5.22 covered the weighting of all these seven types of science talk and answered the second research question in this research for teachers:

Q2. To what extent do children and teachers talk about science during play?

The extent of the discussion of science during play was generally similar for all the teachers in the full scientific play session. The trend was that the amount of science talk when summed up for the five teachers for the 13 types of talk all increased in S2. This increase could probably be linked to the fact that the teachers had become used to the scientific play session and knew how and where to provide support during the lesson. One of the two teachers with a shortened lesson, Mr Wong, slightly increased his science talk, while Teacher 5, Ms Geetha, decreased her science talk.

Order of the Dominance of Talk	Code (All Talk)	Code (Sci. Talk)
1	TIC	QN^T
2	QN^T	TTC
3	TF (R)	TIC
4	TTC	TOH

Table 5.11: A table comparing the order of dominance of the first four types of all talk and science talk for teachers.

The difference that was observed between the teachers for all talk and science talk was that the type of talk the teachers engaged in had moved away from teacher instructing children shown in Table 5.11, where all talk's dominant talk was Teacher Instructing Child (TIC). 'Choice and control' from Falk and Dierking's CML was higher for teachers in science talk and came right after the teacher's questions, the two-letter code, ranking higher in science talk than Teacher Teaching Child (TTC), Teacher Instructing Child (TIC) and Teacher Offering Help (TOH). The more dominant types of talk here were linked to the role of a teacher: questioning, teaching, instructing and offering help to their children. Although teachers spoke only 7.2% of the total utterances, quite a significant percentage (29.0%) of their talk was on science talk. The teachers were asking more science questions and teaching the child science content because these were the more dominant types of science talk they engaged in. The findings point to the role of the teachers, and the extent of the discussion of science during play by teachers will be further explored, analysed and discussed in Chapter 8.

In the next section, Analysis, the results for the extent of the discussion of science during play for the different science teachers will be looked at in greater detail and discussed.

Analysis: What does it mean?

Although the percentage of teachers' utterances overall is low, at 7.2%, science talk made up to close to 30% (29.0%) of the total of the teachers' utterances. Teachers' dominant science talk was a high 12.0% for QN^T. Teachers asked more reasoned questions (TQ) to scaffold the children's learning as well as asking some non-reasoned questions (TN) to follow the conversations. The teachers tried not to give away the answers, but instead asked questions to help the children construct their learning and understanding.

Choice and control from Falk and Dierking's CML was high within the science talk by teachers. As a teacher carrying out his or her role, it is to be expected that Teacher Teaching Child (TTC) would be high in science talk. Here, the teacher would try to teach the children in order to allow them to learn facts from the scientific play sessions. Additionally, the teacher also instructed the children on what to do with the compass when there was a gap in their learning, such as the usage of the compass. Due to prior experience of the float and sink concept learned in the topic of materials during the previous academic term (revealed by the children in the group interviews), many non-waterproof compasses were spoilt as the children placed them in the water.

As directed by the play protocol, the teachers tried to involve themselves in order to offer their help (TOH) to groups who were stuck or struggling, and offered encouragement (TE) to allow them to continue with what they were doing, reassuring them (TGR). Teacher's argumentation did not rank very high because this could only take place if the teacher interacted with the group. Argumentation is not direct, and one would need to build up a particular context before the arguments could be established. Most teachers assumed a more supervisory and observer-like role as they followed the play protocol with fidelity during the scientific play sessions. Unless the teacher was interacting with a group for quite a while, the feedback [TF (R)] would not be the first science talk that the teachers would get themselves involved in. The teachers would question, encourage or reassure the children before they gave them any feedback. Teachers' observations ranked (TO) were low in science talk because it was usually the children who would be making the observation, rather than the teacher. What the teachers saw as observation would usually be framed into teachable moments in the form of a question or teachers' recall (TR) to scaffold and guide the children.

Lastly, it was not easy for the teachers to come up with impromptu stories and characters (TS) on the spot, without the right context. The extent of the discussion engaged in by the teachers was closely related to the role of the teacher and linked to the science skills that the children had picked up during their science lessons and the scientific play sessions held for this study.

5.3 Statistical tests for the grouping of children and teachers

As the researcher was interested to investigate if the talk between children differed between those the teacher had thought that they had 'played well' (Group A), 'played averagely' (Group B) and 'played not so well' (Group C) (during play for learning) and within different teachers, statistical tests were used to look at the difference(s) in the types of children's group on their talk in these groups and the type of teacher talk with different teachers. While this does not directly answer the research questions 1 and 2, it provides some insights that are likely to be important for practitioners such as teachers, and therefore the results are reported here.

For this research study, the 'Primary Science Talk Framework with Play' (PSTFP-refer to Chapter 4) was created to study the type of talk that the children (17 types in total) and teachers (13 types in total) engaged in a scientific play session during their science lesson. This framework was tested using the Cronbach's Alpha in the reliability test, and it has a score of .635 (Figure 5.2) which suggests that the framework used in this study is reliable as the value is more than .05.

Reliability Statistics

Cronbach's Alpha	N of Items
.635	17

Figure 5.2: A figure showing the result of Cronbach's Alpha reliability Test

In this section, the PSTFP, was used with the statistical test-the Kruskal-Wallis test, a non-parametric statistical test because the samples were not normally distributed. The Kruskal-Wallis test was used to determine the significant differences between different groups of children and teachers for all talk and science talk. Then, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .017$ level to see if there is any statistical relationship between the children's group or the teachers.

Although Section 5.3 does not directly answer the research questions 1 and 2, with further quantitative findings found and referred to in Appendices 5.3, Section 5.3 provides a more in-depth and finer grain of analysis which complements and supplements the data in Sections 5.1 and 5.2. This is significant to understand if certain types of talk were significantly different due to the different children's groups or among different teachers for all talk (Section 5.1) or science talk (Section 5.2). These insights are likely to be important for practitioners such as teachers. For example, was asking reasoned questions or providing reasoned feedback different for the groups that teachers perceived to have 'played well' for science talk than the other two groups?

With the above objectives in mind, Section 5.31 reports the statistical results between different groups of children (Groups A-C), while Section 5.32 reports the statistical results between different teachers (Teachers 1-5). The statistical results are helpful to give us insights into the type(s) of children's talk (17 types for children) and teacher's talk (13 types for teachers) that have significant differences by the grouping of the children or teacher for both all talk and science talk. The statistical results for teachers also reflect the relationship of different teachers and the fidelity of the play protocol. They also show how some types of teacher's talk differ between some teachers during the two scientific play sessions, S1 and S2, and when both S1 and S2 were added together.

5.31 Children

The children's utterances were studied in two ways: all talk and science talk. There were 17 different types of talk in all talk, comprising the non-science and science talk in all talk and 17 different types of talk in science talk, which only comprises science talk. This section looks at whether there is a difference between the three groups: 'played well' (Group A), 'played averagely' (Group B) and 'played not so well' (Group C) on how they had played during the scientific play sessions and uttered on every one of the 17 different types of talk in both all talk and science talk.

(a) Children (All talk)

For children, there were no statistically significant differences in S1 (refer to Appendix Table 5.13) at $p < .05$ level but there was one statistically significant difference found in S2 (refer to Appendix Table 5.15) for Child's Encouragement (CE), $\chi^2(2) = 7.000$, p=.025, where further pairwise comparisons showed that there was a significant difference between Group A (mean rank=5.40) and B (mean rank=12.40) (p = .040) (refer to Figure 5.3). In summary, Group B children who 'played averagely well' could have significantly encouraged their peers than Group A who had 'played well'. There was no significant statistical relationship between Group C (mean rank= -5.20), who had 'played not so well', with Group A or B.

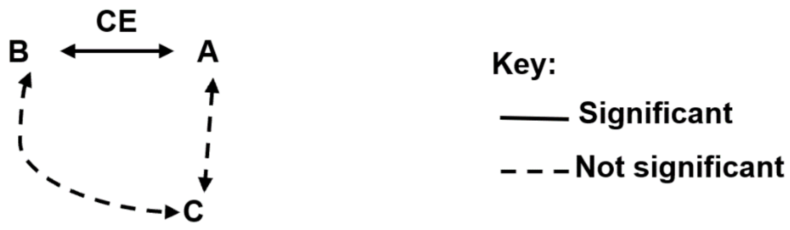


Figure 5.3: Statistical relationship between A, B and C during Scientific Play Session 2 (All talk- Children)

As for S1 and S2 added together (refer to Appendix Table 5.16), two types of talk- Child's Encouragement (CE), $\chi^2(2) = 8.276$, p=.016 and Child's Feedback [CF(R)], $\chi^2(2) = 6.760$, p = .034 were found to be statistically significantly different. After further pairwise comparisons, it had been shown that there was a significant difference between Group A (mean rank=10.60) and B (mean rank=21.70) (p = .005) for Child's Encouragement (CE) and Child's Feedback [CF (R)] between Group A (mean rank= 11.30) and Group B (mean rank= 21.20) (p = .012) (refer to Figure 5.4). In summary. the amount of encouragement and reasoned feedback that Group B children who 'played averagely well' had provided was significantly more than Group A children who had 'played well' but not Group C (mean rank= 14.00) children who had 'played not so well'.

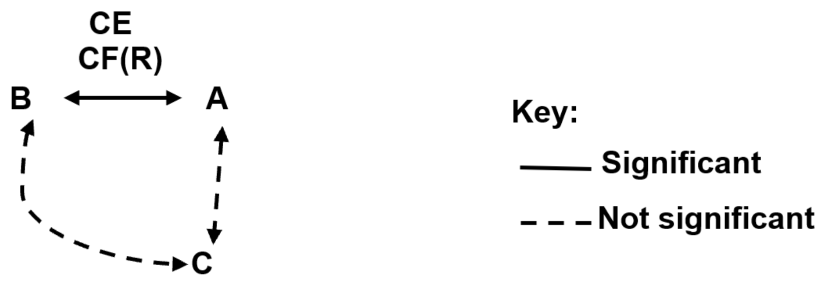


Figure 5.4: Statistical relationship between A, B and C during Scientific Play Sessions 1 and 2 (All talk- Children)

(b) Children (Science talk)

For children in science talk, there was no significant difference in S1 (refer to Appendix Table 5.17) at $p < .05$ level for all 17 types of talk. In S2, only a significant difference (refer to Appendix Table 5.19) was shown in the Child's Non-Reasoned Questions (CN), $\chi^2(2) = 6.020$, p=.049, when the Kruskal-Wallis test was carried out. It was after the pairwise comparisons that a significant difference between Group A (mean rank=4.20) and B (mean rank=11.00) (p = .049) of the children (refer to Figure 5.5) was shown. In summary, the number of more non-reasoned questions asked by the 'children who played averagely well' (Group B) was significantly more than 'children who played well' (Group A), but not by 'children who played not so well" (Group C, mean rank=8.80). The result suggests that the grouping of children could have some difference on Child's Non-Reasoned Questions (CN).

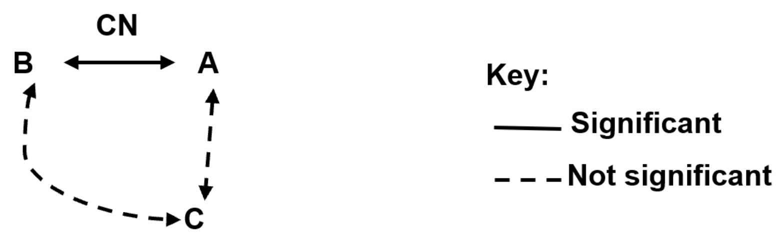


Figure 5.5: Statistical relationship between A, B and C in Scientific Play Session 2 (Science Talk- Children)

Lastly, there was no statistically significant difference for when the utterances in S1 and S2 were added together (refer to Appendix Table 5.20).

5.32 Teachers

For teachers, the statistical tests showed that out of the 13 types of teacher's talk, a higher number of them were significantly different among the five teachers. This number contrasted with 1-2 types of 17 types for children's talk. When carrying out pairwise comparisons in Appendix 5.3, higher significant differences between the five teachers were noted for the different types of talk they used during the scientific play sessions, as shown in Table 5.12 below, when they were compared with the children.

All Talk	**Number with Significant Difference**	**Number with Significant Pairwise Comparison**
S1	3	2
S2	3	2
S1 & S2	8	6
Science Talk	**Number with Significant Difference**	**Number with Significant Pairwise Comparison**
S1	2	1
S2	6	0
S1 & S2	7	6

Table 5.12: A table showing a summary of statistical data for all talk and science talk for teachers.

More details about the statistical tests are presented in Appendix 5.3, and the mean rank obtained from the statistical tests suggests which teacher was carrying out the type of talk more frequently.

(a) Teachers (All talk)

S1

In S1, 10 of the teachers' talk were not significantly different among different teachers (refer to Appendix Table 5.22). Three types of teachers' talk were significantly different. They were: Teacher's Encouragement (TE), $\chi^2(4)=10.436$, $p= .034$, Teacher Instructing Children (TIC), $\chi^2(4)=11.086$, $p = .026$, and Teacher Giving Reassurance (TGR), $\chi^2(4)=10.207$, $p = .037$. However, only two out of these three were significantly different when pairwise comparisons were carried out. There were significant differences between Teacher 4 (mean rank = 2.67) and Teacher 5 (mean rank = 13.33) (p=.035) for TIC and Teacher 1 (mean rank = 12.67) (p=.050) and Teacher 5 (mean rank = 2.50) for TGR (refer to Figure 5.6). In summary, Teacher 5 had instructed the child much more than Teacher 4, and Teacher 1 had been able to give much more assurance than Teacher 5. The post hoc analysis showed no significant pairwise comparisons in all five teachers for Teacher's Encouragement (TE). The statistics indicate that the type of teacher, in this case, three of them, have significant differences in the type of talk that the teacher was engaged during the scientific play session 1.

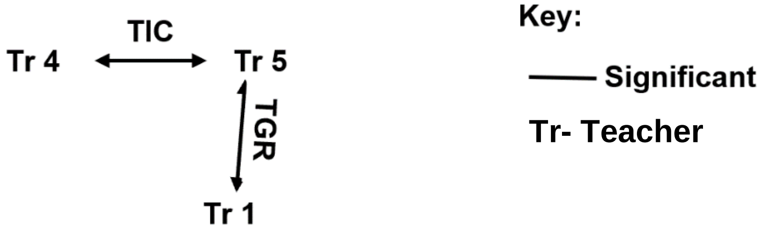


Figure 5.6: Statistical relationship between Tr 4 and Tr 5 and Tr 1 and Tr 5 in Scientific Play Session 1 (All Talk- Teachers)

S2

For S2, 10 of the teachers' talk were not significantly different among different teachers (refer to Appendix Table 5.23). Three types of teachers' talk were significantly different among different teachers (refer to Appendix Table 5.23). They were: Teacher's Non-Reasoned Questions (TN), $\chi^2(4)=9.990$, $p = .041$, Teacher's Reasoned Questions (TQ), $\chi^2(4)=12.368$, $p = .015$, and Teacher Instructing Child (TIC), $\chi^2(4)=12.142$, $p = .016$. Further pairwise comparisons showed that the latter two types of talk: Teacher's Reasoned Questions (TQ) and Teacher Instructing Child (TIC), were significantly different. The way that Teacher 4 (mean rank = 13.67) (p=.020) and Teacher 5 (mean rank = 2.50) asked reasoned questions (TQ) and Teacher 4 (mean rank = 2.33) and Teacher 5 (mean rank = 13.50) (p=.020) instructing the child (TIC) were significantly different. (refer to Figure 5.7). In summary, Teacher 4 asked more reasoned questions than Teacher 5, while Teacher 5 instructed the child more than Teacher 4.

Figure 5.7: Statistical relationship between Tr 4 and Tr 5 in Scientific Play Session 2 (All Talk- Teachers)

S1 and S2

For S1 and S2 combined, only five of them were not statistically significantly different among different teachers (refer to Table 5.24). Eight other types of talk that are statistically significantly different are:

Teacher's Non-Reasoned Questions (TN), $\chi^2(4)=16.100$, $p = .003$,
Teacher's Reasoned Questions (TQ), $\chi^2(4)=21.465$, $p = .000$,
Teacher's Encouragement (TE), $\chi^2(4)=15.577$, $p = .004$,
Teacher's Recall (TR), $\chi^2(4)=9.581$, $p = .048$,
Teacher's Reasoned Feedback [TF (R)], $\chi^2(4)=11.061$, $p = .026$,
Teacher Instructing Child (TIC), $\chi^2(4)=23.283$, $p = .000$,
Teacher Teaching Child (TTC) $\chi^2(4)=11.416$, $p = .022$, and
Teacher Giving Reassurance (TGR), $\chi^2(4)=16.542$, $p = .002$.

Out of the eight types of talk, only two types of talk [Teacher's Recall (TR) and Teacher Teaching Child (TTC)] were not statistically different after pairwise comparisons. From Figure 5.8, there was significant difference between Teachers 1 and 5 for 4 types of talk [TQ, TF (R), TIC and TGR]. In summary, Teacher 1 was asking more reasoned question (TQ) (mean rank = 22.17) (p= .017), giving more reasoned feedback [TF(R)] (mean rank = 20.92) (p=.020), more reassurance (TGR) (mean rank = 25.33) (p=.001) but instructing less (TIC) (mean rank = 9.17) (p=.009) than Teacher 5, who had asked fewer reasoned questions (TQ) (mean rank = 6.25), gave fewer reasoned feedback [TF(R)] (mean rank = 5.50), fewer reassurance (TGR) (mean rank = 6.50) but instructing more (TIC) (mean rank = 26.00) (p=.000).

There was also statistical relationships between Teachers 4 and 5. In summary, Teacher 4 was more encouraging (TE) (mean rank = 26.17) (p=.002), supporting the children with more non-reasoned questions (TN) (mean rank = 13.67) (p=.020) and instructing less (TIC) (mean rank = 4.67) as compared to Teacher 5 where she encouraged the children (TE) (mean rank = 9.50) and supported the children with non-reasoned questions (TN) (mean rank = 2.50) fewer times but was instructing more (TIC) (mean rank = 26.00) (p=.000).

Moreover, between Teachers 2 and 4, Teacher 4 was more encouraging (TE) (mean rank = 26.17) (p=.049) than Teacher 2 (mean rank = 13.50). For Teachers 1 and 2, Teacher 1 (mean rank = 25.33) (p=.001) was giving more reassurance (TGR) than Teacher 2 (mean rank = 11.42). Lastly, Teacher 4 instructed less (TIC) (mean rank = 4.67) but gave more reasoned feedback [TF(R)] (mean rank = 17.00) than Teacher 3 in TIC (mean rank = 21.00) (p=.013) and [TF(R)] (mean rank = 16.25). In conclusion, the type of teacher was significant for at least six types of the teacher talk in all talk for teachers.

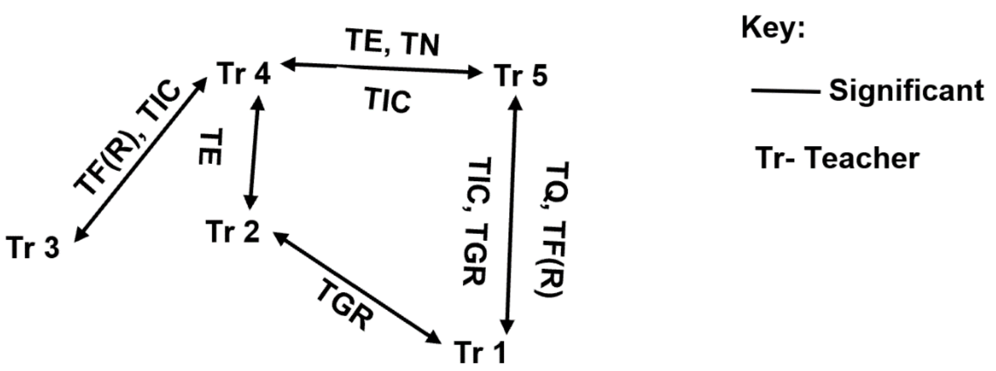


Figure 5.8: Statistical relationship between five teachers in Scientific Play Sessions 1 and 2 (All Talk- Teachers)

(b) Teachers (Science talk)

S1

For the teachers in science talk, 11 types of talk were not significantly different and only two types of talk were statistically significant. They were Teacher’s Non-Reasoned Questions (TN) and Teacher’s Reasoned Questions (TQ). After pairwise comparisons, there was only a statistical relationship between Teacher 4 (mean rank = 14.00) (p=.030) and Teacher 5 (mean rank = 3.50) (refer to Figure 5.9), where Teacher 4 asked more of the non-reasoned questions (TN) than Teacher 5.

Figure 5.9: Statistical relationship between Tr 4 and Tr 5 in Scientific Play Session 1 (Science Talk- Teachers)

S2

For S2, seven types of talk were not statistically significantly different between different teachers (refer to Appendix Table 5.26), and six types of talk were statistically significant. After the post hoc analysis was carried out for all six types of science talk, they showed no statistically significant pairwise comparisons for all five teachers. There was no difference among all five teachers for the science talk.

S1 and S2

For S1 and S2, six were not significantly different between different teachers (refer to Appendix Table 5.27), while seven types of talk were statistically significantly different. These seven types were:

> Teacher's Non-Reasoned Questions (TN), $\chi^2(4)=18.532$, $p = .001$,
> Teacher's Reasoned Questions (TQ), $\chi^2(4)=22.187$, $p = .000$,
> Teacher's Encouragement (TE), $\chi^2(4)=17.848$, $p = .001$,
> Teacher's Reasoned Feedback [TF (R)], $\chi^2(4)=15.822$, $p = .003$,
> Teacher Instructing Child (TIC), $\chi^2(4)=10.789$, $p = .029$,
> Teacher Teaching Child (TTC), $\chi^2(4)=10.488$, $p = .033$, and
> Teacher Giving Reassurance (TGR), $\chi^2(4)=11.508$, $p = .021$

Out of these seven types of talk, with the post hoc analysis, only Teacher Teaching Child (TTC) showed no statistically significant pairwise comparisons in all five teachers. The rest of the statistical relationship was shown in Figure 5.10, where all five teachers were involved. In this section, the discussion will start from Teachers 5 and 1 first, followed by Teachers 1 and 2, Teachers 2 and 4, Teachers 4 and 5, Teachers 4 and 3, Teachers 3 and 1 and lastly, Teachers 4 and 1 in a clockwise manner. The mean rank value will indicate how different the type of teacher's talk is for science talk.

In summary:

Teachers 5 and 1

For Teacher 1, she was able to ask more reasoned questions (TQ) (mean rank = 22.00) (p= .047), give more reasoned feedback [TF(R)] (mean rank = 24.92) (p=.007) and give more reassurance (TGR) (mean rank = 23.67) (p=.019) than Teacher 5 in asking reasoned questions (TQ) (mean rank = 9.00), giving reasoned feedback [TF(R)] (mean rank = 11.50) and giving reassurance (TGR) (mean rank = 10.00). There was a significant difference in how Teachers 1 and 5 engaged themselves in science talk for three types of science talk.

Teachers 1 and 2

For teacher's reasoned feedback [TF(R)], Teacher 1 (mean rank = 24.92) (p=.048) gave more reasoned feedback to the children than Teacher 2 (mean rank = 13.75).

Teachers 2 and 4

For Teacher 4, she was able to ask more reasoned questions (TQ) (mean rank = 25.33) (p= .042), more non-reasoned questions (TN), (mean rank = 25.42) (p= .032) and encouraged (TE) (mean rank = 26.33) (p=.014) the children than Teacher 2 for reasoned questions (TQ) (mean rank = 12.17), non-reasoned questions (TN) (mean rank = 10.92) and encouragement (TE) (mean rank = 13.17).

Teachers 4 and 5

For Teacher 4, she was able to ask more non-reasoned questions (TN) (mean rank = 25.42) (p=.001) and reasoned questions (TQ) (mean rank = 25.33) (p= .004) than Teacher 5 for non-reasoned questions (TN) (mean rank = 6.50) and reasoned questions (TQ) (mean rank = 9.00). Teacher 4 was also able to encourage (TE) (mean rank = 26.33) (p=.002) and instruct (mean rank= 14.17) the child more than Teacher 5 for encouraging the child (TE) (mean rank = 11.00) and instructing the child (TIC) (mean rank = 11.50).

Teachers 4 and 3

Teacher 4 was able to ask reasoned questions (TQ) (mean rank = 25.33) (p= .004) and encouraged the child (TE) (mean rank = 26.33) (p=.012), than Teacher 3 in asking reasoned questions (TQ) (mean rank = 9.00) and giving encouragement (TE) (mean rank = 13.00).

Teachers 3 and 1

For Teacher 1, she was able to ask more reasoned questions (TQ) (mean rank = 22.00) (p= .047), gave more reasoned feedback [TF(R)] (mean rank = 24.92) (p=.007) and instructed the child (TIC) (mean rank = 24.00) (p=.042) than Teacher 3 for asking more reasoned questions (TQ) (mean rank = 9.00), giving more reasoned feedback [TF(R)] (mean rank = 11.50) and instructing the child (TIC) (mean rank = 10.83).

Teachers 4 and 1

For Teacher 4, she was able to encourage the child (TE) (mean rank= 26.33) more than Teacher 1 (mean rank = 14.00) (p=.028).

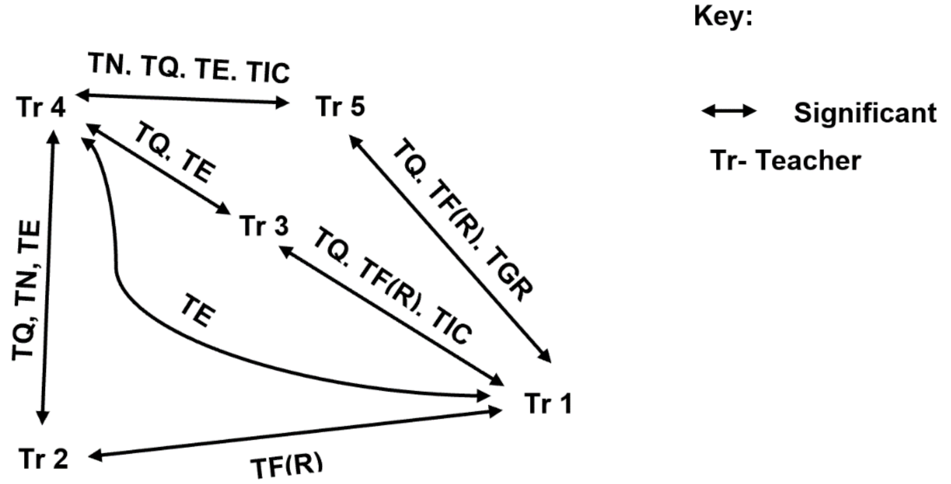


Figure 5.10: Statistical relationship between all five teachers for the total in Scientific Play Sessions 1 and 2 (Science Talk- Teachers)

In conclusion for science talk for teachers, the type of teacher was also significant for at least six types of the teacher talk in science talk for teachers. However, the statistical relationships between teachers had increased from one to two types of talk in all talk (refer to Figure 5.8) to one to four types of talk in science talk (refer to Figure 5.10). That implies that for teachers, types of talk do differ more in different teachers for science talk.

5.4 Conclusion

This study noted that the nature and dominant types of all talk and science talk for children and teachers were different from each other. The nature of all talk among the children during play is predominantly Child's Feedback [non-reasoned (20.4%) then reasoned (14.8%)], Child's Questions (QN^T – 11.2%), Child's Observations (CO – 9.2%), Child Instructing Peers (CIP – 8.4%), Child Seeking Reassurance (CSR – 8.2%) and Child's Own Choice (COC – 7.1%). Children's all talk was generally related and linked to continuing their conversations. Compared to the children, the nature of all talk by the teachers during play was predominantly Teacher Instructing Child (TIC – 46.4%), Teacher's Questions (QN^T – 22.9%), Teacher's Feedback (Reasoned) [TF(R) – 7.7%] and Teacher Teaching Child (TTC – 6.7%). These were linked to the role of a teacher.

From the statistical tests in Section 5.31 (a) for children, there was no statistical significance for the 17 types of children in all talk in S1. A significant difference was found in S2 between children who 'played well' (Group A) and children who 'played averagely' (Group B) on Child's Encouragement (CE) and Child's Reasoned Feedback [CF(R)] and Child's Encouragement (CE) for S1 and S2 combined for all talk for children. There were two significant differences between children who 'played well' (Group A) and children who 'played averagely' (Group B) out of 17 types of talk children engaged in all talk, where the grouping of the children matters. The results suggest that children who 'played averagely' (Group B) could have a difference in a few types of talk with children from children who 'played well' (Group A) but not with children who did not 'play so well (Group C). There were also no significant differences between children who 'played well' (Group A) and children who 'did not play so well' (Group C) for all types of talk. Moreover, synthesising both data from Section 5.11 and Section 5.31(a), the second dominant talk for all talk for children, Child's Reasoned Feedback [CF(R)], was significantly different between children who 'played averagely' (Group B) and children who 'played well' (Group A). These two groups of children gave reasoned feedback significantly differently.

As for the teachers, there were differences in the type of teachers as reported in Section 5.32 (a). The difference was reported between Teachers 5 and 4 where Teacher 5 instructed the child (TIC) more than Teacher 4 for S1 and S2. Besides Teachers 5 and 4, there was also statistical relationship between Teachers 1 and 5 where Teacher 1 was able to give much more assurance to the child than Teacher 5 in S1. In S2, Teacher 4 asked more reasoned questions (TQ) than Teacher 5. There were differences in all teachers in S1 and S2 combined on the six types [TN, TQ, TE, TF(R), TIC and TGR] of the 13 types of talk for teachers, as seen in Figure 5.8. The nature and dominant types of talk among teachers varied for three teachers in S1 and S2 but varied among all teachers, in S1 and S2 combined during the scientific play sessions as seen in Section 5.32 (a). Synthesising both data from Section 5.12 and Section 5.32 (a), the most dominant talk for all talk for teachers, Teacher Instructing Child (TIC), was significantly different for three pairs of teachers. This finding could suggest that the type of teacher matters more for this type of teacher talk. Next, for the third dominant talk, Teacher's Reasoned Feedback [TF(R)], two pairs of teachers were significantly different, which suggests that teacher does matter to some extent for this type of talk.

In summary, the findings show that the nature and dominance of the children's talk were linked to how children used talk to communicate with their peers, and teachers' talk was linked to their roles as teachers of the children. There were also differences between children who 'played well' (Group A) and children who 'played averagely' (Group B). As for the teachers, the differences were seen in S1, S2 and S1 and S2 combined. Teachers do make a difference in the type of talk in all talk. These findings help answer parts (a) and (b) of the first research question.

As for research question 2, the findings for the children show that the nature of the talk by the children during play for all talk and science talk were similar, except that the extent of the discussion of science in science talk was more focused on children teaching their peers (CTP – 2.0%) and more on science skills, such as observation (6.0%) and asking questions (2.0%). As for the teachers, the nature of their talk during play for all talk and science talk is related to their role of teacher, and this was more present and evident in the science talk of the teachers. In their science talk, the teachers focused more on questioning (QN^T – 12.0%), teaching (TTC – 4.1%), instructing (TIC – 2.9%) and helping the children (TOH – 2.4%) while they played during the scientific play sessions. On the other hand, the least dominant types of science talk which both the children and teachers engaged in were similar and did not vary in this study.

From the statistical tests in Section 5.31 (b) for children, there was no significant difference for the 17 types of children's talk in science in S1 and S1 and S2 combined. A significant difference was found in S2 between children who ‘played well’ (Group A) and children who ‘played averagely’ (Group B) on Child’s Non-Reasoned Questions (CN). Therefore, based on the findings in Section 5.31(b) for children’s science talk, the children's grouping would probably not matter, except for one type of talk out of the 17 types of talk between children who ‘played well’ (Group A) and children who ‘played averagely’ (Group B) in S2, for the extent of the discussion of science during the play sessions.

As for Section 5.32 (b) for the teachers, in S1, Teachers 4 and 5 were only significantly different in asking non-reasoned questions (TN) after pairwise comparisons were carried out on two types of talk: teacher asking non-reasoned questions (TN) and teacher asking reasoned questions (TQ). There were six significant differences out of the 13 types of talk when Kruskal-Wallis tests were carried out in which there was no statistical relationship among all five teachers for S2. As for S1 and S2 combined, all five teachers were found to have significant differences in six types of the 13 types of talk [TN, TQ, TE, TF(R), TIC, TGR] (refer to Figure 5.10). Teacher Teaching Child (TTC), which was initially found significant using the Kruskal-Wallis test, showed no statistically significant pairwise comparisons in all five teachers after the post hoc analysis. The extent to which science talk was done for Teachers Instructing Child (TIC), the third dominant science talk, showed that, like for all talk, the teacher does probably matter as there were two sets of significantly different teachers.

In conclusion, this chapter has summed up the findings to answer the first two research questions. In the next chapter, the findings will answer the third research question of this study, which looks at the children’s perspectives on play in primary science in a qualitative manner.

Chapter 6 Children's Perspectives on Play in Primary Science

6.0 Introduction

This chapter discusses the qualitative findings relating to children's perspectives on play in primary science. The findings were obtained from 15 children's group interviews (n= 57) from five classes in three schools and they address the third research question:

Q3. What are the children's perspectives on play in primary science?

Throughout the thesis, quoted sections of the group interview transcripts are indicated by the source code and the line numbers in parentheses. For shorter quotes, the name of the child is quoted with the line numbers, while for quotes that were spoken as a group or for longer quotes, the source of the group's code is used instead, with the line numbers. Square brackets such as [sic] are used to indicate words spoken verbatim with grammatical or pronunciation mistakes, while square brackets such as [words displayed in brackets] indicate an insertion to clarify the context of the child's utterances. Square brackets with ellipses enclosed show the deletion of superfluous words or phrases. An ellipsis marks an unfinished utterance. The words 'children' (C) and 'teachers' (T) have been abbreviated when used to indicate the number of children and teachers represented in the group interviews. Pseudonyms are given to the children in this chapter.

In this thesis, the children refer to their activities during the scientific play sessions (SPS) as 'play' and 'experiment' in the quotes, drawing little distinction between their science-stimulated play and the experiment type of activities they undertook in science lessons. An example is when Miko demonstrated the blurring of the terms:

> *… play is like to learn how to make a magnetic object into a magnet, like the electro… magnets, stroking magnets, then it's like the experiments for a few days.*
>
> A1G3S2

The data obtained from the children's group interviews were inductively coded to generate themes using a qualitative approach based on thematic analysis [see Section

3.73 (b)]. These emergent themes were then mapped onto the theoretical model based on a modification of Falk and Dierking's (2000) Contextual Model of Learning (CML). The CML states that learning is a process and a product of the interactions between personal, sociocultural and physical contexts over time (Falk & Storksdieck, 2005). By considering the personal, sociocultural and physical factors of Falk and Dierking's CML that influence children's engagement with play in science, it is possible to consider the potential of play as an approach to promoting science learning in a free-choice, informal context. However, as the children in this study did not have any choice over the physical context (as the SPS were conducted in the science classrooms or science laboratory), the researcher decided to focus only on the other two contexts of Falk and Dierking's CML – the personal and sociocultural contexts.

In the personal context, the key factors were the children's motivations and expectations, their prior knowledge, interests and experience, and their choice and control. In the sociocultural context, the key factors were the different types of social mediations within and outside the groups, which for this study were summed up and termed 'social mediations'. These key factors are shown in Table 6.1 as the headings in bold prints in Sections 6.11–6.13 and Section 6.21. Themes that were inductively generated and informed by the children's group interviews through the thematic analysis in this study were then further analysed and classified by the researcher to be placed in an alphabetical list under the key factors in Table 6.1.

6.1 Personal Context

6.11 Children's Motivations and Expectations of Using Play in Learning Science

(a) *Play is enjoyable*
(b) *Play is for young children*
(c) *Play is an escape from lessons*
(d) *Play is a form of reward*
(e) *Play is a waste of time*
(f) *Play can be limited by the adults' set of unwritten rules*

6.12 Children's Prior Knowledge, Interests and Experiences in Learning Science

(a) *Play is informed by the children's prior knowledge from school, educational institution, books, home and peers*
(b) *Play is informed by the children's prior interests informed by culture, gender, specific interests and personal preferences*
(c) *Play is informed by the children's prior experiences at school, home and other places*

6.13 Children's Choice and Control in Learning Science

(a) Play is a context to empower the children in their freedom of choice to explore and learn
(b) Play is a way of providing authentic tactile experiences for children
(c) Play can be learning or not learning
(d) Play's nebulous structure causes discomfort to some children
(e) Play encourages creativity and builds children's problem-solving skills
(f) Play can allow the extension of learning at home
(g) Play is challenging to parents and teachers' perceptions of school science

6.2 Sociocultural Context

6.21 Social Mediations

(a) *Play is a way for children to interact with their peers*
(b) *Play is a place where children build their social skills*
(c) *Play offers opportunities for teachers to interact with the children in reduced power relationships*

Table 6.1: Themes generated from the thematic analysis of children's group interviews about the children's perspectives on play, classified according to Falk and Dierking's (2000) CML.

6.1 Personal context

This context is made up of three key factors, namely: children's motivations and expectations of using play in learning science; children's prior knowledge, interests and experiences in learning science; and children's choice and control in learning science. Each overarching key factor is discussed in greater detail in the following Sections, 6.11 to 6.13.

6.11 Children's motivations and expectations of using play in learning science

In this section, children's perceptions of the personal context of play in relation to their motivations and expectations are presented: 'play is enjoyable', 'play is for young children', 'play is an escape from lessons', 'play is a form of reward', 'play is a waste of time' and 'play can be limited by the adults' set of unwritten rules'.

(a) Play is enjoyable

When the children were asked in group interviews to comment on play in science, they used a range of adjectives stemming from the word 'fun' to various degrees (A1G3: 22, C3G1: 763, C4G2: 150 and C5G1: 17). Play experiences appealed to them because they were "enjoyable" (A1G2: 1103, C5G3: 321–322) and "very nice" (C5G2: 58), while for some children, it was "very cool"[1] (C3G1: 894) and "exciting" (C4G1: 39). The children highlighted that they got to "laugh" more than they did in their usual science lessons (C3G2: 531). Some children (A1G2: 59–60; B2G3: 174) called for more opportunities to play and others, such as Audrey, reported that she "never want[ed] to stop the play" (460–461). The children's response times were almost immediate, "with gusto" (A1G2: 936–937) and without hesitation. They also used words such as "love", "of course" (Sam-967) and "super" (Miko-939) with increased excitement to express their intensity.

Play was enjoyable to the children such that they described their minds as being focussed on play and nothing else:

> *We don't think, we just play.*
>
> C5G1S3

For example, Ming Li was oblivious to the things she was supposed to do because her mind was only on the play she was going to engage in, and she asked (443–444):

> *I was like, "Are we supposed to learn or what? I'm just going to play!"*

C4G3S3

(b) Play is for young children

Some children in this research study saw themselves as mature and play as something that young children do. For example, although Li May reported enjoying play, she said:

> *Because I don't really love playing because …, I've grown up but sometimes, when I'm bored and I've finished my homework, I can play with my sister.*

C3G3S3

This shows that, even by the age of 8–9, the children already had the idea that play is for younger children. When they entered primary school, after they had moved from Primary 2 to a more formal stage of learning in Primary 3, they were repeatedly told by their parents and teachers that they were getting older and needed to behave more maturely and appropriately. Play was not for them, even though they might still want to engage in it.

(c) Play is an escape from lessons

The children described play as an escape from lessons in comparison to their usual science lessons. Indeed, they expressed disbelief when told they would have the opportunity to play in science. The children felt that there was "a lot less stress" (C3G1: 49) during play and it was "more like relaxing" (A1G2: 1100–1102) than lessons. Indeed, some children, such as Nurul, discussed play in favourable comparison to lessons:

> *Because I don't like [the] lessons. Lessons are boring!*

B2G1S3

Reasons given for liking play were: fewer worksheets during science lessons (Sophia: 658), the absence of "homework" (Sophia: 718, Mia: 722), less scolding from the teacher during the SPS (Shi Min: 525), having the opportunity to handle the magnets (Li May: 42) and play being more fun (Maya: 217–218). Play was important in relieving the stress induced by usual lessons:

> *So if we're like very stressed at our work, then we can have like a playtime, then we can let go of that stress and don't care."*
>
> C5G2S3

Although play might be fun for the children, and could be an escape from lessons, Sophia was a bit hesitant about engaging in play in science because she did not want to have homework to replace the time 'lost' to play. Mia commented that "a lot of homework" (766) was coming from her teachers or parents soon. Likewise, Kai Cheng said that, in the end, this was what was going to happen:

> *My mum will give me a pile of worksheets.*
>
> A1G3S3

This means that, even though play offered an escape, there was a trade-off for the children. They had to make up the time 'lost' in play by doing worksheets, which they disliked. Therefore, the children's motivation would probably be affected if gatekeepers such as their parents at home or teachers in school did not allow them access to play. Play is an escape from lessons if it is free from the gatekeepers' control.

(d) Play is a form of reward

Many children reported perceiving play as a form of reward because they seldom had the time to play in school. This was perhaps due to how the session was constructed, with 45 minutes of a formal lesson first and then 15 minutes of free play at the end, a purposeful act by the teacher. For example, Li Ming (128–131) reported:

> *Yah, after, after you use a lot of handwriting, hand movements, then after that, you feel very tired then you get at the end, at least you get to play lah! The last section.*
>
> A1G1S1

Many children reported that usual science lessons were associated with a lot of tiring writing and worksheets. Play motivated them to complete their classwork:

> *It’s because like, force [you] to do your work, then after you get to enjoy [the] fun!*
>
> A1G2S2

Moreover, play attracted the children and resulted in them coming to school more regularly. For example, Madam Lee and Madam Bhavani remarked on a visible and better attendance rate for their classes. There was full attendance and children who were often absent turned up for the lessons after their teachers announced the date when SPS would be held. The children also expressed their gratitude at being selected for the research study and reported that their friends in other classes were envious. This means that play appealed to the children and could act as a reward to entice them in various ways.

(e) Play is a waste of time

Even though the children were positive about play, Joanne indicated that they did not need “to play all the time” (521). Yu Han did not think it was good to include play within her class time and said “nah, never” (446). To her, play is addictive and a waste of time. Similarly, Emily explained that, if she played, she would “do nothing” (459).

Mira also saw play as a waste of time; giving reasons that she needed to allocate time “to revise for exams” (752–753) and “play iPad sometimes” (754). At this age, children had already given priority to their studies; “equal time to study and play” (Shena: 757). The children voiced their opinions that 15 minutes of play was appropriate because they were fully aware of what they needed to complete within a typical school day. The children were taught from a young age that study is very important to them and they should spend more time studying. They could not just ‘waste time’ playing.

(f) Play can be limited by the adults’ set of unwritten rules

While the children were encouraged to play as freely as they desired, they met with some incidents that puzzled them. They discovered that they were limited in their play by some unwritten rules that were not announced before they began. They were expected to understand and accept these rules as they unfolded during their play. For example, Maya spoke about how her group’s original enthusiastic intention to make demagnetised magnets was frowned upon and they “were scolded” by the teacher

(372). She used the term “bizarre” (369–371) because they were expecting to be praised for their ideas. While they were learning how to demagnetise a magnet, they also learned that anything destructive was not encouraged and they needed to “be [more] careful for [sic] the magnet” (377).

Another incident recalled by the children occurred when many groups in the second SPS emptied the whole basket of things into the water just as the SPS was getting started. This happened because the children were making a connection with the previous science topic (on floating and sinking). Almost all the newly bought compasses were destroyed during that session. No doubt, there was the intention for the children to explore and play, but the adults’ considerations of costs and limitation on the availability of materials were sets of ‘right and wrong’ unwritten rules that the children had to cope with. There was a mismatch between the adults’ and the children’s perspectives on materials. This means that, at times, the extent of freedom of play was limited by the materials (e.g., whether they were waterproof).

The data on children’s perceptions suggests that their motivations and expectations around play and learning are at times in conflict with each other. Whilst they find play enjoyable and preferable to lessons, they do not see it as a time when they are learning.

6.12 Children’s prior knowledge, interests and experiences of learning science

Before this research study, children had little prior experience of play in science lessons. The children linked their SPS to prior learning from their knowledge, interests and experiences from schools, home, books and science centre, which are discussed in this section. The timing of the SPS was such that the children had been taught by their usual teacher for 45 minutes on the topic of magnets immediately before the session. The materials provided in the SPS were related to this topic of ‘magnets’, and it was therefore anticipated that the children would make links between the lesson and the play materials.

(a) Play is informed by the children's prior knowledge from school, educational institution, books, home and peers

In this thesis, prior knowledge is defined as the learning and understandings that the children brought along with them to the SPS. As reported by the children in this research study, their sources for information were mainly school, books, the media and peers. However, although the children's prior knowledge was informed by their peers, there is an overlap between their personal and sociocultural contexts, with more social mediation taking place in the sociocultural context. As such, learning from peers will be covered in Section 6.21: 'Play is a way to get mediation from their peers'.

In schools, prior knowledge comes mainly from teachers. The children were able to draw on their learning and knowledge from the lesson that took place immediately before the SPS. Hafiz commented that she had learnt to "pay more attention" (525) and "use what the teacher [had] taught" (528–529). Nurul remarked that the teacher had shown them a video (543), which helped her to understand the setup. Similarly, Kai Cheng spoke about how he was informed by the lessons before his SPS, and this had helped him to decide what to do during the SPS. Without the lessons, he claimed, "then we don't know what to do" (121). This was evident in Li Min, for whom what the teacher had taught in the class had an impact on her thinking process. She recalled what her teacher had taught and was very sure of the concept that, when like poles were facing each other, there would be repulsion between the magnets, and when unlike poles were facing each other, there would be an attraction between the magnets. However, she reported what she had observed when she used a horseshoe magnet and a bar magnet during the SPS. She noticed that, instead of like poles repelling when they were facing each other, they were attracting each other (385–387) no matter which poles she was using. Then she thought about it and concluded that probably the horseshoe magnet was demagnetised and not working. The horseshoe magnet was acting like a magnetic material now, instead of a magnet. Her prior knowledge had allowed her to hypothesise about what was happening and come up with probable explanations during her play.

Besides school, children also had prior knowledge gained from educational institutions such as science centre. In this study, one of the schools had arranged for a prior 'taster lesson' on magnets at the local science centre. Here, the children were also taught a little about electricity. As such, these children obtained their prior knowledge of electricity from the science centre and applied it to their understanding of magnetism. For example, Mandy commented that metals can “conduct electricity” (36). She was able to recall that “almost all metals” conduct electricity, but there are only four magnetic metals: cobalt, steel (Mandy: 42–44), iron and nickel (Audrey: 43). Mandy stated that not all metals are magnetic and “some metals can be attracted, and some can’t” (41). This was a claim made by many children, who said that they already knew what to do and what to say because they had “learnt [it] all” at the science centre (C4G3: 133).

Some children also claimed that they had already learnt everything before they went “to the science centre” (Ming Li: 134). For instance, Kai Cheng revealed that he had been informed by a book he had read (898–899) previously. During the SPS, he “tried the stroking method” (898–899) and the demagnetisation of magnets by smashing them (903–906). Moreover, Sam talked about how, when reading “science adventures”, he had come across a “Maglev train that uses magnets” (A1G3: 930–933). However, he had never come across real magnets or how they were used (A1G3: 930–933). Therefore, some children’s play was informed by their prior knowledge gained from books and magazines, which gave them ideas about what to do or test.

Familiarity with the materials and prior interactions and experiences that the children had had with them at home before the SPS informed what they did. For instance, Dione (185, 187) and Shena (187) said they had had contact with a compass before the SPS. They either had one or had used one before (C4G1: 190) in some of their games at home. This prior knowledge helped them to plan and informed what they should do to ensure that the compass worked or guide the group on what to do during the SPS.

Children’s play was informed by their prior knowledge and experience from school, educational institutions, books, home and peers. Prior knowledge is connected to the children’s interest in exploring and finding out more.

(b) Play is informed by the children's prior interests in culture, specific interests and personal preferences

Different factors informed the children's choices about play. These included cultural beliefs, specific interests or subject areas and personal preferences.

Cultural beliefs are related to a person's experience with the diversity of their cultures, beliefs, education and the environment where they were brought up. For example, Mindy believed that she should not *"*make fun of a magnet or else it won't work*"* (289). This was a personal cultural belief that she held, which led her to show respect to the thing she was using. Beliefs were also informed by a child's religious belief. Wei Ming made use of many spherical 'rattlesnake magnets' to form a bracelet-like accessory. He explained that this magnetic bracelet looked like the 'Buddha beads' (346–355) that a Buddhist monk used for prayer purposes. Wei Ming used what he had seen outside school and incorporated it into his play. He went into a role-play, acting very powerfully when he wore it and creating a "bisss…" sound to accompany his imaginary play. Empowered by the bracelet, he started pretending to shoot fire with both his hands. This shows that the family and religious beliefs that the children were brought up in had an impact on the ways in which they played when they tapped into these prior interests as ideas.

Play was also informed by the children's cultural interests.

> *We made a flag and then we sang the … [all three girls started singing in unison Singapore's National Anthem in the Malay Language].*

C4G2S1

Next, the following paragraphs show how the children's specific interests, such as their common views of their own national identity, their views on money, and their specific interests in particular subject areas had informed their prior knowledge. For example, due to their specific interest in national identity, three girls in a group from Ms Geetha's class suddenly went into an imaginary play and stood to attention. They started singing the national anthem together, saluting the national flag while one of them hoisted their 'imaginary' national flag (a piece of a square magnet) slowly up the retort stand using the gigantic horseshoe magnet provided. The children were able to enter this imaginary play suddenly and together without any prior arrangement because it was informed by their prior interest in creating the national flag, and the association of the retort stand, which looked like the pole seen in school at assembly every morning.

Next, play is informed by the children's views on money. For instance, Catherine mentioned that gold or steel is "kind of expensive" (533), and this indicated the children's perception of expensive things that cost a lot of money. They were taught from a young age, both in school and at home, that they were expected to take better care of the more expensive materials while handling them. This belief was confirmed by Emma, who commented that she was shocked to see some of her peers dropping the expensive materials "on the floor" (534–535). In another instance, the association of the coins used together with magnets and placed on the fridge at home made the child feel "very rich" (C4G1: 570–573), because this was how the children perceived coins, as money or wealth.

In terms of specific subject areas, some children, like Nick and Sam, were excited by subjects such as chemistry. Sam said that it was this prior interest that had informed how he played and what he explored during the SPS. He said that he would like "to make [some] awesome and explosive chemicals" (824–826) in the future. Similarly, Ashraff "kept on making Minions" (125–126) during the sessions due to his love for the cartoon characters. Hayden claimed that his prior interest in science was always an area that had helped inform his play, engaging in science. He found learning science "very interesting" (935) and "no matter what, it keeps on going on" (936) for him even after the end of the SPS. This shows that play could be informed by the children's prior interest in specific subject areas to keep them motivated and try out the ideas related to these areas.

Some children planned their play, while others played "anyhow" (BG2: 343), or randomly. The ways in which the children played were not fixed and varied from child to child. Their play was linked to their personal preferences, as illustrated by several examples listed below. For example, some children were attracted by the magnets' shape (C4G1: 104), such as the horseshoe shape, or the size (C4G1: 113) of the gigantic magnet. Nurul had her "own, favourite magnets" (288), which were the "big ones" (292), while others just picked "the nicest ones" (B2G1: 300). Moreover, some children, such as Devi, had "honestly got fun picking" (481–483) all the different types of magnets, while others had reached out for something that they had not seen or had never tried before (C3G2: 178–179). A further example was Kai Cheng, who was fascinated by the U-shaped magnet and motivated to learn more about it. He explained that the magnet has two poles and that “one pole is like a bar magnet” (509–513). He was interested in finding out “if they [the two poles] are [as] strong as a bar magnet” (509–513) because he had pictured the horseshoe magnet as like having four poles on the magnet. The examples discussed above show that the children's choices varied greatly and depended on many different underlying reasons. Play is informed by the children’s prior personal preferences.

As well as prior knowledge and prior interests, there were also the prior experiences that the children had gone through before the SPS, which might have influenced how they played.

(c) Play is informed by the children’s prior experiences at school, home and other places

Children’s prior experiences come from various sources, namely from school, home and other out-of-school settings. Children tended not to have any experience of play in science lessons prior to this research study, so what is discussed in this section will include their experience obtained from the first SPS as applied to the second one, as well as their prior experiences from school, home and other places in the following few paragraphs.

School

In school, children’s prior experiences mainly came from four areas: their previous experiences with experiments in Primary 3 (as this is the first year in which they studied science formally), the pre-play lessons conducted by their teachers, the previous years of teaching by other teachers in Primary 2 and their experiences during the first SPS.

Firstly, children recalled their prior experiences of class experiments from previous classes and applied them to their SPS. For instance, Miko specifically recalled a common shared experience within her group:

Er…. actually, I think …yes, she [the teacher] used some kind of materials, I think she one time try, let us try, because you remembered that aluminium, like if we, we put on water thingy that the …, the small pail of water.

A1G3S1

This was a class demonstration based on materials where a “transparent pail filled with water” (548–552) was used. The children were asked to determine if marbles could stay afloat on floats made of different materials (548–552). The children remembered this prior experience, and during their SPS, this association became connected to their play and they carried out similar actions; they started dumping everything in the water and trying to balance the Styrofoam plate in the water. The children had recalled their prior experiences of the class experiment and applied what they had seen and learnt when a similar context was presented to them in play.

Secondly, some children reported that they were informed by what they had learnt earlier in these lessons and wanted to verify them from the pre-play lessons. For example, Mira chose a “bar magnet and the iron nails” because she wanted to try it out and see if it worked (133) while Dione was “snatching things”, “here like everything” (96), based on the concept of magnetic and non-magnetic materials. Dione had learnt in the pre-play lesson that all non-metals are non-magnetic materials cannot be attracted to the magnets. Through her explorations with the materials, she investigated which ones were made of what material (98–99) and tried everything that she could get her hands on (101). Likewise, Nick and Sam also spoke about their second choices if the availability of magnets limited them. Sam said, “I will grab, for example, the electromagnets” (426–427) if a bar magnet was not available. They had learnt from their previous school experience that “electromagnets are stronger than bar magnets” (A1G1: 428). Mindy learned that a horseshoe magnet was “one of the weakest” (377) and avoided choosing it. Therefore, to a great extent, the prior experiences of learning in pre-play lessons helped the children to inform their play using reasonable grounds of plausible knowledge.

Thirdly, some children reported how they had brought their prior knowledge of magnets to the SPS (Gabriel and Adeline: 270) from their previous school years in Primary 2. For example, Gabriel recalled when his Primary 2 form teacher had taken them to the science laboratory “to try to learn magnet, first starting of science” (274–

275). This is consistent with Table 1.1, which explains that, although the children only begin to learn science as a formal subject in P3, they have already been introduced to it during Kindergarten, Primary 1 and Primary 2, where it is embedded in subjects like English.

This prior experience from Primary 2 was memorable to him, and he was motivated to learn, trying to recall what he had learnt from that experience to apply in his play during the SPS.

Fourthly, children's experiences during the SPS were also sources of prior experiences that they tapped into to inform their subsequent play. For example, as well as learning from the pre-play lessons, the children experienced things themselves by interacting with the magnets. They were testing "which one is the strongest" magnet and just "take it" (B2G1: 304). Their interactions had helped them to pick the 'stronger' magnet – the bar magnet. This was what Nick and Sam said about their choice of a bar magnet:

> *Because it's very strong, so I can like have more (Nick: It's the strongest!) fun, like attracting every metal. (Nick: It's the strongest!)*
>
> A1G1S1 and A1G1S2

Moreover, Seraphina described the bar magnet as "cool and you can like do a lot of things" (C3G2: 171–172) with it, from her prior experience. Therefore, the children's experiences from the first SPS had allowed them to learn and acquire new knowledge, which helped to inform their decisions in the subsequent SPS. A strong magnet can attract more things and guarantees them better play situations, resulting in "more fun" (A1G1: 421–422). The children's play was informed by their previous SPS.

Home

Besides school, some prior experiences came from home through the children playing with their toys, daily experiences and observations. For instance, Sam explained that he had tried to connect his prior experience of his magnetic toy trains at home to what he was doing in school for his SPS. He recalled having the trains repelling each other, and he wondered why they kept moving apart (609–614). He claimed that, before he had learnt the science topic of 'magnets', he "didn't know that magnets could repel" (607–608). However, after he had learnt it, a visible conceptual change was noticed. During the SPS, he tried recalling his prior experiences from home and in school. He had a 'Eureka' moment when he managed to construct a new understanding alongside the prior ones and finally understood why repulsion took place. He then understood what it meant and was able to get closure for a problem that had been bugging him. He was able to connect what he had newly learnt and applied it to a new game that he created during the SPS, where he ensured that unlike poles were facing each other to attract and 'snatch' to win. Play is informed by the children's prior experiences with their toys at home.

In another account, the children's prior experiences came from daily happenings and observations. For example, Catherine recalled a 'strange' encounter that she had had with a set of magnets. She remembered how she had dropped a ring magnet (382–384) numerous times, but it did not become demagnetised (390). In contrast, "the bar magnet like demagnetised itself" (392–393), even though she "didn't even drop it" (394). This incident had caused her to think more deeply as she tried to make sense of what had happened. Similarly, Yu Han recalled how a magnet kit left in her toy box for a long time had caused all the coins to stick to her magnet (527–529). This was the prior experience that she had at home. Therefore, when she noticed a similar phenomenon during the SPS, she was able to recall and make a new connection between the two experiences. In all three examples discussed in this section on 'Home', these children were puzzled during the play and only recalled their prior experiences at home after the SPS when they thought hard and managed to establish a new link between the two experiences.

Other settings: Science centre

For this category, 'others' generally refer to the science centre or any other out-of-school settings that the children had encountered. For instance, Dione commented on how, when she saw "the magnets right in front of" them (80–81), and the topic was on magnets, she knew instantly what they were going to do, informed by her prior experience at the science centre. In another example, Dora recalled and compared the magnets in the school and the science centre. The school's electromagnet was "stronger than the one at the science centre" (C5G1: 265). Dora made this comparison and justified her answer by explaining that the one they had used in the science centre was powered by two batteries (268–269) instead of the one used in school. Therefore, their prior experiences at the science centre had sensitised the children to know what to do when faced with similar contexts and they made a sound comparison and conclusion that the school's electromagnet was the stronger of the two.

The findings discussed in this section, 6.12, suggest that play is informed by children's prior knowledge, interests and experiences from the environments they have been exposed to, mainly in school, at home and in other out-of-school settings. The children had tapped into their prior KIE in an iterative process; recalling valuable information and constructing new knowledge when their prior and current experiences merged to form new links in the process of play. However, these new links could only occur if the children exercised their choice and control and access during the play process. The theme of choice and control will be discussed in more detail in the next section.

6.13 Choice and Control by the Child

This section examines the seven themes that were identified from the children's group interview findings in further detail. They are: 'Play is a context to empower the children in their freedom of choice to explore and learn', 'Play is a way of providing authentic tactile experiences for children', 'Play can be learning or not learning', 'Play's nebulous structure causes discomfort to some children', 'Play encourages creativity and builds children's problem-solving skills', 'Play can allow the extension of learning at home' and 'Play is challenging to parents and teachers' perceptions of school science'.

(a) Play is a context to empower the children in their freedom of choice to explore and learn

Compared with a typical science lesson, both Sam (89) and Lydia (89–90) preferred SPS. Nick argued:

> *… in the SPS, I … can use, I can try to, … use the electromagnets and I can… also can help to expand my science, then I can, and … I'm doing if it would be more interesting that because I can study, what is magnetic and what is not magnetic and I also can do like … magnetic, I can learn some magnetic materials and non-magnetic material …*
>
> A1G1S1

With the freedom of the SPS, play provided the children with various contexts and concrete materials (Lydia: 116–123) and allowed them to explore (Shena: 683), experiment (Devi: 37): and "discover more about magnets" (Miko: 393–397). These contexts made learning easier (Mia: 554) by allowing the children to "visualise it" (Sophia: 557), increased their interest to subsequently learn more (Evelyn: 217) and make "more interesting stuff" (Hayden: 1668). For example, Siu Hwee said that play had allowed her to experience magnetic phenomena first-hand and reconsolidated what she had already understood (746–748). Catherine felt that play had allowed her "to experience more things" (Sarah:146) that she had not "ever experienced before" (132) and that it was a "better experience" for her class (Sarah: 80–81). Play had empowered her to be self-directed in her learning in order to explore and learn.

Play also provided an additional safe platform (C4G1: 346) or context for the children to come up with ideas (C4G1S2: 342) or to mimic the teacher by experimenting with the things (Aminah: 295–296). They could be "pretending to play scientist" and discover new things (Shalini: 739–742). To do science is to "do [like a] scientist" (Adeline: 429) and play is like "a mini part of [the] experiment" which provides the freedom to be how "you want to be" at any time (Shalini: 739–742) and test "what she was trying to investigate" (Shi Min: 819). It was the ability to "do a lot of experiments" (970–971) that Nick reported had motivated him to learn more. It was also special for Miko, who emphasised that she had no freedom at all during the usual science lessons (393–397) and that it mattered to her because she could exercise her choice and control during her play. It was this freedom that had made Mandy feel that play "should be promoted in learning so that it can make children want to learn more and be more excited in class" (944–945).

With their increased freedom, the children reported fewer instructions during play, which had given them more time (Lucas: 428) to do their own thing and play. For example, Kai Cheng saw the freedom as a challenge to do "the opposite" (371–372) of what the teacher had said or taught in class. He argued that, if he did that, "maybe, that will give up [sic] some new discoveries" (388). In another example, Sam had found himself using play to give him the space to explore and self-mediate to discover the answers to the questions he had to learn without asking anybody for help (670–671). Play allowed the children "to explore everything", like the electromagnet, and to experiment and discover things using the materials they were supposed to learn (Hayden: 301–303). This means that the freed-up time had allowed the children to explore, test out and challenge themselves while exercising their choice and control. This then leads us to the next section, which discusses the contexts for authentic tactile experiences.

(b) Play is a way of providing authentic tactile experiences for children

As suggested by the literature, the first SPS was packed with abundant materials for the children to play with. They were able to have authentic experiences that used four out of their five senses: touch, sight, hearing and smell (taste was not allowed due to health and safety guidelines). For sight, Yu Han and Sam found that the SPS had provided them with first-hand, authentic experience. Yu Han got to test the materials as to whether they were "non-magnetic or magnetic" (60), while Sam got to "fidget with" the electromagnets and magnets (52–56) and see for himself. He explained:

> *… I like the SPS because… you can fidget with the … electromagnets and magnets and see how it works and all that, so it's like an exposure, I can just …. exposed to like magnets and everything so, I can find out like, for like the button magnet, they're strongest at their poles where or what they can attract like that.*
> A1G1S2

He felt that, with the real hands-on and concrete tactile experience, he was able to witness and feel for himself how the magnets had interacted:

> *if you only explain, we don't get like the feelings of how it would have happened, but if we have like hands-on activity, at least we get to see in reality how does it happen.*
> A1G1S2

This was essential to one group (C4G1), where play gave them the opportunity to walk around with their group's compass, think about it and try to figure out "which way is the compass doing [sic]" (Evelyn: 226). They were the ones "who wanted to see where is north and west" (69–70) in the science laboratory and they successfully achieved this. Others, such as Sarah, were shocked to see how quickly the magnet was attracted by a bar magnet and the "lots of paperclips" it could attract (315–317). Therefore, by using their vision during their play, the children exercised their choice and control and had tactile experiences.

Next, for touch, some children felt that play had allowed them to feel and touch objects, allowing them to remember their experiences. For example, Kai Cheng had found making “electromagnet and repulsion” interesting (56–57), while Sam had found the newly learnt concept of repulsion unique and fascinating so that he tried it repeatedly to discover how magnets repelled (451–453). These experiences also had a significant impact on Mindy beyond the sessions. She remembered her experiences because she reported on how empowered she felt after the SPS. Before, she was not allowed to “touch so many things” (641–645) at home but now, she was able to do so through the play. She had grown more confident about convincing her mother to let her “play with some stuff in the house so that [she] can experiment [with the] things inside [sic] home” (641–645) due to the prior ‘endorsed’ experience she had had at school. The authentic tactile experiences set up in the play contexts enabling touch had created memorable experiences for the children to exercise choice and control.

As for hearing, Benjamin said that he had learnt “how to make a magnet” (131) and liked the process where he got to “rub the magnet” (86) and listened to “the noise” (90–92) made by the attraction of the magnets. Sarah also said that sound had left an impression on her, so that she had named the “interesting” sound the “kiap” (308–311) sound. Through play, these authentic experiences associated with sound had provided the children with a memorable and enjoyable experience (Michael: 790–792). Play is a way of providing authentic tactile and sensory experiences relating to sight, touch, smell and hearing for the children. However, whether the child learns from the play is subjective and this leads us to the next theme ‘Play is learning or not learning’.

(c) Play is learning or not learning

From the children’s perspectives, it appears that they had ambivalent views about how play is linked to learning. In this section, two views of play in relation to learning will be discussed: ‘Play is learning’ and ‘Play is not learning’.

Play is learning

Fifty out of the 57 children interviewed said that play is learning (C4G1: 693). For example, Yu Han said that play had allowed her to learn both the play and the “lesson” concurrently, achieving “both” kinds of learning:

… the SPS is almost like learning more things like just now what I said, like you can learn, and learn [the] lesson and you get to learn both.

C5G2S3

For many children, play being pleasurable allows more things to be learnt:

Yah, it's like young children, … always like to learn, like to play right, so when you play and learn, you can learn more things while enjoying the things they learn.

A1G2S1

Even though you have fun, you can learn something new.

C3G1S4

Similarly, some children associated play with being able to learn and remember things better, helping them to answer questions in their tests:

Yes, it helps a lot! Like you can remember the fun things and then you can write them in your tests.

A1G2S1

Because you can remember all your fun time … you can write all the answers […] which you discovered when you play [with] the magnet.

C3G3S4

Therefore, play allows for more things to happen and something new to be learned more enjoyably and easily from the children's perspectives, by making things easy to remember. Play is learning to them.

Furthermore, with their authentic experiences of seeing and experiencing the process, Sophia and Mia argued that they could "learn better" (56) when they saw things for themselves. Mindy said that she felt that she "got [to do] the experiments" (303–304) and that they had helped her to get "the scientific idea" (307–308) and learn. Maya also said that the access to magnets provided in the SPS had helped her (238–240) to learn more about magnets:

It help [sic] you to learn better, to learn more things because like, magnets, right, are very hard to find, like those, those, big magnets because …

C5G3S2

Similarly, Michael and Nick said that SPS had caused them to recall the science facts that they had learnt during this topic on magnets, such as that the attraction of magnets will be "strongest at the poles" (A1G2S1: 584–586) and that the magnet can "attract and repel" (A1G2S4: 584). For example:

> *So, let's see whether we use … the north pole to go together, if attract if repel because magnet [will not attract] not, Madam Lee tells us magnets, only magnets can repel and attract, so we check which one …*
>
> A1G2S1

Lydia was able to use play to learn. She recalled what she had learnt before the session and applied it in her play to learn what a magnet was. A further example came from Sam, who had applied his learning in the games he came up with in his play:

> *Because, by snatching the stuff, you, you need to find the correct pole to snatch, you can't just anyhow, "dut, dut, dut"…*
>
> *Maybe, […] I put south and south together, they will repel, so I must find north and put with south so that I can snatch …. away!*
>
> A1G1S2

However, when asked to explain whether play is learning, a few children found it "hard to say" (C5G1S3: 652), while others answered that they had learnt more (130) in the SPS than in their usual science lesson. Aminah said that, although she did not need "to do much [sic] thing" (127), except to play, it had helped her in her understanding (240–241) because "it's just easier" (250). Play had helped the children to learn and understand the lesson (B2G3: 201).

Wei Ming said that he understood the lesson with play because he got to "practice more" (492–493). Dione found that play was "quite helpful" (635) in assisting her to learn science. This was because if "you don't know [a] thing", "you can use experiment" (636) and learn. This was reflected similarly by Mia, who commented that play offers her an alternative to learning (112–113):

> *So, … it's better because instead of, like, trying the experiment in your head, you can actually do it!*
>
> C3G1S3

Noah said that play helped him learn because he had found his teacher boring and would like to do the experiment (427–428) himself, learning independently. However, Sarah replied “sort of” (224) when she was asked if she had learned more by playing. She explained:

> *… because sometimes, when you play, you get attracted [by what you’re playing with] and you can’t really remember that much [sic] things.*

C5G3S2

After a follow-up question posed to discover what she had meant, she said that she was so engaged that her mind was on the play and the activity once she was playing. She was oblivious to other things around her, and not sure if learning was taking place. However, she still preferred play and learning to be “merged together” (269–270) to support her original stand that she learned more by playing. Lastly, Sophia commented that learning, when made easier, would allow one to “learn these things, like memorise and you will get it” (424–425) and come to like the subject (427).

The above depicts children’s perspectives on how learning was perceived or achieved in the case of blurred boundaries to learning when the child was in the flow of play and not aware of their surroundings. This was where the children’s perspectives started to become less definite and spanned two viewpoints of play being learning and not learning at the same time. Nurul was one who claimed to have “short [term] memories” (943) and that play was only good for learning for the first couple of days, when she remembered some things, but they ‘faded’ away after many days. Li May also said that, although play had helped her to improve her knowledge, it did not help her in the learning of science (217). Finally, in the next few paragraphs, the children’s perspectives on ‘play is not learning’ will be discussed.

Play is not learning

Seven out of the 57 children interviewed felt that play is not learning, and when one plays, one is not learning:

> *They [her group] played, [they] didn’t learn anything.*

A1G1S3

… because later …. you don't have sufficient meaning, … then, there is no time, then you play too much then, then you don't have to learn anymore.

A1G2S3

Well, we won't learn that much [with play]!

B2G1S3

Catherine felt that play was not learning (292) and claimed that she did "not have the brainpower" (297). Catherine and Yu Han commented that, even if their teacher were to teach in the usual way without play, this topic would not be more difficult for them to understand (302). Similarly, Emily commented that, if she played, she would "do nothing" (459), not learning anything. This was in line with Lydia, who was concerned about spending more time on playing because it would result in less time to learn (79–80):

... because if you add longer [time to play], you might not have enough time to study, then maybe we can, we have to put, we have to … to be held for recess, in order to do the extra work that we never do.

A1G2S1

This shows that some children viewed play and learning as two separate entities. This belief is influenced by how Asian society in general perceives play; play is a waste of time and, when you play, you are not learning. Play is for enjoyment and nothing else, while the time after playing was considered the "time to learn" (67–68) and the "time to do those work" (Mindy: 69) that they needed to complete.

As well as what has been discussed in this section, some children had played and yet still struggled with the topic. Play was not learning for them yet because they had found the topic to be "a little bit difficult" [Emma (295–296) and Yu Han (293–294)] and, like Shena, who was still "a bit confused between a magnetic object and a magnet sometimes" (652–653). "There were too many things to remember all at once" (Shena: 626–627) while learning science through play. Not entirely understanding what they had been taught, meant that play was not learning for these children as they struggled with the content and sometimes with the nebulous nature of play. This will be discussed in the next paragraph.

(d) Play's nebulous structure causes discomfort to some children

To some children, play occurred naturally, but others thought otherwise and had difficulties fitting in with play. Play being open and nebulous caused some children discomfort because they were not used to it and disliked the partial or total freedom of choice that play offered. For example, Dione did not like free-choice learning at all because she preferred "to do it [step] by steps" (62). Although she argued that she liked the structure of the instructions, "if you force" her, she would "rather do it" herself (63–64), an indication that she would appreciate the freedom of choice only after she had followed the step-by-step instructions which had guided her initially. Mira and Dione shared that they preferred "things to be in steps and procedures" (66).

Similarly, Devi and Hayden, who were used to a teacher giving directions and instructions, were "not used to that [play] method" (1343–1344) when free choice was given to them. They were initially "a bit lost" because Devi did not know "what to do" (1328–1329). However, Hayden explained that "when you go on further [along in the] year or "when the lesson" (1330–1331) and their "experiment goes by" (1330–1331), he "will know it better" (345–1347). Both Hayden and Devi explained about how they started to understand what SPS was about, got used to it and knew "what to do next" (1330–1331). However, due to the unpredictability of play and his discomfort with the adjustment needed, Benjamin's interest had decreased (520) a little (521). Play was "a bit difficult" (527) for him to catch hold of and adjust accordingly. Play's fluid structure had created some form of discomfort in him. However, within this fluid nature, some spaces allow creativity to develop and skills such as problem-solving skills to be built up when the children played. These will be discussed in the next section.

(e) Play encourages creativity and builds children's problem-solving skills

Figure 6.1: Photographs showing some of the creative structures built by the children.

During the SPS, the children were creative and came up with many different ideas. The pictures above show how they had manipulated the materials to come up with innovative structures, informed by their sound knowledge of magnetism. An example is where a group (C5G3) built “a house using a [sic] magnet” (251) and “made a person” (255) using “bar magnets” (268) and “horseshoe magnets” (270). Group C3G1 created a toy and named it “Mario car” (64). Moreover, Safiq (310–316) came up with the idea of a magnetic boat and Gabriel helped to elaborate on his peer’s idea by suggesting that magnetic fish would be attracted to it (319–321):

> *It’s like, … if our four wheels were made of iron but the water is water, then our boat is magnetic, then after that, all (Adeline: All the iron stuff will …. attach to the boat) the iron fish come and “Ting….izs!”*
>
> B2G2S3

Another group of children came up with the idea of a “bungee jump” (126) using the retort stand with a string-suspended bar magnet. In one group (A1G2), Sam came up with ideas to make use of magnets to create cars (904) and a “plane fighting thing” (906–907). Then, these structures were used in games the group had created:

> *…we play like, we take one magnet, then we must snatch each other’s magnetic materials or magnets.*
>
> A1G1S2

Therefore, through the various structures built by the children and the games they came up with linked to magnetism, play encouraged creativity and allowed the children to make choices and take control to venture out in unlimited ways.

Besides creativity, play also allowed the children to build their problem-solving skills by testing their ideas. Sam said:

> *I go and put the magnets into the water and see whether it [sic] still attract each other.*

> *And then we, we take the Styrofoam … plate or something, we put one magnet on top, and then we put the magnet on top, then we attract right … so the magnet attract, then we put in the water and see whether it can stand.*

Then we tried putting a little bit [of] water on the Styrofoam plate, but after that, it sinks.

A1G1S2

Sam was trying to investigate whether the magnet could still attract when it was in the water. He tried out various ways to position the magnet and tested his ideas in the group. Similarly, Mira was trying to test whether a magnet sinks in water and saw for herself first-hand that the magnet did, in fact, sink (204).

Other groups tested their ideas diligently. One group was seen stroking all the nails provided, regardless of the materials, and another group stroked the recording device, thinking that it was made of a magnetic metal material (Ming Li: 152–157). She said:

I seriously, you know at the start, the first part, I thought this could be magnetised, so I tried.

C4G3S3

She had thought it through and problem-solved the situation. From her testing of the recording device using a magnet, she had concluded what it was like (152) and "should be plastic" (157) and was non-magnetic. Play helped to build the children's problem-solving skills. Besides school, in the next section, we will discuss how play can allow learning at home.

(f) Play can allow the extension of learning at home

In this research study, play did not solely take place in school, but also at home. When the children went home, they continued with their play and extended their learning. There were three ways in which play be a part of their learning at home. These were through interactions with: (i) some daily materials found at home, (ii) educational resources or toys bought by the children's parents and (iii) with their family members.

And then I go and try the new Singapore coins and the old Singapore coins, then the old Singapore coin does not attract to the magnet.

C4G1S2

(i) Interactions with some daily materials found at home

This first kind of interaction was limited by access to the materials available and the children's choice. Many children said that they would play if they had access to the materials at home (A1G2: 700–701). For example, Wei Ming, Benjamin (331) and Mira reported how they had tried out what they had learnt in school while C4G1 "did [the experiments or testing of their ideas] at home" (525).

Mira had gone back and tried out the new and old Singapore coins on her own and discovered that the old coins were not magnetic. Wei Ming, who had batteries at home (293), could recognise the different types of batteries used at home and in school. He was able to recall the sizes and shapes of the batteries very well, such as "those round one, very big one" (327–328) for the size D batteries used in school, and relate them to the ones he had at home. These children had carried out self-mediation through exploration on their own at home.

On the other hand, some children extended their learning by applying what they had learnt in school at home. For example, Li Ming (718) and Mindy (721) said that when they conducted their self-exploration with magnets at home, they discovered that their home fridges and the handle of the oven were magnetic (726). Li Min managed to link this with her recollection of the similar location of magnets on the door of a wine cooler (728–732) which she had discovered while playing. Mindy had also identified some electromagnetic locks (752–753), which she had discovered and witnessed for herself and acquired new knowledge. This extension of learning would not have been possible if the materials had not been accessible to the children or if they had not chosen to play.

Realising that not all children had access to magnets at home, Madam Lee gave every child a pair of magnets to take home to explore. However, although Hayden (1047–1048 and 1050–1051) had no magnets at home, he was inattentive and returned the ones he was given, resulting in him not being able to try them out at home. Therefore, even with the teacher's help, the child's choice made a difference to whether or not play could be continued.

For children without the materials at home, play was hampered despite their choice to go ahead if they had the materials. For example, Shena originally had a few magnets, but was left with none when her brother broke them all (546). There were also children such as Mira, who had magnets at home (533) but chose not to carry out the activities. Her learning was then restricted to the school context as she had exercised her choice and control to keep it at school.

(ii) Interaction with the educational resources or toys bought by the children's parents

Alongside the physical materials provided for the children to have hands-on experience, learning took place through ideas obtained from educational magazines and other educational toys bought by their parents. For example, Nick tried to test out "the freely suspended magnet" (752–753) that he had read about in "The Young Scientist" magazine. In another case, some parents had supported their children's learning by buying educational toys such as magnetic slime (AG3: 1731–1732) and a "solar panel" (AG3: 1740) during the school's trade fair. Playing with these had allowed the learning to continue at home.

(iii) Interactions with their family members

The children reported how different family members such as siblings, parents, and even soft toys (whom some children identified as their siblings), were involved in their home interactions. A child's learning could be very different, depending on who he or she was interacting with. The extension of learning could take place for their family members and the child involved.

Li Min (628–629) and Mindy (631–632) shared how both their younger sister and brother (respectively) would "ask, ask, ask". Both their siblings were "very talkative" (A1G2S1: 631–632) and loved to listen to their older siblings who had brought home stories for them, such as what they had learnt in school (A1G1S4: 628–629). For example, Shena, who had a younger "four-year-old" brother (511), recalled how she had gone home and started her investigations using an iron nail she had found at home with her excited brother (513–514). She taught him "how to make a temporary magnet". Her little brother became over-excited and stayed up the "whole night, trying to do it" (504–505). Although her brother did succeed and made a powerful magnet

(522), nobody, including her mother or her, was expecting that level of excitement from him.

Although children from this research study were able to teach their younger brothers and sisters, there was a limit to how young these active younger siblings could be. Benjamin (333) explained that he could not ask his baby brother because:

> *My baby [brother] is too small [sic], he will eat everything.*
>
> B2G3S4

Benjamin also faced a problem with his baby brother, who “on purpose spilt [sic] saliva on it” which “jammed the thing”, causing damage to the setup which he had observed and learned, if his younger brother was around.

Although their siblings’ age sometimes posed a problem, the choice and control of the participating siblings were also important in determining whether learning could occur. Nurul did not find it easy with her younger sister because, whenever she “tried to teach” her, she got distracted easily and kept “playing with something else in front of her” (708–709). However, in an example with older siblings, although they had allowed the child, Catherine, to talk about what had happened during her science lessons (560), they were not listening to her (564). Therefore, the siblings’ willingness and age were the most critical factors in determining whether learning could occur.

Frequently, having older siblings did not help the children either. For example, Devi and Hayden each had siblings with whom they found it challenging to share their learning, due to their age differences:

> *My brother definitely no because [he’s] older than me.*
>
> A1G3S1

Next, there were also problems faced by some children when they were the only child at home:

I have no friends and no siblings.

A1G3S3

This was in contrast with Dora, who commented that although she “didn’t have any siblings” (162–163), she was able to talk to somebody at home. She said that she would talk to her “half-sister, half cat” – a soft toy (162–163) – about what she had learnt in school during her imaginary play.

Lastly, as well as siblings, children could share their learning experiences at school with their parents. For example, Wei Ming shared with his parents (335) about how to make magnets (338–340) by demonstrating to them using the ‘stroke method’. He recalled how happy his parents were (344) when he shared with them because they had said, “Last time, they don’t know” (341). Evelyn also shared how her mother had encouraged her to finish her worksheets (291) and then do her experiments (292) in her play in order to extend her learning. Yu Han said that she played with her father at home, who had helped her learn. However, she said that play was dependent on her father because he could not play with her when he was busy. Even when he was not busy, he did not want to play with her (180–181) if he was tired.

In summary, play can allow the extension of learning at home to take place if the children have access to the necessary materials and the choice and control of the participating parties are met.

(g) Play is challenging for parents’ and teachers’ perceptions of school science

From the children’s perspectives, it appears that most parents and teachers had different and mixed views on play. In this section, two views of parents’ perceptions of play in school science will be discussed: ‘Parents are against play’ and ‘Parents are alright with play’. As the children did not talk much about their teachers’ perceptions, this section will mainly focus on the parents’ perceptions, while the latter part will highlight the teachers’ perceptions.

(i) Parents are against play

Some parents were very supportive and took an interest in their children's studies. They tended to associate play with 'not learning' and often placed study above all things, including play for their children. For example, Mindy and Li Min gave the reason why their parents were against play as they "must study, study, study, study, study" (885–891), an indication of the importance of 'study' for their children's education. The children had repeated the word "study" five times. The idea of 'study' had been repeatedly drummed into the children and they were expected to study whenever they had any time. Abigail was such an example; she said that she was always reading her books because her parents did "not want her to play" and wanted her "to always study" (241–242). Audrey also faced a similar situation (185–187):

> *Because most of the time when I get home, … when I've finished my homework, I always like, feel like playing… but then my mum, she says like study.*
>
> C4G2S3

Sometimes, these parents tried to explain to their children that they had asked them to study because they wanted them "to get clever" (Mindy: 897). These parents believed that studying was best for their children and tried to suppress play in various ways. Firstly, they would arrange additional tuition and enforce a 'no play' rule for them. For example, Ming Li raised her voice in exasperation while she recounted the numerous tuition sessions arranged for her (220–221). She said that she did not have any time to play (224). Joanne commented that she had "a lot of work to do" (232) due to the additional tuition after school. Secondly, even when the children were free, these parents would intervene by drawing up schedules, such as Mira's father, who had "made this schedule" by which she needed to revise every day (752–753) without play. The situation was similar for Sam, who shared that he could not spend much time playing (246) at home because his father "always thinks that study is more important" (251) than anything else "so that I can get [a] job" (253–254). He said that, if his father were to find out that he was playing, he would "even die" (248–249). Although he understood his father's intentions, he also smiled and admitted sheepishly by dipping his head that he sometimes still played when his father was not around. Thus, he still had access to play in some ways.

There were also parents who actively stopped their children from playing (128):

> *I can never do it ‘cos my mother will scold me.*

C3G1S1

Kai Cheng said that play was overwritten most of the time and he was expected to be:

> *Doing worksheets because if there’s homework, if I go home and do a bunch of worksheets, my mum won’t bother me, and she won’t give me homework.*

A1G3S3

Although he wanted to play, reality sank in, and he said that he did not prefer to play because “that’s what happened” (342) in the end, so that he would not get any chance to play.

Play is challenging to the parents, primarily due to examination issues. Li Min and Mindy talked about the stress they would experience due to the school-based ‘streaming’ exercises, which were based on their academic results (900–908), if they did not study:

> *When you’re Primary 1, you stick to the same class as Primary 2, but Primary 2s, and Primary 3, you get out right? Then you have to like, …, you will change classes. More stress!*

A1G2S2

Streaming stressed the children because if they did not do as well as expected, they would be ‘kicked out’ of the class and into a different class. This stress was also seen in Shena, who wanted science to start in Primary 3 and not during the first two years of Primary 1 and 2 because her mother would have forced her to study (611) earlier and cut all play.

Lastly, some parents were concerned about the safety of their children and banned play. An example was Kai Cheng, whose mother was very concerned about his safety and would never give him a nail “because she thinks it’s too dangerous” (1000) for him and “she doesn’t want me to touch any battery” (1002).

(ii) Parents are alright with play

In this section, there were two types of parents; one type who allowed their children to play with conditions attached and another type who did not stop their children from playing at all.

The first type of parents were the ones who drew up schedules for their children, dividing up time to study and play. For example, Shena's parents split the time equally for her, which she did not resist (757):

> *I have … equal time to study and play.*
>
> C4G1S1

Similarly, Yu Han remarked on the fact that, although she liked to play "sometimes", she would still be asked by her father "to do [her] homework" (163–164).

Although some parents might not have allowed their children to play freely, their views about play in science were different. Li Min's father said, "Science is fun because you get experiments and can play a lot of things" (646–647), while Mindy's father felt that "when you play, you're learning something new" (648–650). Hayden said that his father had a different perspective on play: studies still come first, then you will get your rewards, "so your reward is like playing on your freedom" (822–825), which was the SPS.

However, there were children who were able to play without any conditions attached. The children who had both parents working very hard for a living reported that they got to play a lot because they were unsupervised. They were puzzled, like Sam, who felt that there was "nothing to worry about" (893–894) in relation to his studies if he played because he did not need "to study science" (892).

Despite the children liking the SPS, they did express concern that some teachers were not open to the idea of play (871–875). Hayden said that the teachers' attitudes were similar to his parents' attitudes towards play (876–877). Although some children were prevented from playing in some situations, they exercised their choice and control and found their own ways to play. Play is challenging for parents' and teachers' perceptions of school science.

6.2 Sociocultural context

In Falk and Dierking's (2000) CML, the sociocultural context is one of the three strands of this theoretical model where social mediations take place. According to Braund (2004: p.118), "what we learn in a situation is often mediated through our gestures and by a conversation with others." These school groups were called a 'community of learners' by Falk and Dierking (2000), and could include peers and teachers.

6.21 Social mediations

In this study, the children interacted and these interactions were mediated by their peers and teachers during the process of play. Their utterances were coded and classified under three themes, namely: 'Play is a way to interact with their peers'; 'Play is a place where children build their social skills' and 'Play offers opportunities for teachers to interact with the children in reduced power relationships'.

(a) Play is a way for children to interact with their peers

In this section, the discussion mainly concerns the roles of peers, where the children interacted with them in several ways: (i) Giving Ideas, (ii) Teaching Peers, (iii) For Companionship and (iv) Asking Questions.

(i) Giving ideas

The first role of peers was the "giving of ideas" (Li Min and Mindy: 1126), where the children helped to challenge and guide one another in their understandings. For example, after an 'accident' where a plastic bowl cracked and water spilled across the whole table during the SPS, Sophia suggested that a "metal bowl, not [a] plastic" (223) bowl should be used because metal is a stronger material. However, upon hearing this, Mia challenged her idea and pointed out to her that metal might not be such an ideal material because metal lacks the 'transparency' that plastic has (226–227):

> *…metal bowl then you cannot see … have to see them from the….*
>
> C3G1S3

This suggestion gave Sophia some ideas and resulted in her rethinking. She came up with a new suggestion which incorporated both ideas of transparency and strength together and she answered: a "very strong plastic bowl". Sophia had moved away from her original idea, heeding her peer's suggestion and coming up with a better idea.

There was also another group (C4G3: 234–235) which had a member with lots of ideas. She initiated the play and bound the whole group to work together (C4G1: 238–239) to build a house, which the group liked (C4G1: 263).

(ii) Teaching peers

As well as giving ideas, the roles of their peers could be to "like help one another, like teach each other [about] magnet[s]" (Devi: 1111–1113) or correct them if they did the activities wrongly:

> *Teach each other or helping other, like, let's say I'm actually doing this wrong, and my friends actually help me with it.*
>
> A1G1S1

Similarly, Siu Hwee said that the role of a friend was to "help to explain if you don't understand" (703–704) and "like learn new stuff" from friends (703–704). Aminah taught her peers that "north and north can repel" (264), and Wei Ming learned that "like poles can't attract but repel" (267) and "unlike poles attract" (268). Thus, the children helped to teach their peers on the topic of magnetism.

(iii) For companionship

For some children, their peers were like "companions", "company" (Joanne: 601) or someone to respond to. The role of a peer includes the offer of support when needed. Shalini recalled how she had accompanied her peers in their play when she took "turns to hold the tablet" (710) for her friend who "wanted to play" (707–708).

For others, their peers were their audiences when they played during the SPS. Kai Cheng recalled a time where he had come up with a gun design using magnets (1120–1126) and showed it to Hayden. However, Hayden just reacted with an "oh" (1137) and looked away. Kai Cheng was discouraged, and Hayden was quick to explain that he had no ill intention but felt that Kai Cheng’s design was “too normal” and “too kiddish” (1150).

(iv) Asking questions

In this research study, most children (A1G1: 507–510) preferred to ask their peers rather than teachers for help when they had questions. Shalini (359–360) asked her peers because:

> *[…] sometimes, our friend, they explained it easily, and ... explained it step by step.*
>
> C3G2S5

Most children chose to ask their peers because they were closer in proximity and access to them. They felt more at ease with them, rather than the uneven power relationship with their teachers. An example was Siu Hwee, who said (367–368):

> *Because your friend is right beside you, so you see, you ask, … so you don’t need to raise [your] hand and wait till ….*
>
> C3G2S4

Similarly, Li Min claimed that she was “quite lazy”, and so she would just ask her “partner” (511–512) while Ming Li said that she “don’t [sic] care” (663) and claimed that she was “too shy to talk to the teacher” (664) to ask her. Sam also explained why he asked his peers:

> *First, I will approach my friend, then, if they also don’t know, then I will approach like the group beside me and if they also don’t know, then I will approach Madam Lee or you [the researcher].*
>
> *Because sometimes, our friends know and we don’t need to be so troublesome and walk at, all the way to the teacher.*
>
> A1G2S2

It was the distance between the teacher’s table and their tables and the children’s reasons of being too lazy or shy that had resulted in them asking their peers rather than walking to the teacher’s table (Mandy: 624–625). It could also be due to their inattentiveness in class that they decided to ask their peers first before the teachers. Dione explained:

Because, sometimes, we're a bit scared of the teacher because like, sometimes, you just do both things and then like, because sometimes, we don't pay that much attention in class and I'm scared that the teacher scolds us, so we ask our friends first.

C4G1S3

Similarly, Yi Lin said her group "could not understand" (360) what the teacher was explaining when they asked a question because she claimed that the teacher had explained "a bit too fast" (360, 362). Moreover, Shalini also remarked that:

And sometimes, the teacher misses us [cannot see the children raising their hands to ask a question].

C3G2S5

It was not easy to catch their teacher's attention, and when the teacher missed them, they just gave up and sought help from their peers instead. However, there were also some children (Sam: 691–693) who thought more of his teachers and decided to approach his "friends" when he needed help because his teacher might be busy:

Maybe the teacher is also busy so we, we may not want to disturb them first.

A1G2S2

There was also a classroom norm in Ms Geetha's class in which the children were instructed to ask their friends first, instead of asking the teacher (Audrey: 619–622):

Because Ms Geetha, … always says that we should always ask all of our, like friends, yah because like if … like we just straight ahead go and asked Ms Geetha, …my other friends might already know, and you don't have to like walk all the way to Ms Geetha.

C4G2S3

Through the four roles of peers discussed above, it can be seen that play is a way to mediate the children's interactions in a sociocultural context. Apart from achieving social mediation by the children's peers, play also helps the children to build their social skills to interact with one another, and this will be presented in the next section.

(b) Play is a place where children build their social skills

This section discusses why the children played in groups with their peers (or "friends" as they are more commonly called by the children) or alone in their assigned social groups during the SPS in order to build their social skills. The children were free of instructions and could choose to do anything they wanted during the SPS. However, when they started the SPS, some groups were initially lost and reverted to their usual classroom routines. They started to assign roles to their peers. For example, Li Min talked about how they named themselves (413–414) and assigned different parts of a task, like “one tie the string” (416–419) and others “try other stuff” (James: 415). With their roles assigned, most groups started the SPS and played together. They were able to build their social skills and co-operate. Mandy said that the SPS had allowed her “to make friends” (158) and “to learn more about each other” (161–162). This was also the case where the children chose to move around, away from the group, and play with other groups (Abigail: 525–527).

Most children played together for many reasons. For example, another child- Shi Min, reported that her group had played together rather than alone due to the fear of being reprimanded by the teacher (411):

> *Later, Ms Koh will scold us for playing alone.*
>
> C4G3S4

This could result in the kind of situation that Audrey blamed for why she was unsuccessful:

> *So, I’ll just like go to one corner and I enjoy playing by myself. Then a few moments later, a lot of friends will just start crowding around me, “Can we play? Can we play?”*
>
> C4G2S3

Despite the new freedom given to the children in play, they still chose to follow their usual routines and continued to play.

However, when an appealing group idea such as the “Mario Car” emerged, the children worked more as a group. Carmen who “didn’t play with the [sic] classmates” (677) initially, became convinced when she saw the whole group building the “Mario car”. She decided to join the group “because it’s more fun” (690) and more interesting (691) than playing alone. Sophia enjoyed the group play with her “classmates” (676):

> *Like, I think when she started the Mario, then we all got, ... we all got the attention, and we all did [it] together.*
>
> C3G1S2

The children were drawn by the common goal of building the “Mario car” and worked as a group to complete the car. Mandy (330) reported that, to cope with the challenging task assigned to them, she would prefer group play:

> *Unless you want to make a very difficult thing and then we do [it] together.*
>
> C4G2S1

Thus, a difficult task, when carried out in a group, allowed the children to face the challenge more easily and co-operate in a group setting.

Play is an activity that can lead to conflicts and judgement. Some children preferred to play in groups, while others preferred to play alone. Sometimes, children did not “co-operate” (Michael: 1157–1158) in group play, because “half of [the] time, [different children had] different ideas” (1158). The rationales for playing alone were to avoid conflicts, fear of judgement and their desire for independence. Sam preferred to play alone because it was more challenging to play in a group when there were more people (308–313):

> *Because I don’t want to like work in one group where has a lot of people, so different people will give different ideas, so we will be stuck quarrelling like a lot, a lot, … so I prefer one on my own then, I have my own idea, maybe I can get, maybe other people say, no, maybe … I can get my own ideas so … I won’t have to quarrel [about] anything.*
>
> A1G2S2

He felt that, by playing alone, he was able to test his “own idea” (308–313), without wasting time disputing whose ideas were better, thus avoiding conflicts. Similarly, Audrey (302–303) decided to play alone because she wanted to avoid being judged when what she liked was different from her peers:

> *For me, it's like when, … I like this thing and the other people might think that it's like weird or they don't like it.*
>
> C4G2S3

Mandy also wanted to play alone because of her desire for independence (328–329) and to do her own thing (299–300):

> *Because we all want to make our own thing and we want to cover ground [play with all the materials provided] faster.*
>
> *I just want to do my own thing and I know that I can make it myself and I want to do my own thing and I don't want to bother anybody else.*
>
> C4G2S1

Mandy felt that, if they played alone, they would be able to do their "own thing" as well as divide the 'work' and "cover [more] ground" (299–300).

Play includes child–child interactions. With different interactions taking place, conflicts are inevitable, and as different children brought with them different prior knowledge, interests and experiences, they would also have brought along their different ways of looking at things and judging others. The mediations that their peers brought about were observed during the SPS and they played some role in building up the children's social skills. In the next section, 6.23 (c), we shall see how play offers teachers opportunities to interact with the children in reduced power relationships.

(c) Play offers opportunities for teachers to interact with the children in reduced power relationships

As well as their peers, in a sociocultural context, teachers also play important roles in the SPS. Play provides opportunities for the teachers to carry out their role as perceived by the children, helping them within the new, reduced power relationship.

The responsibility and primary role of the teachers was supervisory; "checking" and "helping" them to see "what they were doing" (C3G3: 613–614). Their teacher was supposed to "watch over" them (Hayden: 1184) and make sure that they did not "do anything wrong" (C4G1: 788) or "do anything dangerous" (Shena: 790). Teachers had multiple roles:

> *…. like, help us right, to ask us some questions so that we can learn more. Encourage us to guess and also, like, let us learn more.*
>
> A1G3S1

There were also instances where teachers were invited to join in and became 'co-players' in the play. An example of this is a group in Mr Wong's class who they got him to join them and explained to him how their 'Mario' car moved (C3G1: 731). Mr Wong participated in their play and asked them a few "questions" (733–734) about "how" they made it move (732). These interactions made the children happy and encouraged them to think more deeply. Following this, Mr Wong "explained a lot" to them after asking (733–734) and they were enabled to learn some science ideas from the lesson.

Some children reported their trust and preference for their teachers over their peers, as Mia explained:

> *They [her peers] ... sometimes, you know, they don't understand and then, like, and you ask them and they just anyhow answer and then after that, get the wrong information and you write the wrong thing in the exam and then you don't get the marks!*
>
> C3G1S3

The teachers were there as figures of knowledge with whom the children verified and "confirmed it [the answer]" (Shalini: 376). Michael felt that their friends did not "know much information" (523), while Li Min felt that "the teacher's got more information" (489). Also, Li Min said that, sometimes, her friends could "not [be] so sure" (526) and she wanted a more "accurate answer" (527). Therefore, even during play, the teachers' role remained quite similar, but they were made more approachable by the reduced power relationships, allowing the teachers to interact with the children.

6.3 Conclusion

This chapter has presented the children's perspectives on play and answered research question 3:

> Q3. What are the children's perspectives on play in primary science?

The number of themes generated from the children's perspectives was more than for the teachers due to the number of children who participated in the study. In this study, the children found play to be fun and enjoyable. They were motivated by it because some found it to be an escape from lessons and it acted as a type of reward for them, in this study, after the first 45 minutes of the science lesson. However, the children were influenced by their parents' and teachers' perceptions of play in school science, and this may have resulted in them not being able to play fully as they held back a little while playing. Play is perceived by some adults in these two groups of stakeholders as a waste of time. These children were often told repeatedly by these adults that play is for young children and that they were too old to play; therefore, some children in this study would exercise some choice and control and make the decision not to solely play, but instead divided their time in order to balance their time between play and studying. Although free play was offered to the children, sometimes they were stopped by the adults from doing what they wanted due to the limitations on some equipment and different perceptions of the intended learning objectives. The above thus present the themes related to the key factors in children's motivations and expectations.

The children's play was informed by their prior knowledge, interests and experiences (KIE). Play provides many opportunities and authentic experiences to empower children to explore, be creative and solve problems. However, depending on whether the children perceived play as learning or not, those children who entered the SPS accepting it as play were observed by the researchers to be smiling and laughing more (which is audible in the audio recordings), compared to those who perceived it as a task and struggled to play. Although the children in this study were not used to engaging in play during their science lessons and experienced some doubts (they could not believe that they were allowed the freedom to play) and discomfort, the appealing and motivating part of play soon attracted them and allowed them to immerse themselves in play. As previously mentioned in an earlier paragraph, the influence of parents and teachers on how the children perceived play did affect whether they perceived it to be learning or not. Those parents who supported their children's education and were in favour of the notion of play would allow and encourage them to explore at home, extending their learning.

Lastly, in the sociocultural context, play is a way to interact with their peers where they play different roles in mediating the other children, giving them ideas, allowing them to ask questions and teaching them, seeking help as well as companionship from them while playing in a group. Play also helps to build up the children's social skills and reduces power relationships, increasing their access to the teachers, allowing teachers to sometimes be co-players in their play, and to mediate their learning.

In conclusion, the themes generated in this chapter have answered research question 3 and highlighted the children's perspectives, which were consistent with Falk and Dierking's (2000) CML. The findings suggest that play motivates children and can be informed by their prior KIE. Play also provides varied contexts in which children are empowered to explore and it helps them in their learning of primary science. These themes are further explored and discussed in Chapter 8 of this thesis.

Chapter 7 Teachers' Perspectives on Play in Primary Science

7.0 Introduction

This chapter discusses the qualitative findings from the pre-play and post-play teachers' interviews (n=5) from three schools [see Section 3.51 (b)]. The findings answer research question 4:

Q4. What are the teachers' perspectives on play in primary science?

Thematic analysis was used, in which the teachers' data from the individual interviews (Pre-Play and Post-Play) was inductively coded to generate the themes. As this study looked at what happened when children were allowed to play freely during scientific play sessions in a science classroom, the findings from the teachers' interviews indicated that play was linked to the personal and sociocultural contexts in which the children were involved. The findings from this study are congruent with Falk and Dierking's (2000) Contextual Model of Learning (CML) as both looked at how children interact in terms of the individual, their sociocultural environment and their physical environment (Falk & Storksdieck, 2005) in free-choice settings (and in this study during children's play). Therefore, Falk and Dierking's CML was used as a theoretical framework. The themes identified in the data from the teachers' interviews were then organised to fit into the CML and classified within the two broad contextual categories: (a) Personal and (b) Sociocultural Context (see Table 7.1) of this model.

This chapter is presented in a similar way to Chapter 6, where the key factors used in Falk and Dierking's CML were used as headings to classify the themes of the findings generated from the teachers' interviews. In the personal context, the key factors were children's motivations and expectations, their prior knowledge, interests and experience, and choice and control. In terms of the sociocultural context, the key factors were the different types of social mediations within and outside groups, which for this study were gathered together and termed 'social mediations'. These key factors from Falk and Dierking's CML are shown in Table 7.1 and are used as the headings in bold print in Sections 7.11–7.13 and Section 7.21. Themes that were inductively generated and informed by the teachers' individual interviews were further analysed and classified by the researcher and placed in the list under the key factors in Table 7.1.

7.1 Personal Context

7.11 Motivations and Expectations
(a) *Play generates curiosity*
(b) *Play is enjoyable for children*
(c) *Play is a way to provide tactile experience in school*
(d) *Play is a distraction from practising/drilling for examinations or conflicts with learning*

7.12 Prior Knowledge, Interests and Experiences
(a) *Play provides a context for the application of knowledge, interests and experiences and scientific language*

7.13 Choice and Control in Learning Science
(a) *Play is open-ended or self-differentiating*
(b) *Play challenges parental perceptions of school science*

7.2 Sociocultural Context

7.21 Social Mediations
(a) *Play is suitable for some classes*
(b) *Play is better for some groups than for others*
(c) *Play is a way to discover what children think*
(d) *Play is an opportunity for children to learn from one other*
(e) *Play is a place for conflict*
(f) *Play is a place for developing social skills*
(g) *Play is a cause of behavioural management problems*

Table 7.1: A list showing how 14 themes were classified within the two contexts in the Falk and Dierking's (2000) CML from the teachers' interview data.

Within each context, the findings will be presented with a clear indication of whether the data was from the pre-play or post-play interview. This differentiation was made in order to trace the teachers' perceptions before and after the scientific play sessions. The type of interview is presented with the line numbers of the transcripts.

7.1 Personal context

A theme was identified as a personal context when it was related to and could be classified under one of these three key factors: (i) Motivations and expectations, (ii) Prior knowledge, interests and experiences and (iii) Choice and control.

7.11 Motivations and expectations

(a) *Play generates curiosity*

Ms Geetha said that her girls were "very curious" (Post-Play: 464) to see the freely suspended magnet and other play materials provided, and that they kept playing with them. She added that this was why the girls were "very inquisitive" (Post-Play: 464) about the playing. Ms Geetha recalled that her girls were curious and "daring in their play". She said that her girls were bold and had ventured beyond what they had been given to test new boundaries.

Similarly, Madam Lee commented on how the children became puzzled and started asking questions after they had encountered a problem:

> *They placed everything in the water only to [realise to] their horror that they were not supposed to. Then, they actually asked questions.*

Madam Lee (Post-Play: 737–739)

Although the children had been told that they could do anything they wanted, the teachers and the researcher were shocked when they emptied everything into the basin of water, which ruined the non-waterproof school compasses. The children were baffled and started asking a series of questions, one after another, such as:

> *But shouldn't it be waterproof?*

Madam Lee (Post-Play: 740)

> *Er……the person who made it, why didn't they think of using a waterproof material so that, it doesn't damage our compass?*

Madam Lee (Post-Play: 741–742)

> *What if I'm going on a tracking experience, and then, you know, my compass dropped into the river, yah, so…..?*

Madam Lee (Post-Play: 743–744)

Madam Lee was surprised by the children's action and found that the series of questions they raised was quite good (Post-Play: 746):

When they actually went over in that direction [asking questions], yah, I was like, you're actually linking what is learnt.

Madam Lee (Post-Play: 747–748)

Madam Lee felt that it was "quite interesting" (Post-Play: 753–754) that they had linked their prior experience with the topic "Material" (Post-Play: 756) and associated the concept of "waterproof" with the compass:

Yah, they linked to, like, what they'd learnt a lot earlier, waterproof yah, so, quite interesting lah[11].

Madam Lee (Post-Play: 753–754)

The free-choice play in which the children were engaged generated interest, motivated them to ask questions and made them wonder. This indicates that play generates curiosity in these children.

(b) *Play is enjoyable for children*

Several teachers reported that their students enjoyed the play. For example, Ms Koh reported that the children aged 9–10 years old were "a bit more open" (Post-Play: 82) and able to speak up. They had approached her during or after class to say that they had enjoyed the play sessions (Post-Play: 62). Ms Koh said:

Yah, they will give feedback, they will tell me this is lots of fun, er … when, especially when you're [the researcher] walking around, like, "Ms Koh, can we do this again?" I'm like, I'm ok, I actually quite like it when they feed back to me.

Ms Koh (Post-Play: 77–81)

From the girls' feedback, Ms Koh knew that they had enjoyed the play sessions:

Thank you… it was great fun! My girls love it! I can tell you my girls enjoyed it, because they always asked me when the next session will be. Yah, they like it.

Ms Koh (Post-Play: 1260–1265)

[11]Lah- A typical Singlish particle placed at the end of a sentence or phrase for reassurance or emphasis.

Likewise, Madam Lee and Mr Wong said:

> *Erem … some of them will, Oh, like, like James' group, … they actually said they enjoyed the play the most!*
>
> Madam Lee (Post-Play: 731–732)

> *Arem…. the thing about no direction for them, it equates to fun. No instructions, they can do whatever they want, so it's like no host, but they can do whatever they want.*
>
> Mr Wong (Post-Play: 10–13)

In addition, Madam Bhavani also defined play as something that "definitely" piqued "the interests first" and made the children "very excited" (603–607). She reported that learning happens more easily when the learner is "interested and engaged" (603–607). She reasoned that if "you're disinterested" in what you are doing, then "it's pointless" (608). She articulated how play excited the children first, then followed by providing them with hands-on activities that were linked to memory for them.

Similarly, Madam Lee reported that the children were "really more engaged" (173). She also said:

> *And we always think that children don't want to learn, right? They're just lazy but when you just give it to them right, surprisingly when they do what they want to do, it works better than when you tell them what to do.*
>
> Madam Lee (Post-Play: 173–176)

This suggests that, when the children were given the freedom to choose what they wanted to do, they worked better than when the teachers told them what to do (Post-Play: 176–177). Play was easy for the children because it was "their innate nature" that they would "want to play" (Post-Play: 529).

Although some teachers, such as Madam Lee, believed that they might be able to "still get the same outcome" from "drill and practice" (Post-Play: 575), the "enjoyment level and the retention level" might "not be long term" (Post-Play: 576–577) in comparison to play. Play is enjoyable for children.

(c) *Play is a way to provide tactile experience in school*

Ms Koh said that play had "a lot of advantages" by which one got "to see in real life", providing tactile experience in school. She said that play was especially good for physics (Post-Play: 450–455), which was very abstract for young children. She explained:

> *[…] it's especially so for physics, I feel that for physics especially, you need to, they need to really have the items with them, […] to be able to see, to be able to touch, to be able to see what the movement is, what the final result is, in between also.*
>
> Ms Koh (Post-Play: 450–455)

Moreover, Madam Lee reported that:

> *Er… for me, it's like, I'm glad that I can give the children the experiences lah, yah! Hopefully, next time, when they move on and when they, when you ask the children, what is something that you remember of your science lesson, at least, they will say, I had a chance to play*.
>
> Madam Lee (Post-Play: 1097–1099)

Play is a way to provide the children with a tactile and authentic experience, to have hands-on experience and make use of their senses to learn in school.

(d) *Play is a distraction from practising/ drilling for examinations or conflicts with learning*

Mr Wong commented that he found the play sessions "very engaging for the risk" (Post-Play: 240–242). He called this study "a risk" because the play sessions had taken away some time from the standard practice of drilling and doing worksheets, which had been claimed by some teachers to "promise some results". Although he had volunteered himself for this study, he was unsure whether the play sessions would equate to better learning, which could be visible and captured on paper and via assessment. Although Mr Wong felt that his pupils could engage in free-choice learning through play, the conflict with learning was a bit unsettling for him. He explained:

> *Objective […] because I mean if you don't have, [the] aim and objective right, a lot of times, you won't be able to know where, which direction to go.*
>
> Mr Wong (Post-Play: 41–42)

Madam Lee felt that the teachers still preferred to carry out "drill and practice" (Post-Play: 568) because they felt that "play is a waste of time" (Post-Play: 568). To these teachers, teaching the children in the usual manner was "a lot faster" and they would "learn faster" (Post-Play: 569). She supposed that whether or not play could be implemented was "teacher dependent" (Post-Play: 566), depending on the "nature" and "characters" (Post-Play: 571) of the teachers delivering the lessons (Post-Play: 1037–1039). The teacher's comfort level in allowing children to play was also an important factor. She said:

> *Yah, if the teacher don't [sic] believe in play and don't see the value in play, the teacher will, won't want to do it, what.*
>
> Madam Lee (Post-Play: 572–573)

Teachers were keen to make decisions based on evidence about the link between play and learning. For example, Madam Lee said that the children's results could be the "best way to convince the teachers" (Post-Play: 850–852). She suggested that it would be best if the teachers got to "look at the kids' results" and "the kids' satisfaction" (Post-Play: 850–852). If the results with or without play were "the same" (Post-Play: 854), then the children's decisions on which one they enjoyed best would be a better indicator as to whether or not to use play (Post-Play: 855).

Madam Lee said that play seemed to be more feasible for middle primary teachers, who would not mind trying play in Primary 3 and Primary 4 (600–602). Upper primary teachers might not be as interested or "so keen" (846–847) because they had issues with time (306) and needed to prepare the children "for the national examination". Play would be deemed a distraction from the preparations for examinations, conflicting with the intended learning.

7.12 Prior knowledge, interests and experiences

This section discusses how the curiosity generated by play had set up contexts in which the children applied their prior knowledge, interest and experiences, and their use of scientific language.

(a) ***Play provides a context for the application of knowledge, interests and experiences and scientific language***

Free-choice learning during play means that no instruction was given and the children had to depend on themselves and take control of their own learning. This leads to the setting up of contexts in which to apply their prior knowledge. For example, Madam Lee noticed that the children in her class were more alert about what they had seen and been taught earlier during the science lesson (which was before the scientific play session). Due to the nature of play and the context in which the play was set up, these children were "forced to retain the information" they had learnt previously, and more actively, to enable them to play (Post-Play: 422–426). Madam Lee found that, if the children were thinking for themselves (Post-Play: 433–434), the chances were that this active and voluntary self-directed learning would result in them remembering "certain concepts" (Post-Play: 435) that had been taught earlier on.

> *But if they think for themselves, chances are they have to remember certain things which is what I want them to do, right? To remember certain concepts lah.*
>
> Madam Lee (Post-Play: 433–435)

Likewise, Ms Geetha believed that the children learned and remembered "by doing" (Pre-Play: 486), tapping into their prior knowledge. Ms Geetha also said that when she taught some concepts, it was "very dry" (Pre-Play: 487) and the children would not remember it (Pre-Play: 488). She said that she "would love to" support play as pedagogy because she believed that the children would not learn "through concepts" (Pre-Play: 483–484) but that learning would be possible through play. However, in reality, due to time constraints and being a subject teacher (who only taught science to the class), even though she had indicated that she would love to give the children "an hour plus to write down and discuss" (Pre-Play: 480–481), she concluded that play was not really feasible in class without the support of other teachers and the school management.

In addition, Madam Lee explained that most of the children would somehow get "a chance to try" and participate during the play sessions, unless there were some conflicts within the groups (Post-Play: 31–33). Madam Lee also maintained that, even with conflicts happening in a group, her play session would "still cover" the lesson and they would get to learn (Post-Play: 31–33). She described the play experience as memorable: “something that one would not forget” (Post-Play: 597). Madam Lee also stated that upper primary teachers gave feedback on how, when the children reached Primary 5 or 6, they could not “remember what they had learnt in P3, P4, the lower block science” (Post-Play: 601–603). She advocated play and hoped that, through play, the children would be able to remember in the future what they had learnt while they were in P3 and P4:

> *Yah, so, hopefully with play, they remember the experiences and these experiences will translate into their learning socks.*
>
> Madam Lee (Post-Play: 604–605)

Likewise, Ms Geetha said that the play had set up contexts and allowed the children to link their play to a previous lesson that she had conducted on leaves.

> *Because I already, remembered I draw and show them, the leaf. So, they want to use that to apply, so it’s good lah!*
>
> Ms Geetha (Post-Play: 682–683)

Ms Geetha was pleased that the girls were applying what they had learnt from the previous lessons. Furthermore, she also observed that play had helped the children to confront the targeted misconceptions, for example, that a bigger magnet is a stronger magnet, in the first play session. She said that this experience was “good” (Post-Play: 35–36) and easier (Post-Play: 219–221) for the children as they were able to explore and verify with their own eyes. She found that play had allowed the children to look at concepts like “a re-emphasise [sic]” (Post-Play: 157–158) on what they had learnt during the first 45 minutes of a lesson before the play sessions, re-emphasising “the pedagogy” (Post-Play: 135–136). Besides these benefits, she said that “it was good” (Post-Play: 699) to allow the children to have experience and to teach them the “knowledge first” in order to provide them with some content knowledge (Post-Play: 155–156). This allowed them to tap into this prior knowledge during play.

Likewise, Madam Lee recounted that, even after all the play sessions had ended and the class had reverted to the usual science lessons, she was seeing an increase in the number of children participating in class discussions than in the past.

> *Definitely lah, there's a difference lah. They're more willingly […] I mean in terms of [a] number [of children who are more willing], I can't really tell yet!*
>
> Madam Lee (Post-Play: 681–683)

Madam Lee said that the children were able to join in more because play had allowed them to "relate back to what they had seen" and "what they had learnt" (prior knowledge) (Post-Play: 125–127). The children were able to apply their prior knowledge to their examination-style worksheets. Madam Lee felt that the children who had played had "a little bit" of difference and they were "able to answer the more challenging questions" (Post-Play: 859). Madam Lee said:

> *So, they will still say things [like], "Oh, I … last time, we did this or like, we did that, so, I think," … it already should be transferred, permanent memory already lah, 'cos play … I don't think it's just, I hope that it won't be just temporary and after, they forget lah, yah.*
>
> Madam Lee (Post-Play: 228–231)

The children had transferred what they had learnt while playing to their "permanent memory" (Post-Play: 228–231).

Moreover, in terms of prior interests and experiences, Madam Lee recalled an incident where she had tested the children using a spinning eraser (which looks like a magnet). She remembered seeing the children recalling what they had experienced and learnt during the play sessions (Post-Play: 128–132) and applying it to the question posed by her. She was amazed by the children's reasoning that, since this freely suspended 'magnet' did not point in the north–south direction after being spun, they were able to infer and conclude that this "magnet" was not a magnet. Play had allowed the children to gain authentic experience and to apply their prior interest and the knowledge obtained through the scientific play sessions to questions posed, helping them in their understanding of science in class (Post-Play: 124).

On another occasion, Madam Lee recalled an instance when she had linked the children's prior interests and experiences during play, making a "Magnetbot" (a robot created by the children out of different pieces of magnets), to the questions that they were answering. She was pleased with the children when the concept of assuming and inferring about the poles was not foreign to them due to their prior play experience and that they had remembered what they had played.

> *I think, when I tell them that you need to assume the pole, it didn't came [sic] as a, are…. like completely foreign to them, lah, "Oh, it's a [sic] exam, exam question." So, I actually linked it back to their Magnetbot, lah. They could see it quite clearly that er…. Magnetbot can only be arranged in [a] certain way.*
>
> Madam Lee (Post-Play: 627–632)

In addition, Madam Lee also said that she was pleased to see some children picking up the link on what was covered in the lesson and applying it in their play after a few play sessions:

> *Like every time, after I delivered the lesson, right, roughly they know that today you know, this is what we're learning, so, probably my play will be related to what I've learnt.*
>
> Madam Lee (Post-Play: 384–386)

Similarly, Madam Bhavani said that play had "definitely helped" (Post-Play: 51) her and had made it easier for her to introduce a concept or build on their understanding.

> *Ok, yes, ah... The thing that … definitely helped. Ahrem ... before the science experiment even sometimes, you don't have to do the experiment because they've already done everything on their own, pretty much. So, yes. It is easier!*
>
> Madam Bhavani (Post-Play: 50–56)

She was able to build upon and establish "the link" between what they had already done and "the next thing" that they were going to do (Post-Play: 63–64).

All the contexts presented above were often associated with the usage of scientific language during play. For example, Madam Lee said that play had provided a context for the children to use it. She explained how her current class had "no problem" with using the correct science vocabulary, such as "attract" (Post-Play: 887–888), compared to her previous classes, and that they kept using "attract, repel, attract, repel" (Post-Play: 890) freely and easily. This was noticed more visibly in the "stronger groups", who had used "scientific language" while they played:

> *Sometimes, [it] could be normal every day but certain groups that I see, lah, the stronger groups are, scientific language starts to come out when they play, so they start with, "Oh, this one attracts, can attract this, this one can attract that."*
>
> Madam Lee (Post-Play: 332–335)

However, Madam Lee had some reservations about whether the children were able to fully understand what they were saying because they might just be repeating those scientific terms. She felt that there was a need for the children to know what they were saying first, then to expand and remember other phrases (Post-Play: 893–896). Madam Bhavani also acknowledged this and said that much more work needed to be put in to improve the way in which the children answer questions, their answering techniques (Post-Play: 72–73).

On the other hand, Ms Koh made this observation and said:

> *The takeaway [of play and something that she had tried] … the thing that they [the girls] can, they actually are quite active when they come to you [the researcher].*
>
> Ms Koh (Post-Play: 173–174)

During the play sessions, she observed that her girls were "quite active" (Post-Play: 173–174) when the researcher was around and that the children in her class had started verbalising their thoughts on their own, which she had not expected.

> *I will, as far as for this class, they're actually quite kinaesthetic so they're willing, […] they actually do, verbalise their thoughts which is something that I didn't expect, I thought that they will [sic] just do, they won't really say but they verbalised their thoughts, which I'm quite happy with.*
>
> Ms Koh (Post-Play: 175–179)

Moreover, Ms Koh also noticed that even her quiet girls tried and participated in the play sessions, "mouthing it" [the things they were interacting with] (Post-Play: 199–200), and verbalising their thoughts. Although these girls did not "really say [it] out loud" (Post-Play: 201), they were doing it (Post-Play: 201–203). Ms Koh felt that some of her girls could "do it better" (Post-Play: 225–227) when they were not in front of people as they had "confidence issues" (231), due to which their confidence was "hindered":

And when they come, they just within the small [group] first. Is a confidence, all about confidence at… issue. And their confidence is hindered a lot also by the fact that they are very, concerned about other people's opinion of them, yah!

Ms Koh (Post-Play: 228–233)

She explained that, during "normal play", with "no one" observing them (Post-Play: 220–222), play had provided a non-judgemental context for the girls to try out and apply their learning:

It's like a… you know, normal play, they won't have… because no one is observing, ahrem… maybe I've been walking around.

Ms Koh (Post-Play: 220–222)

Supporting Ms Koh's view, Madam Lee also said that the children were "forced", in a positive way, to "think a little bit more" (422–426) in a play setting.

Erem…, they don't think. They are forced to think a little bit more because now, teacher don't [sic] give me instruction on how to build it, teacher doesn't tell me, what I need to do, to get it moving, I have to rely on what I see [sic] earlier, to, so they have to retain, they're forced to retain the information, in order to do it.

Madam Lee (Post-Play: 420–426)

Lastly, Mr Wong felt that one "can still put play into science" (Post-Play: 740). So, play was "part of the pedagogy" for him (756) as a "strong pedagogical tool" (883–884) to create the different contexts for the children to apply their knowledge. Play can be like "an engagement" as a type of "unconscious learning" (Post-Play: 741) to get the girls "interested in science" (243):

Sometimes, you ['ll be] very surprised when they play and then ask them a certain thing, and they're able to tell you. And, so you know they are unconsciously [sic], they have learnt something. Even, they cannot put it into exact words they want, you know that, they, they know something about it.

Mr Wong (Post-Play: 748–752)

Therefore, play generates different contexts for the children to make sense of and apply what they have learnt, applying their prior knowledge, interest and experiences into the new contexts, and using scientific language.

7.13 Choice and control

(a) ***Play is open-ended or self-differentiating***

The play session had an open-ended format in which the children had the freedom to direct their own learning, in contrast to a typical practical session where instructions were stipulated, and they were expected to follow these step-by-step. Moreover, the children were given a range of things which they might not have tried before, attracting the learners (Post-Play: 691–693).

> *Before the play session, they'll be like, "Oh, I did this at my tuition centre already, or I tried this with my parents already but when it comes to play session, because there is [sic] so many things right, they can't say, "Oh I ['ve] done this before", yah, 'cos they can try out more things, lah.*
>
> Madam Lee (Post-Play: 46–49)

Undeterred by the shift from instructing the children to no instruction, Madam Lee disclosed that she would persist and "still use it [the play pedagogy]". She had learnt to remove the instructions for the children because she could see that they "enjoyed [it] more without me [the teacher] giving them specific learning outcomes and instructions" (Post-Play: 379–380). She also talked about "letting go" of control to "let them play" (Post-Play: 658) because she recognised that "if the teacher dictates, then the play is not a play" (Post-Play: 1040).

Madam Lee was surprised to witness the difference in attitudes when these children were able to do what they wanted to do (Post-Play: 176). She said that giving the children the freedom to choose what they wanted to do worked better than when you had to tell them what to do (Post-Play: 176–177). She added:

> *The word is their rebellious nature, lah, but I tell you, that's why they don't want to do it, but if I want to do it myself, I don't mind, you know, ... exploring, yah!*
>
> Madam Lee (Post-Play: 178–180)

Self-differentiating by nature, play is open-ended and allows learners of various levels to join in. No two sets of play were similar, and the children did not mind joining in the play at time.

(b) ***Play is challenging to parental perceptions of school science***

When it came to parental views and involvement, there were varied stands on play: some parents were in favour of the implementation of play pedagogy while others were against it [similarly to the results seen in Section 6.13 (g) for the children]. Play is challenging to parental perceptions of school science. With reference to those who supported play, Ms Geetha commented on why she had supported this extension of learning at home:

> *The parents are very much interested because [their children were in the] first year, they are very involved in science, so they [their children] like to do a lot of things with their parents.*
>
> Ms Geetha (Post-Play: 271–273)

Ms Geetha felt that the “kids” were “very hands-on” (Post-Play: 268) because of the strong parental support. This was good because “parents like to be involved in all these [extensions of learning at home]” (Post-Play: 274). Active parental involvement was ideal because “it keeps the interest [in science] going” (Post-Play: 275).

However, some parents had different perspectives on school science and teachers found that some parents “will think” differently:

> *So, … parents being there, they will think that how, … you are going to study, not to play.*
>
> Mr Wong (Post-Play: 732–733)

Mr Wong said that he “personally disagreed” (Post-Play: 739) with the parents who had perceived play as not learning:

> *So, you [are] here to study, not to play.*
>
> Mr Wong (Post-Play: 736)

Some parents see play as a distraction and in conflict with learning. To these parents, studying means not to play, but the teachers were still motivated to try play in class, although they agreed that play is a distraction from worksheets and possibly conflicts with learning. Conversely, it was also difficult when these parents had traditional mindsets and reacted in this way:

> *They start to panic, like no worksheets come back. You know, no homework done, no worksheets, now, they are very like, 'Aeh'…. they want to go home and revise, that's why I do give worksheets now and then, the parents start questioning me, say, "Aeh…. Ms Geetha, you got no worksheets?"*

Ms Geetha (Post-Play: 370–373)

Therefore, to deal with parents who were not so much in favour of play, having a good relationship and proper communication will help:

> *I said don't worry, relax, you are doing practical as well as, which is good for the concept and all these.*

Ms Geetha (Post-Play: 374–375)

Ms Geetha managed to convince the parents by staying "in touch" (Post-play: 364), updating them on the topics covered and keeping them informed. Play can be challenging to parental perceptions of school science.

7.2 Sociocultural context

One theme was identified as belonging to the sociocultural context in Falk and Dierking's CML (2000). This theme involves the teachers' recall of their interactions with the children, as well as the types of social mediations the children experienced while they played in this research study.

7.21 Social mediations

The themes that were inductively coded and classified in the sociocultural context with social mediations as the key factor from the teachers' data are: 'Play is suitable for some classes', 'Play is better for some groups than others', 'Play is a way to find out what children think', 'Play is an opportunity for children to learn from each another', 'Play is a place for conflict', 'Play is a place for developing social skills' and 'Play is a cause of behavioural management problems'.

(a) *Play is suitable for some classes*

Before the play sessions, Ms Koh believed that play was more suitable for some groups than others. She reported:

> *My, this class is very kinaesthetic, so anything that requires movement bringing them around the school for bio-related, things and, animals and plants, … they remembered it a lot better, yah, … letting them see, move and touch, is a lot better for this class, compared to my other classes, yah! I used to have one that is a lot more about writing, so they prefer like, you know, those crossword puzzles, that kind of thing, they like.*
>
> Ms Koh (Pre-Play: 502–508)

Her current class (the class participating in this study) could engage in writing in a typical lesson, but after "10, 15 minutes", "they must move" (Post-Play: 99–101). She said:

> *You need to help them a bit first, guide them a bit first, before they can do ah, like, Daffodil [the name of another class] and what, they are more, they, they have background knowledge, they at home, the parents will definitely tell them a bit, so they come here, they are not totally lost. My one is totally, "Hah… never seen this before!"*
>
> Ms Koh (Post-Play: 20–25)

Ms Koh said that her students did not have the "background knowledge" (Post-Play: 20–23) and might not have seen things before, which resulted in them not knowing what to do. Therefore, Ms Koh said that she needed to scaffold her students' learning by teaching them some content and demonstrating experiments in order to guide them in how to use some of the equipment before they could carry out the experiments or, in this case, play. Although Ms Koh reported that her girls were "easy to please" (Pre-Play: 809–810) and when you gave them "things to do" (Pre-Play: 809–810), they would complete what they were tasked to do, she still said that she needed to "try out first to see" whether her girls would be interested (Pre-Play: 805–806) in the play sessions in order to determine the suitability of play with this class.

This indicates the teacher's consideration about the makeup of the classes and the fit of the play activities to the learners in her class. Play is suitable for some classes while, for others, adjustments are needed in order to bridge the children's learning in the class contexts.

(b) *Play is better for some groups than others*

In some schools in Singapore, children are grouped by their prior attainment during their previous school year. In these class contexts, the adjustments were dependent on the grouping of the children, and teachers' perceptions of play varied according to the group they were teaching. Typically in Singapore, children are grouped into three categories which the teachers described as: "low-ability (LA)/ low-progress (LP)", "middle-ability (MA)/ middle-progress (MP)" and "high-ability (HA)/ high-progress (HP)".

Some teachers felt that play worked well for particular groups of children and not so well for others. Madam Lee said that play was "good for the mid-ability to the high-ability children" (Post-play: 50), but not for the "low-progress children" (Post-play: 51). This was because "with so many materials", the children from the low-progress group would not "know what to do" (Post-play: 50–52). Mr Wong agreed:

> *I think the high-ability will design more creative stuff, the low-ability wise will try to follow what the same, …, the safe because they, … don't want to make mistakes.*
>
> Mr Wong (Pre-Play: 265–267)

The teachers associated the prior attainment of "HA groups of girls" with creativity, better vocabulary and clearer conceptualisation. For example, Ms Koh observed that the "HA girls" were the ones who explained and used "better terminology" (Post-Play: 409–411). Ms Koh expected the "MA" and "HA" groups of children "to come up with conceptual thoughts" about what they were doing (Post-Play: 606–607). She added that, for the best of the "HA", she "would expect them [the girls] to come up with an experiment, protocol or things like that" (Post-Play: 609–612), in contrast to other groups of children. This group of children had *"*come up with a test or something", that was "based on that" concept learnt during the lesson (Post-Play: 613–614). Play had created an opportunity for the children to have dialogues and participate in discussions, learning from one another (Nuthall, 2007). This opportunity for the children to learn from one another is further discussed in Section 7.2 (d), below.

Teachers tended to have lower expectations of children in the bottom sets, the "LA" group. Ms Koh said that it was "just more like, let you do this" (Post-play: 609); allowing the children to "touch the materials" and being able to "see simple actions happening" (Post-Play: 603–604). She explained why and how her "LA girls" learned:

> *Because my girls once, after one day right, everything [they learned just now] is reset back to zero.*
>
> Ms Koh (Post-Play: 42–43)

Similarly, Ms Geetha felt that play sessions were not suitable for an “LA” class (Post-Play: 98–99):

> *But, LA classes right, I don’t know what's the point, but the LA classes might have challenge, ... doing …, if [they] play with it, they might not know, they might not know, they might not have the schema.*
>
> Ms Geetha (Post-Play: 78–81)

Besides believing that the “LA classes” could not manage the play, she also added:

> *So, this might be a bit too open for an LA class, lah, they need to be, … there needs to be [a] specific focus and specific differentiating instructions. They might not know.*
>
> Ms Geetha (Post-Play: 98–99)

She felt that “the way they [the “LA” children] tackle [play] will be different from the way HA tackle [it]” (Post-Play: 86–87) and “they might be a bit lost” (Post-Play: 102–104) due to the free-choice nature of the play sessions:

> *And at the end of the day, if the teacher doesn’t guide them, you know, because we are not supposed to say anything, if the teacher doesn’t guide them, they might be a bit lost!*
>
> Ms Geetha (Post-Play: 102–104)

Likewise, Madam Lee also remarked that she had observed that the children generally had many questions to ask, but those groups who were “still struggling to play” would ask “quite low-level” questions and kept “doing the same things again and again” (Post-Play: 75–77).

Moreover, there were teachers, such as Madam Bhavani and Madam Lee, who taught two science classes with different progress groups and said that they were curious to see whether the play sessions would work for the other group (which was not participating in the study). Madam Bhavani commented that the “HA” already knew “how to test” (Post-Play: 307), while Madam Lee disclosed that if she were to have a “high-progress” class, she “would definitely want them to play first” then teach (Post-

Play: 500–501). However, if she had “a mixed class[12]”, she would “still want to teach first” because:

> *If not, what happens is there will be some children who are smarter, they already know certain things right, and then they will be the one dominating the play, versus the child who may not know lor[13], so at least, I want to give them a baseline lah, so at least, everybody can, like [be] equal lah for the play.*

Madam Lee (Post-Play: 502–507)

What she wanted was to ensure that all the children started with the same “baseline” (Post-Play: 502–507) for play so that the children who did not have any additional support at home would not be disadvantaged. This suggests that teachers’ views about what play is to their children do not lack consideration but approach it with great care to ensure that the children have something to rely on to inform their play.

Madam Lee reported that the “HA” children were more confident and daring about dismantling the setups provided to them. These children were “more willing to try” (Post-Play: 214) than the “mixed-ability children”, who played within a safe boundary. She said that the children would “like [to] take out everything” and tried to “figure out” what could be done with the equipment (Post-Play: 215–219). As these children were “really strong in their concept”, they understood “the theory behind it” (Post-Play: 215–219). They “would want to try out what they had seen in the textbook” and test it to see if it was “true or not” (Post-Play: 215–219). They wanted to experience and feel things for themselves (Post-Play: 220). This suggests that children’s prior knowledge is important for the extent to which their play is conceptualised.

In relation to gender, Madam Lee noted that “the boys enjoyed the play session a little more than the girls” (252–254) as she had seen the groups of boys participating more (278). She said that the boys were “more playful” (257) and resourceful in taking “all the materials” (258) given to the group. In contrast to the girls, the boys were “more

[12] Mixed class: is a term used when children are not segregated into categories and grouped.

[13] Lor: A typical Singlish particle placed at the end of a sentence or phrase. It carries a sense of resignation and finality when used at the end of a sentence: “there’s nothing to be done about it, let’s move on.”

kinaesthetic" and willing to "take everything" and "bring them together". The girls were less adventurous and tended to "stick to what they know" (259–261). For example:

> *Like, if I know I can make a magnet, a temporary magnet with this, I just want to do a temporary magnet. But the boys will like, try and attract every other thing, take things from their pencil box, and then I add inside, that kind of thing lah.*
>
> Madam Lee (Post-Play: 262–265)

The boys were able to do things more beyond the scope of the lesson (Post-Play: 267) and improvise their own. They were resourceful about finding things on their own within their group or from other groups and adding them (Post-Play: 264–265). On the other hand, the group of girls were:

> *"I know that Madam Lee probably wants me to erem do this right, so because she talked about this, I will just do this lah later." More like, want to please lah, eager to please lah!*
>
> Madam Lee (Post-Play: 267–270)

In contrast, when speaking about the boys, Madam Lee said:

> *But the boys are like, … "you said play right, I take you literally, I'm going to play! I don't care what is your learning objective, but I just want to play."*
>
> Madam Lee (Post-Play: 272–274)

Madam Lee said that the boys took the word "play" literally and went all out to play, true to their interpretations, ignoring what "the learning objective" was and just enjoying their play (274).

Therefore, the makeup of the groups determined their synergy and whether they were able to play properly. Play is better for some groups than others.

(c) Play is a way to discover what children think

From the findings showing that play was better for some groups than others, we can also see that play is a way to discover what children think. The teachers made many comments in the post-play interviews about what they had observed. There were also observations noted by the researcher in the field. For example, the researcher noticed that Ms Koh's students had acted differently during their play session than in the usual science class.

In this group, the girls were observed by the researcher to have spoken coherently, loudly and confidently while playing within their group. They were having no problems and stated scientific facts ("magnetism can pass through non-magnetic material") (Post-Play: 206) five or six times in succession while playing in a group. However, when they were questioned immediately after the play sessions about the same scientific facts behind what they had observed and played with during the class, they suddenly "clammed up" (Post-Play: 208–211) and did not say anything.

Ms Koh attributed these observations to the issue of "face" (Post-Play: 215) in an Asian context. She explained that, during "normal play", the children felt safe and said whatever was on their minds because there was "no one" observing them (Post-Play: 220–221). Ms Koh elaborated on how, in a girls' school like hers, "the bad thing" was that the girls "were not very willing" to "talk in front of people" (Post-Play: 212–214). These girls were "very worried about what other people say" (Post-Play: 218–219) and "their confidence" was also "hindered a lot" by the fact that they were "very concerned about other people's opinion of them" (Post-Play: 232–233).

These girls had grasped the concept, but once they were required to present or describe it in front of the whole class, they clammed up and were not willing to answer or respond. This "clamming up" by the girls means that the teachers would not be able to accurately assess exactly what the children knew during a normal science lesson. The girls were very self-conscious; did not say much and were fearful of making mistakes because they did not want to appear silly, losing "face". This indicates the importance of providing non-formal contexts, such as play, in which children are free to make mistakes and take risks in order to discover how they think. Play enabled the teacher to determine what the children understood.

Likewise, Madam Bhavani, who was appointed to participate in this study, also displayed a visible change in her attitude towards play. Her perceptions of play changed after completing all the play sessions because she was able to observe how the children were thinking. She recounted how, "after the first session", she told her

Head of Department (HOD) of science about “the value of this [the play sessions]” (Post-Play: 713–714). She had discovered herself “walking around” (Post-Play: 347) and just looking “at what they [the children]” were doing (Post-Play: 220), refraining from commenting such as, “Oh, this is wrong or correct” (Post-Play: 222–223). Madam Bhavani said that play had freed up her time to walk around (Post-Play: 347) to observe how the children think and how “certain misconceptions” were raised in the children’s answers when they were “just exploring” (Post-Play: 75–78). The researcher had observed how Madam Bhavani skilfully picked up the children’s misconceptions (Post-Play: 75–78) and, according to her explanation, immediately addressed and introduced “the scientific concept” (Post-Play: 75–78). Moreover, Madam Bhavani added that, if play were to be used as a school approach, she would “definitely be one of the ones who will support it” (Post-Play: 340). She even had an idea about what to do the next time when she said:

> *If possible, then like, I do the same cycle again, the next P3 batch, I’ll try to come out with something, so that the whole level, you know, we have this.*
>
> Madam Bhavani (Post-Play: 425–430)

Madam Bhavani had also changed her mind about supporting play; she asserted that if she had not “seen the value”, she would not have bothered “putting in the effort” (Post-Play: 711–712) to try out play in her lessons. She was, however, convinced of its value and concluded that play was “not something that is a waste of time” (Post-Play: 715) and “it was a good one” (Post-Play: 719). This suggests that she had discovered the value of play as a way to gain entry into what the children were thinking and pick up possible misconceptions that they were holding within the session.

Other teachers perceived that play was most effective when the children had prior knowledge. For example, Ms Koh said that the second play session was “a bit more difficult” because one needs to know what the children are thinking and the sessions “need planning” and “theory beforehand”, compared to the first session, which was “a lot easier to incorporate” (Post-Play: 302–304). Similarly, Ms Geetha said that for the second play session with the “north and south pole”, certain prior knowledge was needed (Post-Play: 166–168). This knowledge had to be taught “earlier”, before the play session, so that the children could play smoothly. If not, they “might have done a different kind of play” (Post-Play: 150–151).

For one teacher, the absence of teaching before the second play session was evident in the lesson in which, on her own initiative, she changed the sequence of the lesson and jumped straight to the play session after a short period of teaching. As a result, the children were lost and did not know what they could do during the play session. Consequently, the teacher had to stop the play session and teach the content of that intended lesson before she could resume the play session. Only then did the children have some ideas about what they could do and then they had a fruitful session, according to the teacher. On the other hand, Mr Wong said that not all the groups were able to apply what he had taught earlier on in class because he believed that the "fun element" of play had overwhelmed the girls and caused them to forget what they had learnt (Post-Play: 69–72).

Ms Koh also said that she needed "more time" with the children "to have the ability to say more" because "they don't have the content knowledge" (Post-Play: 183–184). As she had previously mentioned that her class was "LA", whose learning resets to zero easily [See Section 7.2 (b)], she recommended having more time between sessions to allow "theory and a practical" (Post-Play: 189–190) to slot in the content knowledge needed. Ms Koh added that the girls probably knew that something was happening but they did not "know how to verbalise it in words or they don't know [what] is the theory behind it" (Post-Play: 186–188). She felt that the girls were restricted and did what the teacher instructed because that was the safest thing to do (Post-Play: 321–322).

As mentioned by some teachers earlier, Mr Wong talked about how the teacher was able to walk around and gain a feel for how the group was thinking and working together. He illustrated this with an example where he went to a group and asked some questions. He explained:

> *Then, the rest will pretend that they're not listening, […], so that's the main difference […], I know that, so when only one person answered and the rest are not looking at me, I know that, that group ah are not working well.*
>
> Mr Wong (Post-Play: 434–437)

Play enables the teacher to work on how and when to intervene later on to facilitate the children's group interactions. Mr Wong explained how play had helped his class:

[…] in terms of learning wise, yes, I can use that […] to teach, I mean, […] what they've done, what I've observed to teach them, to remember what I like,…for examp [sic] … remember what some other group has done, so what do you do about, like that, so I think that could be a good, good thing.

Mr Wong (Post-Play: 15–18)

This suggests that play has enabled Mr Wong to collect various kinds of information about his girls and access their thinking and learning.

Madam Bhavani was experienced in summing up the lesson based on what she had picked up from walking around the class during the play session [see Section 7.2 (c)] about the children's thinking. Like, Mr Wong, she managed to build on what the children were thinking, and then meaningfully conclude and highlight the learning objectives for the children, delivering an excellent lesson.

Conversely, Madam Lee raised an issue that she had observed during the play session:

[…] like showing things like, they took the magnets and put it under the table and then tried and moved certain objects, I mean that in itself is play already. Showing how magnetic force can pass through […] a table.

Madam Lee (Post-Play: 983–986)

She could see the children were playing and trying different ways to explore the magnets and what they had learnt in the lessons (Post-Play: 983–986). She felt that these children did have some knowledge of the concepts but were not good at expressing them at that stage. It was like the initial stage of contact with the concepts. They were bewildered and replied, "Huh? What did it mean?" (986–987). Teachers might have initially thought that they did not understand, but after much prompting and encouragement, the teachers could listen to what they had to say about their play. The subsequent responses given by the children provided more insight into what they were thinking and understanding, such as the remarks narrated by Madam Lee:

I [was] just making it move lah, because the magnet can attract the … let's say, the coin, so it can move.

Madam Lee (Post-Play: 988–989)

Madam Lee explained that, to find out what the children were thinking, the teachers would add science vocabulary words to help them, tapping into what they had learnt in science:

> *That's when we add on the vocabulary to help them to link up what they […] actually try to explain certain things that they do, using […] their scientific knowledge lah.*
>
> Madam Lee (Post-Play: 996–998)

Madam Lee commented on why it was not necessary to give the children answers:

> *So, maybe the children may not think like, "Aer…, I actually know it ah, but it's just coming, it's coming to see the linking, teaching all like, actually you know it now, I don't have to give you the answer, you already know how to ans… explain yourself, so, why don't you try?"*
>
> Madam Lee (Post-Play: 999–1003)

Madam Lee said that "throwing them [the children] questions" would help to make them think about things instead (61–62). She claimed that she had to make a conscious effort to keep the teacher's habit in check, whereby the teacher just dictates and directs the children in what to do:

> *Of course, teachers' habit is "I just tell you lah, then you go explore your… you go and see whether you get it lah", but I tried not to!*
>
> Madam Lee (Post-Play: 64–65)

Madam Lee explained that:

> *[…] if the teacher dictates, then the play is not a play […]*
>
> Madam Lee (Post-Play: 1040)

On a similar note, Madam Bhavani reported that play had a role in revealing "certain misconceptions" from the children's answers when they were exploring (Post-Play: 75–78). She could "immediately address and introduce the scientific concept" she felt would be helpful (Post-Play: 75–78), which she did during the second play session. Madam Bhavani, in particular, was one of the teachers who was skilled in picking up what the children did during the play session. She then built on what they had learnt, creating the linkage for them. However, Ms Koh remarked that, because the play session was “a free-form play lesson”, the difficulty that she had met was that “not all misconceptions” were pulled out (Post-Play: 465–467).

On the other hand, Mr Wong said that play could be a “good thing” (15–18) for him to use to teach the children to “remember what some other group” had done, as well as what they had done. He felt that it was through all these play sessions, “the free play” which he had endorsed, that he was enabled to see “what kind of misconceptions” the children had, as well as at the same time checking “for prerequisites” (885–887) in the children’s understanding.

Lastly, Madam Lee agreed that, sometimes, it was not easy to see the children’s learning (Post-Play: 626–627) just by looking at their play alone. She pointed out that it could be a good suggestion to couple a follow-up strategy, such as giving the children “exam-style questions”, with their play experiences in order to follow their lines of thought. This suggests that play is a way to find out what children are thinking.

(d) ***Play is an opportunity for children to learn from one other***

Teachers perceived play sessions as a way of enabling children to play and learn together. Madam Bhavani planned the groups carefully and deliberately placed two vocal children together:

> *Somehow, he puts her in place, because no one [will], if you are too quiet, you won’t put her in place.*
>
> Madam Bhavani (Post-Play: 261–262)

Similarly, Mr Wong and Ms Koh had also carefully planned their lessons so that the children could learn from them. Mr Wong had purposefully designed his lesson to tie in whatever the girls were supposed to learn in the lesson to help them in the play session (Post-Play: 60–62). Mr Wong believed that play could help the children to “register”, “get it” and be “able to use” what they had been taught (Post-Play: 66–68). Similarly to Mr Wong, Madam Lee also planned her lesson with much thought and ensured that she had incorporated something of what she intended the children to do during her lesson (Post-Play: 410–411).

Madam Lee stressed her point that what was unique about play was its role in encouraging the "retention" (Post-Play: 594) of concepts for the children to learn from one another. She supported her point with her explanation that what you have experienced directly is "something that you won't forget" (Post-Play: 597). She had made use of the play to create an opportunity for the children to engage in learning that was meaningful because the children always remembered the experience (Post-Play: 613).

Likewise, Ms Koh said that, despite a group having issues working together, she still believed that the girls could learn from one another (Post-Play: 406). She explained that her groups were "usually arranged" with "HA, MA and LA" in each one. With the "higher ability girls", who were "using the better terminology", her ideal plan was to have these girls explaining to their peers. However, sometimes this plan failed, and this will be discussed in the following Sections, 7.2 (e) and 7.2 (f).

(e) *Play is a place for conflict*

Some groups were enthusiastic and worked well together, while others were not able to work as a group and experienced conflicts. For example, Madam Lee raised an observation she had made of a group in which a child appeared not to like the play sessions:

> *She doesn't really like the play session but I'm guessing it's because of the group that she is in, …yah, there's [sic] more boys, but she's not the only one in … all boys, a girl among all the boys' group lah.*
>
> Madam Lee (Post-Play: 243–245)

The group tried to give in to her to get her involved, but they were unsuccessful (252–254). Madam Lee explained what had happened in the group:

> *It's … maybe the boys, they just cannot co… she has her way of wanting to play but the boys have their ways of wanting to play, they just cannot get along, so**,** for her, the play session, she finds it, I think she just finds it... After a while, they will try to get her involved, but…*
>
> Madam Lee (Post-Play: 248–250)

This was the "difficult part" (Post-Play: 530) which Madam Lee had experienced during the play session. It was related to "conflict management" in groups (Post-Play: 58) and “managing them as a class” (Post-Play: 530) or “helping them to work in their groups” (Post-Play: 59–60). Play is a place of conflict too. Madam Lee had to “disperse” the “quarrelsome” children by placing them into groups where they could work together with “at least one or two” members of the group (Post-Play: 113–114). Madam Lee admitted that, even after doing all the planning, in the end, she still ended up with at least two groups that somehow did “not work out as well” as she had expected (Post-Play: 115–116). This was also an issue for Ms Koh. She spoke about an “argumentative group” (Post-Play: 403–404) where she had found it to be “very hard for them” to learn much or cooperate with one another [as mentioned in Section 7.2 (d)].

As free-choice learning in play was encouraged in this study, conflicts were inevitable, and they did arise due to the frictions and interactions between different children with different personalities.

(f) Play is a place for developing social skills

As much as the teachers wanted to tap into the affordances of play to develop the children’s social skills and train them to help each other, Ms Koh talked about the difficulties that she had encountered when she tried to pair up and rely on her “HA girls” to explain things to their peers [as mentioned in Section 7.2 (d)]. She said:

> *So, … they are the higher ability girls who’ll explain. They are probably the ones that is [sic] using the better terminology, … [but] my “HA” girl for this group is very, very quiet, so that’s the problem.*
>
> Ms Koh (Post-Play: 409–412)

Ms Koh said that this problem arising from the study suggests that play can be a place for children to develop their social skills to work with one another. Ms Koh said that even though some of the children sometimes could not work well as a group, they still helped each other (Post-Play: 417) at the end of the play sessions. Even Madam Bhavani agreed, and said:

> *So, the knowledge stays with them, and the last thing that play does is it forces them to work on their social skills as well.*
>
> Madam Bhavani (Post-Play: 614–615)

Similarly, Madam Lee also said that the play sessions would ultimately enable these children to develop social skills because they would not always be able to work with people they liked and they had to learn to work with one another (Post-Play: 117–118). Play is a place for developing social skills.

(g) *Play is a cause of behavioural management problems*

Prior to the play sessions, in the teachers' pre-play interviews, some teachers, such as Madam Bhavani, "had a lot of apprehension" (Pre-Play: 355) and were concerned about how the fluidity of play would lead to other behavioural issues. But this did not turn out to be the case in the actual play sessions. On the contrary, Madam Bhavani reported that she was having fewer behavioural management problems because the children were more engaged and focused (Post-Play: 628–630) due to the play:

> *I did feel… I was scolding less as the lesson went by. […] they don't really, other than Hasan who stopped the recording, […] the rest of them don't really, […] they're quite focused.*
>
> Madam Bhavani (Post-Play: 623–630)

She had found herself "scolding less" (Post-Play: 623–625) and "the noise level" was "getting lower as the weeks" passed (Post-Play: 327–328) and the lessons "went by".

> *There will be a routine, the noise level is getting lower as the weeks go by already, if you notice.*
>
> Madam Bhavani (Post-Play: 327–328)

The children were getting used to the "routine" of a play session (Post-Play: 327–328). Her class "super loved" (Post-Play: 21) the play session. This enjoyable nature of play was, however, problematic. For example, Madam Bhavani described her children as excitable and "very hard to calm down" (Post-Play: 29) after the play sessions, which affected the next lesson (Post-Play: 24–30).

> *Because it's fun. … I think it's very enjoyable for the kids. … sometimes even too enjoyable, to the point that the lessons after that, teachers will all come to me and ask what happened, why is the class like that. In class, they are like so excited that it's very hard to calm [them] down.*
>
> Madam Bhavani (Post-Play: 24–30)

Although Madam Bhavani’s discipline problems had decreased, play was a cause of behaviour management for the teachers who were taking over the period immediately after the play session. She explained why the children were so excited and high:

> *If they’re used to play for a lot of play, it will be ok, but since we’re not used to this play, when it happens once or a few times a year, they get very excited.*
>
> Madam Bhavani (Post-Play: 38–40)

She recommended that play should be “a consistent thing”, such as having the lesson every day or every science lesson (Post-Play: 33–34) and not just “for one topic or once a year” (Post-Play: 334–335) so that the children could get used to this level of excitement. They “should be, you know, constantly playing” (Post-Play: 336), and it should not be a “novelty”. Only then can play become routine so that it will be easier for the teacher to manage the children. If not, the interest level will be “really high” and the children will not be able to “focus on anything else” (Post-Play: 331–332).

Furthermore, Madam Lee said that it would be nice if there could be laboratory technicians (444) to help with the logistics and preparation of materials to free her up and allow her to try play, as well as “another teacher” in the class to help out. This is because, with ten groups of children to handle “at one place and at one time” (446–449), the interactions that the teachers had were limited and they could not answer every group’s “burning questions” (451–452). She said:

> *Yah, so of course, the more people you have to support it, the better it is lah but [the] restriction in manpower, yah!*
>
> Madam Lee (Post-Play: 453–454)

This suggests that play can be demanding on teacher’s time but if the logistics of the preparation and setup were to be taken over by laboratory technicians, this would help to lighten the preparation load for the teacher. It would also reduce any behaviour management problems because the teacher would have more time to cater to the children, helping them.

7.3 Conclusion

This chapter has identified the teachers’ perspectives on play in primary science and answered research question 4:

Q4. What are the teachers' perspectives on play in primary science?

The majority of the findings were related to the personal and sociocultural contexts of free-choice learning. In the personal context, the findings were associated with the learners' motivations, expectations, prior knowledge, interests and beliefs, as well as their choice and control. The teachers witnessed that play generated curiosity among the children and allowed them to have real and authentic experiences. This encouraged them to ask questions and link what they had learnt to real-life situations. Teachers believed that play was enjoyable for most children. Because it was open-ended or self-differentiating, the teachers welcomed this nature of play, which allowed multiple entries for learners at different levels. Due to the free-choice learning and hands-on opportunities, the children had tactile experiences, which allowed them to apply their knowledge and use the scientific language they had learnt during the lesson. One interesting finding that surfaced for both children and teachers relates to the parents' perceptions of school science. These findings had an impact on how children and teachers perceived play and, most of the time, the children and teachers did in a way take the parents' perceptions into consideration while playing. Parental perceptions were also a contributing factor to the challenges facing some teachers, who found themselves caught in a dilemma due to the way in which play conflicted with assessment-related objectives, and a shift from practices they were most comfortable with (e.g. worksheets). Despite this, all five participating teachers commented that they would still try play as a pedagogy in the future because the motivational aspects and the satisfaction levels of the children were something that they repeatedly reported, and were not to be ignored.

In terms of the sociocultural context, many of the findings relate to play as a social activity, where children interacted within the group. Play is suitable for most children, but it can be better for some groups than others. In addition, play is a tool to find out what the children are thinking and it creates the opportunity for children to copy or learn from their peers. Play is also an activity during which large numbers of social interactions take place, possibly resulting in conflict between children, and this requires the teacher's intervention. Play can provide opportunities for children to learn social skills through conflict resolution. Interestingly, the teachers also talked about behaviour management problems due to the novelty of the play and how the children were motivated and excited to the extent that their behaviour affected the next few lessons.

In conclusion, these findings have broadened the scope of teachers' perspectives on play in primary science. With a better understanding of what play can bring about, teachers will be in a better position to judge if it is an appropriate pedagogy for them. The motivational aspect of play was a frequent consideration for teachers, while there was some learning that took place within the scope and timeframe of this study. Although the extent of learning was not as extensively covered by the teachers, this will be discussed further in the next chapter, Chapter 8, which discusses all the findings of this research study.

Chapter 8 Discussion of findings

8.0 Introduction

In this study, a mixed-methods methodology was used and Chapters 5–7 present the analysis of the primary data. These data were obtained from frequency counts of the types of talk in group utterances during the scientific play sessions (Chapter 5 – mainly quantitative data with exemplifying qualitative quotes), children's group interviews (Chapter 6 – qualitative data) and teachers' individual pre- and post-play interviews (Chapter 7 – qualitative data). Both quantitative and qualitative data were collected concurrently and analysed separately in a convergent design (Creswell & Plano Clark, 2018) for this study. This chapter presents a discussion of the analysis given in Chapters 5–7 with reference to the literature reviewed in Chapter 2. In this chapter, two sources of data were merged using an approach called simultaneous integration (Morse & Niehaus, 2009), where common concepts across the findings were matched and merged. Then, the quantitative and qualitative results were compared, and these integrated findings and interpretations were used to determine how they confirm, refute or complement each other (Creswell & Plano Clark, 2018). The interpretation of the integrated data will be discussed in light of the literature review discussed in Chapter 2, with the support of the location of the evidence in brackets. Any differences (if any) will be resolved in this chapter in a narrative discussion to account for what happened during the scientific play sessions.

Play has its place in primary science and this study's results have provided insights into what happened when children were given the freedom to play during science lessons, what type of talk they engaged in and what they and their teachers thought about play in primary science. Play was enjoyable for the children and helped to provide them with many contexts that could be linked to their cognitive, emotional and social development while playing with scientific ideas. The findings presented in this chapter are important because they answer the four research questions:

Q1. What are the nature and dominant types of talk among (a) children and (b) teachers during the scientific play sessions?

Q2. To what extent do the children and teachers talk about science during the scientific play sessions?

Q3. What are children's perspectives on play in primary science?

Q4. What are teachers' perspectives on play in primary science?

As mentioned earlier, Chapter 5 presents mixed data (Small, 2011) and is predominantly quantitative, complemented with excerpts from the qualitative verbatim transcripts of the group interactions. In that chapter, qualitative data (the teachers' and children's utterances) were transcribed and coded inductively using *Nvivo*. Then the coded utterances were mapped to the PSTFP (see Chapter 4) and counted accordingly using *Nvivo*. The findings reported in Chapter 5 show that the children were doing most of the talking during the scientific play sessions while teachers' talk was linked to their role as teachers. This could be seen from the nature and dominant types of talk employed by teachers, where they mainly instructed, questioned and gave feedback. Among the children, the dominant type of talk was not about science. They mainly gave feedback, questioned and observed in all talk. For science talk, what they said was linked to science skills, where they mainly made observations, asked questions and taught peers. Play was a low-risk context for the children to make mistakes. Additionally, the children's science talk also revealed their types of learning theories for learning about magnets. For the teachers, the findings showed that they were engaging in more science talk than the children. They mainly questioned, taught and instructed the children when they engaged in science talk. The teachers also gave feedback to the researcher that they had found themselves being freed up and had more time to walk around and listen to what the children were saying, hence supporting the children's learning of science. Play allows children to talk and think together in spoken language within a science classroom. This is important because what the children did during play by talking and thinking in language resembles tools that can help to build their understanding of science (Olusoga & Keen, 2019). Play helps to develop children's cognitive, emotional and social skills, which are useful in learning and understanding primary science.

The data was obtained from the same group utterances but was interpreted in two different ways, with the qualitative data being transformed to become the quantitative data. This is what Creswell and Plano Clark (2018) defined as data transformation integration procedures in triangulation, and Chapter 5 displays a strong intertwining of complementary findings to give the case study its depth and richness. The findings presented in Chapter 5 were integrated with the children's group interview data (Chapter 6 – qualitative data) and these integrated findings were used to answer research questions 1 and 2 for the children. The findings contained in Chapter 5 for the teachers were also integrated with the teachers' interviews (Chapter 7 – qualitative data), and these integrated findings answered research questions 1 and 2 for them. Similarly, in Chapter 6, the children's perspectives were integrated with Chapter 5 to answer research question 3 and in Chapter 7, the teachers' perspectives were integrated with Chapter 5 and some parts of Chapter 6 to answer research question 4. Therefore, in this chapter, the discussions of the integrated findings are presented in four sections:

Section 8.1:	Addresses research question 1 on the nature and dominant types of all talk by children and teachers through the observations of scientific play sessions using a frequency count of the types of all talk.
Section 8.2:	Addresses research question 2 on the extent of science talk by children and teachers through the observations of scientific play sessions through a frequency count of the types of science talk.
Section 8.3:	Addresses research question 3 on the children's perceptions of play in primary science.
Section 8.4:	Addresses research question 4 on the teachers' perceptions of play in primary science.

Table 8.1: A table showing the sections and the research questions addressed.

In this chapter, the findings from the three sets of data (quantitative data relating to the frequency count of the types of talk, children's interviews and teachers' interviews) are integrated, analysed and triangulated in alignment with the literature review (discussed earlier in Chapter 2). These findings are then discussed and presented in the sections shown in Table 8.1.

8.1 Nature and dominant types of talk in all talk

This section is divided into two sub-sections: Section 8.11 focuses on the discussion of the key findings of the nature and dominant types of talk that the children engaged in during their scientific play, while Section 8.12 focuses on a discussion of what the teachers talked about during 'all talk' when they engaged in scientific play during science lessons. These findings were used to answer the first research question:

Q1. What are the nature and dominant types of talk among (a) children and (b) teachers during scientific play?

8.11 The nature and dominant types of talk by children

As can be seen in Section 5.12, Table 5.3, the key findings were that the majority of talk was by children (92.8% of all talk), rather than teachers, and that the dominant types of children's talk (see Section 5.11, Table 5.1) were mainly feedback (35.2%), questioning (11.2%) and observation (9.2%). When the teachers spoke (only 7.2% of all talk- Table 5.3), they mainly instructed, questioned and gave feedback (Table 5.2).

(a) Nature of talk: Children did most of the talking

Children did most of the talking and, as Meckley's (2002) characteristics of play states, the children in this research study were the ones playing. Although this finding contrasted with the literature review on the type of talk in a traditional science class, where it is a more teacher-directed and teacher-dominated type of talk (Lemke, 1990; Newton, Driver & Osborne, 1999), the setting here was free play and converged with Meckley's (2002) characteristics of play when the play is child-chosen. The utterances resulted from their play and not from the teachers. With free play offered and teachers instructed to interfere less often in the children's play (unless there was a need or request from the children) so as not to corrupt the real essence of play (Bodrova & Leong, 2015), authentic contexts with loose parts (Casey & Robertson, 2017, p.6) materials were set up. Loose parts are natural or synthetic materials which are open-ended for children to use in their play in many different ways (Dfe Australia, n.d.). Contexts with a bit of purposeful play (MOE, 2012) were planned to provide opportunities for the children to talk. This was important because, from McInnes et al.'s (2010) study, it is known that the teacher's presence signalled to the children that it was not play. The children were convinced that this study's scientific play sessions were play and commenced their play when the teachers were distant from them. The children's behavioural threshold for learning (BTL) (Howard & Miles, 2008) was lowered due to their perceptions and they became more confident about interacting with the materials provided, seeking less help. This theoretical aspect coincides with the integrated data because Child Getting Help (CGH) was the least dominant type of talk of all 17 types of talk engaged in by the children in this study. According to Burghardt's (2011) criteria for recognising play, the reduced stress and lower BTL (Howard & Miles, 2008) experienced by the children helped to initiate the play behaviour and enabled them to enter play in a culturally constructed place, like the school, and culturally enacted (Fleer, 2017) in the social contexts in the schools, fulfilling a few features of Fleer's cultural-historical view of play (Fleer, 2017).

Play did initially trigger some discomfort when free play was initiated [see Section 6.13 (d)] for some children. Due to the children's prior experiences in class in an Asian setting [see Section 6.12 (c)], they were used to step-by-step instructions and teacher's control. Some children were not used to the new mode of play and were lost. This category of children in a few classes was observed to be 'momentarily frozen' during the first scientific play session, and unsure of what to do. However, when these children looked around and observed what others were doing, they realised what they were free to do. They started breaking free from the deep-rooted Confucian-inspired way of learning (Chin, 2007) and their ownership of learning returned. They started participating in play [see Section 6.13 (a)] and enjoyed themselves [see Section 6.11 (a)]. Play provided the children with opportunities to articulate their ideas in talk, which could have contributed to their conceptual understanding of science (Howe, McWilliam & Cross, 2005; Howe, Tolmie, Duchak-Tanner & Rattray, 2000; Mercer, Dawes, Wegerif & Sams, 2004; Snow, 2010). Play is a context that empowers children by giving them the freedom of choice to explore and learn [see Section 6.13 (a)].

The high percentage (92.8%) of children's utterances compared with the teachers' utterances suggests that they were less restrained in the free play setting and could talk more than they were usually permitted to do. Play empowered the children, giving them the freedom of choice to explore and learn [see Section 6.13 (a)]. This means that free play provides many opportunities to provide freedom and space for the children to interact, observe and be heard. Children verbalise their ideas and use scientific vocabulary; play is learning [see Section 6.13 (c)]. This is important because children only retain words if they can use them in discussion, debate and writing (Snow, 2010). The integrated findings were convergent and confirmed that the children did most of the talking.

(b) Dominant types of talk: Children mainly gave feedback, questioned and observed in all talk

In all talk, children's feedback was the most dominant type of talk, and the children were heard giving feedback in various ways. This feedback included singing songs and incoherent strings of words. These sounds or songs were 'child-chosen', 'child-invented' [see Section 2.15 of Meckley's (2002) characteristics of play] sung in response to what other children had said, to entertain themselves or accompany their play. These responses expressed their joy in their play and it was fun to them [see Section 6.11 (a)]. These behaviours displayed what Burghardt (2011) describes as criteria for recognising play. These spontaneous, voluntary, pleasurable and autotelic behaviours, done for the sake of doing [see Section 2.11, Table 2.1: Burghardt's (2011) criteria for recognising play], were defined as play taking place and play was enjoyable [see Section 6.11 (a)]. Play is a place where children build their social skills [see Section 6.21 (b)]. Dominant talk by the children giving feedback is also an indication of developing positive peer relationships (Hartup, 1993; Rubin, 1990) because almost all of the children would try to respond when spoken to. It was deemed rude if they did not do so. The findings show that the children were practising social skills while playing as they would always answer their peers, by giving reasoned or non-reasoned feedback as an indication, in response to their peers' conversation. In the observations, it seemed that the cyclic conversation noticed in the children showed this, and the group tended to stay on the same topic until all members of the group had checked in and responded.

Play in science provides a good context for developing children's cognitive, emotional and social skills. As free play was given, the children were free to become actively involved, as Meckley (2002) defined it. Based on their prior experiences [see Section 6.12 (c)], they made associations with things like the tall retort stand to become the flagpole up which the school and national flag were hoisted in school, based on their real-world experiences [see Section 2.13: Fleer's (2017) cultural-historical view of play

Table 2.2: the first central concept]. The children changed the meaning of the retort stand into an imaginary flagpole, made an impromptu flag (the second central concept) and stood to attention as they did in morning assembly and sang their school songs and the national anthem, displaying acts of collective and individual imaging (the fourth central concept). The children moved in and out of their pretend play (the third central concept), from the real world to the pretend world and back, laughing and fully aware of what they were doing. This whole episode of imaginary play was accompanied by utterances such as the verses of the songs they sang, and these were classified as non-reasoned feedback because they were sung as part of their fun play, with no clear direction [see Section 6.12]. The children's play actions coincided with the four central concepts of Fleer's cultural-historical view of play (2017). Children's play is "culturally constructed and culturally enacted" (Fleer, 2017, p.144), based on the context of the learning environment, and this was observed during the free play. Free play allowed the children to be creative and imaginative, setting up contexts for them to apply what they had learnt in science about magnets to their everyday lives.

Free play affords the space and freedom for children to interact, observe and be heard. The most dominant type of talk for all talk under feedback in the data (see Table 5.1) showed that the children did give a lot of feedback and this confirmed the integrated findings to be convergent. For the next convergent findings, children's observation will be discussed. Observation, the third most dominant type of talk in all talk, allowed the children to have authentic hands-on experiences as they played and derived meaning through their play experience [see Section 6.13 (b)]. The children were intrinsically motivated because free play had been provided to them as a form of reward [see Section 6.11 (d)]. They were focused on the meaning-making part, which could include utterances about the things they observed (Bruce, 2005; Kennedy & Barblett, 2010; Moyles, 2005) or thought (Cremin et al., 2006), and finding connections (Falk & Dierking, 2000) in a series of cumulative processes during the process of free play. This enabled them to learn [see Section 6.13 (c)] and develop thinking skills (Johnston, 2014) [see Section 6.13 (e)]. Observation ranked high in all talk because, during their free play, the children developed observational and questioning skills, which are essential science processing skills (Glauert, 2009). The above discussions confirm the integration of the data to be convergent. However, there is also a divergent part of the research question, and this will be discussed in the following paragraphs.

The findings show that both teachers and children asked a lot of questions during play, which is important for science learning. Play allowed the children to develop their science skills by asking questions and making observations while interacting with the materials. This is important for the development of a conceptual understanding of science through the children's actions and their talk (Stone et al., 2019). The children asked their peers more questions than their teachers, although their perception reported by them in the group interview was that they asked the teacher more. Although asking questions was the third most dominant type of talk among the children, there was a divergence from the children's perspectives. The children reported that they had found their teachers to be more approachable to ask questions during the scientific free play setting when they were walking around. The children reasoned that it was this closeness that enabled them to access the teachers' help while the teachers were somewhere near them, without having to walk up to the teacher's table. The availability of materials and the increased access to their teachers had reduced the power relationship between the teachers and the children. The children had started to accept their teachers as co-players in their free play [see Section 6.21 (c)]. Due to 'conflict, negotiation, resistance and subversion' (Wood, 2014, p. 4), the children usually faced a power relationship and had to make choices. However, play had helped to free up the children and made it easier for them to make decisions. During the children's scientific free play, they faced their peers, who presented fewer power relationship problems than the teachers, who were often seen as someone in authority (Wood, 2014). When the children invited the teachers to join them in their play, the exchange of questions was effectively increased compared to when the children were playing amongst themselves. In some situations, the teachers were particularly requested to come to the children's tables so that the children could show them what they had discovered, seeking reassurance from their teachers.

However, when looking at the integrated data, the dominant talk of asking questions shows that the children asked their peers more questions [see Section 6.21 (iv)] than their teachers. Children asking their peers questions made up 9.3% of their all talk, while asking the teacher accounted for only 1.8%. Therefore, the children would ask their peers about five times as many questions as the teachers. Their perspectives show that teachers engaging in social mediation with the children in reduced power relationships, questioning and scaffolding the learning for them was refuted by the data because they had ended up asking their peers more questions. Although the integrated data was not convergent for this area, the children did ask their teachers some questions during their scientific play sessions. The teachers were able to respond to questions generated by the children, so their conversations were more meaningful and engaging for the students.

The divergent findings could be attributed to the limitations of the method used in Chapter 6. From the children's perspectives, they did say that they were able to engage in social mediations with their peers [see Section 6.21 (a)] and teachers [see Section 6.21 (c)]. The problem was that there was no exact weighting of their perspectives in this study to determine if their perceptions of asking their teachers or peers were greater than the other. Therefore, the concept of relatability (Dzakiria, 2012) can be applied here, where the reader will decide the degree of relatedness and whether this knowledge about question-asking by the children is relevant to or can apply to the same or other contexts in another timeframe in the future.

Lastly, there are also some limitations as to what the results can tell us in this study. For example, in this study, the main mode of data collection was by audio recording in Chapter 5. Therefore, the results can only show what was spoken and picked up on the audio. The findings cannot show what the children were thinking. The results cannot tell us what the children were learning when silent play took place while they were in the 'flow' of play. The results are able to tell us about some sample populations but as some groups of children (e.g. all boy groups) were not represented in this study, it is not possible to generalise to all classrooms.

From this presentation of the discussion, the answers to research question 1 (a) were: the children did most of the talking and mainly gave feedback, asked questions and observed in all talk. Next, the discussion proceeds to answer part (b) of research question 1.

8.12 The nature and dominant types of talk by teachers

(a) Teachers mainly instructed, questioned and gave feedback

Teachers participated in only 7.2% of all talk, and most of this was instructing (46.4%), questioning (22.9%) and giving feedback (9.4%). These findings indicate that the teachers responded to what the children were doing and saying when their role was changed in this study, due to a free play format being used. The changed role of the teachers probably resulted in them instructing the children, which is part of the "choice and control" section of the Falk and Dierking's (2000) Contextual Model of Learning (CML) This overtook other types of talk and ranked as the highest and most dominant type of talk in all talk.

The transcripts showed that, in all talk, teachers' talk mainly occurred at the end, when they spoke in an instructional manner to ask the children bring their play to an end. This is in line with fidelity to the play protocol, in which the teachers were advised not to interrupt the children's scientific play sessions and only to intervene when requested or when they saw that there was a need for it. This finding shows that, when the teachers' roles were changed to allow free play to take place, less talk was done by the teachers and the duration of the conversation and time for talk increased in the 'children only' group compared to a regular science class, in which the occurrence of children's talk was low. The present study's finding validates Stevenson's study (1991), where the duration of time for the 'children only' group was greater than the time in the teacher–children group [see Section 2.5].

These findings agree with Rogers' (2013) argument about the probable outcome if play were to be implemented in educational settings, where it is often viewed through an educational lens, with an increase in outcomes predetermined by adults. Some teachers were observed to find it challenging to set up the context for children's conversations to take place, and to manage the talk that resulted, as reported in Simon et al.'s (2008) study. This accounts for the fact that the nature of the teachers' talk reflected what a teacher would usually do – instruct the children – which was the most dominant type of teachers' talk in this study. The teachers reported that they were uncomfortable with the new play settings [see Section 7.21 (g)] and restricted their repertoire of teaching to initiation, response and feedback (IRF), as in Lemke's study

(1990). This is shown in the findings, where Teacher Instructing the Children (TIC) was seen as the initiating move, along with responding to the children through questioning (response) and feedback (reasoned feedback).

Between the first (S1) and second (S2) scientific play sessions, Teacher Instructing Child (TIC) decreased (from 54.7% to 35.6%) and there was an increase in asking reasoned questions to almost double the number (from 7.1% to 13.5%). TIC may have decreased in S2 because the teachers were getting use to the play protocol and knew what it was essential to say to start and end the scientific play sessions. The teachers were able to avoid giving additional instructions within the scientific play sessions and allowed the children to carry out more free play, according to how they wanted them to be. The teachers knew more about how free play worked after S1, and were now more skilled in walking around to listen to what the children were saying during the session and scaffolding some groups' learning by asking reasoned questions. The increase in questions could also have prompted the teachers to guide the children towards a better understanding of the concepts [see Section 7.21 (c)]. For example, Madam Lee recalled what she did to question the children about linking and making sense of what they were learning. She also talked about not providing answers to all their questions because sometimes the children already knew the answers but were just not confident enough to express them. This could account for questions being higher in the utterances in the findings [see Section 7.12 (a)]. Besides asking questions in order to determine what the children understood, Mr Wong mentioned asking questions to get a feel of how the children were working or thinking in a group [see Section 7.21 (c)].

For all talk, the teachers were involved in talk that demonstrated the role of teachers. Because it is associated with the role of a teacher, Teacher Teaching Child (TTC) should be high, but in this study, TTC was the fourth most dominant type of talk. This contrasts with what a teacher typically does in a regular science class where they teach, instruct, question and answer the children. During free play, the teachers were not teaching most of the time and only stepped in when help was needed.

The teachers' findings confirmed and were convergent with determining what the children were thinking through the questions they asked the children from the integrated findings. As for the rest, the findings point to the teacher's role in a class, instructing, asking questions and giving feedback, and these findings answer research question 1(b). A limitation of this study is that, despite the teachers being assigned to the researcher, some of them were better disposed towards play in the first place, and they might be more likely to participate. This might have resulted in different conclusions than if the teachers were less well disposed towards play.

From this presentation of the discussion, the answers to research question 1(b) were: teachers talked very little and they mainly instructed, questioned and gave feedback in all talk. Next, the discussion will proceed to examine the extent to which both the children and teachers talked about science during the scientific play sessions.

8.2 The extent to which children and teachers talked about science during the scientific play sessions

This section is divided into two sub-sections: Section 8.21 describes the extent to which children talked about science during the scientific play sessions and Section 8.22 covers the extent to which teachers talked about science during the sessions (which was labelled 'Science Talk' in Section 5.2). These findings were used to answer the second research question:

Q2. To what extent do children and teachers talk about science during play?

8.21 The extent to which children talk about science during scientific play

The key findings showed that 24.7% of all talk by children was science talk [see Table 5.4], while 29.0% of all talk by teachers was science talk [see Table 5.10]. Teachers used more science talk than children. Moreover, from the data in Tables 5.4 and 5.10, it can be observed that children's science talk decreased from 31.1% to 18.2% (a decrease of 12.9%), while teachers' science talk increased from 21.3% to 39.0% (an increase of 17.7%) between the two scientific play sessions. The teachers increased their science talk much more than the children from the first scientific play session to the second. This difference could be due to the shortening of the second play sessions for six groups of children from two classes when their science lessons were affected by school activities and greatly reduced in length from 15 minutes to five. The duration of five minutes did not allow the children much time or context to talk very much as they were limited by the time. Nevertheless, the types of science talk that the children engaged in during this study were mainly observation, questioning, teaching peers and exerting their own choice, while teachers mainly questioned, taught and instructed the children.

(a) Children mainly did not talk about science

In terms of the talk's science content, 24.7% of the children's all talk was classified as science talk, meaning that most of the things they said (75.3%) did not pertain to science. Most of the children's non-science talk concerned feedback, questions and observations. Feedback involved responding to other children [see Section 6.21 (b)], questions related to how to do things with the materials or how to get the materials to behave in a certain way [see Section 6.13 (a)], clarifying and getting more information about what they were doing [see Section 6.13 (b)] and observations related to what they saw when interacting with the materials during play [see Section 6.13 (b)]. This demonstrates that the children had freedom to play as they desired and were in control, which is vital in defining play (Hewes, 2014).

Even though many of the utterances did not sound like science, according to Burghardt's (2011, p.10) definition as one of his five criteria to recognise play, they might be 'not fully functional' in the context in which they were expressed, despite the presence of some science content. For example, in an example of non-reasoned feedback [see Section 5.11], the children enjoyed their play and were imagining and giving 'life' to their play. Nick created sounds [see Section 6.13 (e)], such as *"bang, bom"* where "*bang*" was the sound of the two unlike poles meeting head on and "*bom*" was the sound of the repulsion of the two like poles. These utterances coincide with the cultural-historical view of play (Fleer, 2017), where children created an imaginary situation. Although the feedback uttered by the children did not have much meaning of its own on the surface, the sounds they created reflect Erickson's (1994) "emanating model" of learning about magnets, where the magnet emits energy in the direction of its like pole to repel [see Section 6.13 (b)]. Perhaps there was some science content going on when this feedback was made. Although play gave the children the opportunity to develop misconceptions, if a proper intervention was made, their alternative conception could be a source of constructive ideas that could be used as 'seeds' (Preston, 2016) to achieve conceptual development in science.

The findings reported in Table 5.4 show that the children did not talk about science most of the time. In fact, 75.3% of all talk was non-science. These findings for this research question converge with the discussion above, integrating the children's perspectives [see Section 6.13 (g)] with the observation that play is challenging for parents and teachers' perceptions of school science [see Section 7.13 (b)]. If the children did not talk much science in their play talk, stakeholders like their parents and teachers may not be willing to provide free play for the children because the time would be deemed wasted and the children would be seen to have learnt nothing. Play did not manage to provide or warrant the 'learning' the teachers or parents were seeking for the children. The three sets of findings (data from Table 5.4, plus the children's and the teachers' perspectives) converged and confirmed that the children mainly did not talk about science.

(b) Children mainly made observations, questioning and teaching peers when they talked about science

When they did talk about science, the children mainly made observations (6.0%), questioned (2.0%) and taught their peers (2.0%). According to Roth (2005), talking is the medium by which science is done, and in this research study, the children were given opportunities and empowered to talk freely during their free play [see Section 6.13 (a)]. During the scientific play sessions, the children did talk about science, making observations and questioning to gain scientific knowledge in the science lesson. It was visible that the children were engaged in talk, and sometimes science talk, in which cyclic conversations [see Section 5.21] took place in all the groups. Cyclic conversations (see Figure 5.1) took place when all the children in a group participated and took turns to give feedback (reasoned or non-reasoned), make observations or even ask questions on the group topic that they were engaged in at the time. As in turn-taking, the cyclic conversation was considered complete when all the members had 'checked in' and had made his or her comments in the group utterances. These cyclic conversations helped to provide opportunities for everyone in the group to speak up [see Section 6.21 (a)] and work with peers [see Section 6.21 (b)], and could account for many of the children's utterances and contribute to their conceptual understanding of science (Howe et al., 2005; Howe et al., 2000; Mercer et al., 2004).

Although the children did not directly talk about science, talking and thinking together using spoken language during the scientific play sessions was a powerful tool for them to be engaged and understand science in a socially [see Section 6.21], in common with Olusoga and Keen (2019), as they engaged in critical scientific skills such as observations and asking questions. Through talk, children can develop specialised vocabulary and understand current scientific explanations, models and ideas (Fleer, 2013). Moreover, Alexander (2005) argues that talk can promote reasoning in a science class with opportunities afforded by free play [see Section 6.13 (a)–(b)]. Reasoning is essential and is a key contributor to science learning because this is the type of talk that will help to develop children's ability to build scientific arguments (Kuhn, 1993; Snow, 2010; Wellington & Osborne, 2001). Observation and questioning are high, indicating that much talk had taken place. From the findings, there was a visible shift in the person dominating the talk; the children talked more, expressing their voices in the science class. Talking is good because, as Galton and Rudduck (1999) argued, there is limited opportunity for children to explore their ideas or raise questions in a typical science class. With the free play offered in this study, hands-on and minds-on activities took place, which stimulates questions and speculation and could account for the high dominance of science talk involving observation (6.0%) and questioning (2.0%). This is what Wellington and Ireson (2018) argue enables children to explore the materials with freedom [see Section 6.13 (b)], making use of their senses (Braund, 2004) to learn science.

For this section, most of the integrated findings converged to both data sets, except the children asking questions of teachers. The integrated findings show that the children did get a chance to talk when given free play. The three dominant types of all talk (feedback, questioning and observation) and the two dominant types of science talk (observation and questioning) belong to the two-letter coded types of talk in this study. These two-letter forms of coded talk were more dominant than the three-letter coded forms. This might suggest that the children were more involved in talk linked to the personal context of the CML (Falk & Dierking, 2000), under children's motivation and expectation [see Section 6.11], together with their prior knowledge, experiences and interests [see Section 6.12], rather than 'choice and control' [see Section 6.13], which come under the personal context of the CML model but were coded using three-letter codes. Those types of talk coded under the three-letter codes give more emphasis to the child's exertion of self and exercising self in tandem (Child's Own Choice – COC), such as instructing peers and exercising own choice (e.g. "I want to attract the magnets"), where the pronoun 'I' was mentioned and emphasised. With the power relationship minimised during free play [see Section 6.21 (c)], the children could make their own decisions to do many things and engage in free-choice learning (Wood, 2014). In this study, the children started to instruct their peers more as they gained more 'power' and engaged in free play, which converges with the integrated data to identify COC as the fourth most dominant type of science talk [see Table 5.6]. Therefore, the integrated findings converged to confirm that the extent to which the children talked about science would be linked to the personal context based on their motivation and expectations [see Section 6.11] and prior knowledge, experiences and interests [see Section 6.12], before they exercised choice and control [see Section 6.13] to teach their peers during their science talk.

The children reported that play offers opportunities for the teachers to enter their play and be more involved with them, supporting their learning and talk as they were engaged in a reduced power relationship. However, from the data collected and shown [Tables 5.5 and 5.7], this integrated finding was divergent and contradicted the children's perspectives [see Section 6.21 (c)]. Although the children did ask their teachers questions, the findings show that they were asking their peers more questions [see Table 5.5] than their teachers [see Table 5.7]. This could explain why Child's Own Choice (COC), as illustrated by the children expressing what they intended to do, was the fourth most dominant type of talk as the children became more comfortable with the play after some time and started to take control and ownership of their learning in order to make their own choices, and started telling their peers what they were going to do with the pronoun 'I' being emphasised [see Section 6.21 (a)]. This finding is similar to Section 8.21 (b), where the findings indicate that the extent of children's science talk was more dominant in the two-letter coded science talk than the three-letter coded science talk. Two-letter codes are the codes present in Simon et al.'s (2008) original framework which looks at children's talk and engagement in science, allowing the children to carry on with their talk while the three-letter codes are the codes derived from Falk and Dierking's (2000) Contextual Model of Learning (CML), where talk was associated with the choice and control of children, taking ownership of their own learning.

Lastly, from the practice's point of view, the integrated findings show that, when the teachers' roles were diminished to allow the children more ownership through free play, the amount of children's talk increased significantly. This increase in talk was beneficial because, through these opportunities, the children could learn to articulate their ideas with talking, writing, discussion and peer collaboration all contributing to their conceptual understanding of science (Howe, McWilliam, & Cross, 2005; Howe, Tolmie, Duchak-Tanner, & Rattray, 2000; Mercer, Dawes, Wegerif, & Sams, 2004; Snow, 2010). More time for free play could be encouraged to help children learn science in an enjoyable and meaningful way. As the children made observations, asked questions and taught peers, they became involved in exploratory talk (Mercer et al., 1999). They did science talk and acquired valuable skills for learning science.

With the knowledge obtained from these integrated findings, practitioners could note the nature and dominant talk of the children and work on them. For example, the children could be taught how to describe their observations more accurately by using appropriate science vocabulary. Possible question frames could be used to teach the children how to ask better questions and they could be taught how to teach their peers to empower them appropriately. Therefore, alongside the experiences through free play, the teachers' teaching before or after the play sessions could also help to inform their play and reconsolidate their learning. Children would retain the newly learnt science words (Snow, 2010) if these words were embodied with meaning and experiences.

(c) Children found it easy to talk due to play's lower behavioural threshold

According to Howard and Miles (2008), these active participations could be attributed to behavioural threshold theory (see Section 2.18). According to Howard and Miles' (2008) behavioural threshold theory (BTT), the children gained the confidence to participate when they perceived the scientific play sessions as play. The children's behaviour in this study corresponds to those in Howard and Miles' (2008) study because they were readily able to make observations about what they saw without prompting from the teacher, contributing to observations making up the highest percentage by frequency in the children's utterances, making it the most dominant type of talk for science talk. After they had stated their observations, they would decide what they wanted to ask. An example is the sample of utterances from the findings where Dora asked questions, followed by Evelyn and Zoey, one after another [see Section 5.21 (b)].

Dora:	**Anything magnetic?**
Evelyn:	**What happened, Nickel?**
Emily:	That one like magnet.
Emily:	And yesie [sic], yes and yes.
Zoey:	**Why this one cannot?**
Dora:	Try do this.
Emily:	Only the small one
Evelyn:	Ah, ah……
Zoey:	Aeh, it doesn't work.

Child's Questions (QN), T4G1S1

The evidence from the field notes shows that the children became less inhibited and started talking. Even the quietest children talked during the scientific play sessions [see Sections 6.13 (d) and 6.21 (a)]. With their observations and the questions they asked, the children appeared to gain confidence and become more encouraged and empowered to participate even more [see Section 6.13 (a)], so that they started teaching their peers [see Section 6.21a (ii)]. Here, Dora suggested that the group should do something, and Emily added the suggestion to try the smaller magnets to get a more successful outcome [see Section 6.21a (i)]. Thus, the children appeared to perceive the scientific play sessions as play [see Section 6.11 (a)] and participated actively.

Almost all the children were observed to have participated in the play and uttered something, probably due to the cyclic conversations, in which they took turns to talk. This finding contrasts with the children's perspectives that play's nebulous structure causes discomfort for some children [see Section 6.13 (d)], resulting in a divergent discussion. This integrated finding is divergent because, even with the discomfort, the conversation continued as the behavioural threshold level had been reduced by play and enabled the children to talk more easily. Therefore, play afforded easier access and empowered the children to learn [see Section 6.13 (a)].

Next, the framework created in this research study to analyse the science talk of the children has given us more insights into what types of talk took place in a science class when play with free choice was being used. In common with McInnes et al. (2010), the teacher's absence from their proximity during free play allowed the children to perceive the scientific play sessions as play and enabled them to play fully without any restrictions.

On the other hand, this section also shows some convergence with the integrated findings in which the children described having been observed to be excited because play was enjoyable [see Section 6.11 (a)] due to the hands-on nature of the free play [see Section 6.13 (b)]. In line with Howard and Miles' BTT (2008), the free play context had lowered the behavioural threshold (Howard & Miles, 2008) for the children and allowed them to exhibit positive affective behaviours of smiling and laughing (McInnes et al., 2009). Play is enjoyable [see Section 6.11 (a)]. BTT had encouraged the children to participate, motivating them to comment more without much inhibition [see Section 6.13 (a)], raising their voices in the scientific play sessions, allowing everyone to hear what they thought about the topic and their points of view, sometimes with evidence [see Section 6.21a (i)]. These affective behaviours confirm that the children did find it easy to talk when play was provided.

Therefore, in this section, the findings were found to be more divergent, and there was some convergence with the field's observational data when the children were observed to be smiling more [see Section 6.11 (a)] and finding play enjoyable during the scientific play sessions. This is in common with those in the study by McInnes et al. (2009), where laughter could be heard frequently in the audio recordings due to the lower BTT, converging as COC was the fourth most dominant type of talk in the science talk.

However, the integrated findings also give some insights into how some Asian children behave when free play is offered, and the findings may be relatable to children in other Singaporean schools, except the 'all boys' schools which were the school types that were missing from this research study. Although the children were allowed to play freely, it was likely that their prior experiences had played a role in their behaviours. Children's perspectives on what play was, were contrasted with what they had seen as learning in a formal setting (their school). Practitioners should reflect on these considerations when designing play based interventions, to support children's learning and well-being. As the setting for the scientific play sessions had the children seated in groups, Singaporean classroom norms are such that children might assume that they were supposed to obey all the usual class rules and routines. Indeed this may be the case in some other Asian learning contexts. Such behaviour was seen in this study, as the children tried their best to keep the whole group together. This research study has helped to understand the children and can enable adults working with them to be in a better position to guide policy and enhance teaching practice (Waldman-Levi & Bundy, 2016) with informed understanding. Therefore, for practice, the children must understand that they are allowed to play freely without penalty and mingle with whomever they wish during their play as it is child-chosen (Meckley, 2002).

Free play helps to create contexts for children to exercise and affirm group or individual agency (Wood, 2014), and encompasses more children's views. The scientific play sessions provided contexts for the children to become involved in the sociocultural context in their classroom. The integrated findings show that the scientific play sessions offered the children valuable contexts for free play. What the children did in this study matched Burghardt's (2011) criteria for recognising play [see Table 2.1], Meckley's (2002) characteristics of play and Fleer's (2017) cultural-historical view of play. The children were involved in play and did perceive the scientific play sessions as play. Their behaviour threshold (Howard & Miles, 2008) was lowered, and the free play provided them with a space for experimentation, risk-taking and learning.

(d) Children's science talk revealed their types of learning theories for learning about magnets

During the scientific play sessions, the children's utterances via science talk such as observation, feedback, child teaching peers and argument revealed various types of learning theories [see Section 6.13 (c)] on how they learned about magnets, namely a terminology-based explanation (Cheng and Brown, 2010) and chemical composition (Haupt, 1952; Barrow, 1987).

-Terminology-based explanation

This is an example of utterances spoken by a child who had observed what happened and described what he saw by using a terminology-based explanation [see Section 6.13 (c)].

Sam: One of the magnet…. One of the metal ruler[s] can be attracted to a magnet but the other one can't.

Child's Observations (CO), T1G8S1

In this case, Sam used a terminology-based explanation – the word 'attracted'. Sam's intuition and rich imagination enabled him to build a model, in common with Cheng and Brown (2010). The term 'attracted' was used based on the child's prior knowledge obtained from general science lessons in kindergarten and through English lessons in a big book activity in Primary 2 [see Table 1.1].

-Chemical composition

Lydia: **Yah, and this can't stick on this!**
Sam: And the marble cannot, and **the marble cannot stick to the magnet**.
Sam: The **marble can't stick to a magnet**.

Child's Observations (CO), T1G8S1

In the next example, above, the children used the chemical composition theory and the word 'stick'. The word 'stick' corresponds to the attraction of the magnets and implies that there is some kind of chemical inside the magnet. This is in line with what Haupt (1952) and Barrow (1987) proposed as the chemical composition. Although the children were using non-scientific terminology (indicated by the 75.3% of non-science talk in Table 5.4), they used chemical composition in a layman's way to explain what they saw. These children's talk opened up opportunities for both the teachers and themselves as they were able to talk and make their ideas visible to the teacher [see Section 7.21 (c)], who could pick these up during the scientific play sessions while walking around. These utterances would then allow the teachers to know what the children were thinking [see Section 7.21 (c)] and enable the teachers to support their learning further, either by asking good questions to allow them to think more deeply or by intervening to help them to get rid of misconceptions or use the correct scientific terminology.

As well as the theories showing how the children learned about magnets, when they were able to teach their peers [see Section 6.21a (ii)], it can be assumed that the children understood the content necessary to teach them. This could imply that the children's preconceptions or alternative conceptions had already been dismissed and replaced with scientifically accepted ideas [see Section 7.21 (d)], in common with Cheng and Brown (2010), in order for them to be able to teach their peers. This process took time, and the children needed to move ahead and replace the misconceptions with the correct ideas before teaching their peers. However, there is a risk of the children becoming exposed to non-scientific terminology used by their peers, and it took others to correct one another and set them right. An example would be:

Abigail:	Put that non-magnetic thing here.
Joanne:	Non-magnetic
Abigail:	De-magnetic [sic]
Joanne:	No…….!
Shimin:	It is!
Li May:	It is!
Shimin:	I told you one. [sic]
Shimin:	**These both magnetic?**
Li May:	**It attract [sic] with any magnet, is it?**

Child's Non-Reasoned Questions (CN), T2G9S2

In this example, Joanne knew the correct term and was adamant that Abigail was wrong when she used the wrong term, 'de-magnetic'. This helped to correct Abigail [see Section 6.21a (ii)], but when more children became involved, such as Shimin and Li May, who were not comprehending what Joanne was objecting to, they jumped in and argued with their own evidence supporting their point of view. It is interesting to note that they were all right in their own way, but were responding to different aspects. Usually, this would need more talk within the group until they understood why they were objecting to their peers' perspective, which could be constructive.

In terms of the extent of science talk among children, the integrated findings in this section were convergent. From the findings [see Table 5.5], it can be seen that the children did use science talk, spread across 17 different types. Their learning theories can be seen from observation (6.0%), questions (2.0%), child teaching peers (2.0%), child's own choice (1.9%), feedback (reasoned – 1.8%), argumentation (1.0%) and recall (0.9%). The first four types of science talk above were the most dominant, and a higher frequency of such utterances was recorded. Most of the utterances depicting their learning theories for magnets were visible and captured to confirm the integrated findings to be convergent. However, it is also crucial to note that the limitations of the study could sometimes limit this discussion, as previously indicated in Section 8.21 (a).

Some sounds, understood in context, could also indicate to the teachers the types of learning theories, which some would dismiss if they were not scrutinised in context.

In summary, for the extent of science talk among children, the integrated findings in this section are largely convergent and only divergent for the children asking questions and a little on the discomfort with play [see Section 6.13 (d)]. This discomfort was not seen in most children and, as the children reported, it was only visible in some children. Therefore, the children's easier access to play due to BTT (Howard & Miles, 2008) applies to the rest of the children, who went on and talked about observations, making it the most dominant type of talk in the science talk [see Table 5.5].

Conclusion:

A lot of the children's talk was not about science. Nevertheless, play provides a social setting for the children to interact, talk and be supported by their peers and teachers, optimising their learning not only about science but also about social skills (Vygotsky, 1978). Play in science allows science talk to take place and the children can develop science skills such as making observations, being inquisitive to question and applying what they have learnt to teach their peers. Play in science is a good way to allow children to access science more easily because the appeal of play attracted the learners to interact with the materials and each other and learn science without fearing the subject. Play allows children to approach the learning of science as enjoyable and the learning can be targeted at the children's affective domains in order to create meaning and attach meaningful experiences to them. This is important because this experience can help children to retain words linked to the learning of science (Snow, 2010). Play can lead to learning for the children because they accept it as play and do not treat it like a task. The results show that, once children take what they are doing as a task and do not associate it with play, the behavioural threshold increases, and they will find it difficult to continue. It is talk that allows children to develop their use of specialised science vocabulary and their understanding of current scientific explanations, models and ideas (Fleer, 2013). This was seen in this study, where the types of learning theories they used for learning about magnets were revealed.

From the discussions presented here, the answers to research question 2 for children were: they mainly did not talk about science, but when they did, they mainly made observations, asked questions and taught peers. They found it easy to talk due to play's lower behavioural threshold and their science talk revealed the types of learning theories they used for learning about magnets. Next, the discussion proceeds to answer the second part to research question 2, about the extent of science talk by teachers.

8.22 The extent to which teachers talked about science during play

(a) Teachers were doing more science talk

From the findings, the teachers were doing more science talk (29.1% of the teachers' talk) than the children (24.7% of the children's talk). It was observed that the percentage of science talk increased from 21.2% in scientific play session 1 to 39.1% in session 2, almost a doubling in the science talk. As the setup for this study focused on free play and not on written work, science talk was emphasised to both the teachers and the children. Science talk did not need to be secondary in preference, and it was no longer optional, as Alexander (2005) argued. With teachers getting used to the free play setup, the changing role they were experiencing enabled them to start thinking and factoring in more time to make science talk an essential feature of learning science [see Section 7.12 (a)].

The increase in science talk by the teachers allowed them to set contexts for 'exploratory talk' (Mercer et al., 1999). The active exchange of utterances with the children during the science talk helped to provide a strong stimulus for learning (Dawes, 2004). The teachers' mediation through oral language (Fleer, 2013) accounted for the increase in the percentages of science talk. Teachers being the more knowledgeable ones, with more advanced scientific knowledge, used more science talk that helped the children to develop their scientific concepts in the classroom.

For the extent of science talk for teachers, the integrated findings were convergent. Due to the role of the teachers and the subject knowledge they possessed, they engaged in more science talk. It is also evident from the increase in science talk during the second scientific play sessions [see Table 5.10] that the teachers' confidence in using play had made science talking (Osborne & Simon, 1996) easier for them. Moreover, the discussion in the integrated findings confirms that the teachers were engaging in more science talk to provide the contexts for the application of knowledge and scientific language [see Section 7.12 (a)]. The integrated findings were convergent, indicating that the teachers were doing more science talk. Next, the discussion will proceed to the types of science talk that they used during scientific play.

(b) Teachers mainly questioned, taught and instructed the children when they used science talk

Teachers mainly questioned (12.0%), taught (14.0%) and instructed the children (9.8%) when they used science talk. From the findings, the amount of science talk during scientific play session 1 was lower and then increased during session 2. This increase in science talk could possibly be due to the fact that the teachers had got used to the scientific play settings and were also becoming more confident in their subject knowledge about how free play worked. With the teachers becoming more confident about how free play worked, the science talk became easier for them and they started to use more of it (Osborne & Simon, 1996) in scientific play session 2. In contrast with the findings in all talk for the teachers, where instructing the children (TIC) accounted for most of the talk, the teachers used questioning [see Section 7.12 (a)] as the dominant type of science talk, teaching themselves before instructing the children [see Table 5.7]. This was what Madam Lee recounted when explaining what the teachers did to discover what the children were thinking [see Section 7.21 (c)], by questioning and by adding science vocabulary words to teach the children [see Section 7.12 (a)], tapping into what they had learnt in science [see Section 6.12 (a)] and instructing them towards the end if they were lost or needed help to proceed further [see Section 7.21 (b)]. What Madam Lee did align with the findings because play could be open-ended or self-differentiating for different children [see Section 7.13 (a)].

What the teachers did in this study was more of a quasi-guided form of play from their perspective. The teachers were systematic in observing the children and tried to provide a scaffold [see Section 7.12 (a)] for them by questioning or, in common with Fisher et al. (2013), engaged in a dialogic inquiry to gain a sense of what the children already knew [see Section 7.21 (c)], followed by some teaching to help the children proceed with their play [see Section 7.21 (b)]. The guided play supported by the teacher was considered a quasi-form because what the teacher did was to provide scaffolding to the children [see Section 7.12 (a)]. This contrasts with the guided play proposed by Weisberg, Hirsh-Pasek and Golinkoff (2013), whose study focused on children's free play [see Section 7.13 (a)] and not on the teachers directing the children towards the teachers' learning outcomes. The teachers acted as facilitators and provided scaffolding for the children [see Section 7.12 (a)] to enable them to become independent inquirers during their free play. This is what Kogan (1983), Metz (2004) and Sylva et al. (1976) argued to be the role of teachers. There were differences noted between the teachers, whose role in the free play varied [see Section 7.13 (a)] due to their professional knowledge and understanding of children's development, in line with Lim's study (2010).

The integrated data indicates that the type of talk the teachers were involved in was associated with the role of a teacher, whereby they mainly questioned, taught and instructed the children when they engaged in science talk. The convergence of the integrated data shows that the teachers could get to know their dominant types of talk and develop a greater awareness of themselves. As the teachers became used to the free play structure and gained knowledge about it, they gained confidence and increased their science talk, from 21.2% to 39.1%, making science talk easier for them (Osborne & Simon, 1996). With the children talking most of the time, the duration of time for the 'children only' group was greater (Stevenson, 1991), and they were more involved in talk that promoted reasoning in a science class (Alexander, 2005), which is often missing or unheard of (Lemke, 1990; Newton, Driver, & Osborne, 1999). These integrated data show how teachers were able to support the children with good quality questions that may be more open-ended, and made themselves into good role models to follow. Some science vocabulary for teaching or giving feedback could be taught. A more skilled teacher can understand how free play works and can easily enter the children's play as a co-player to support their learning within their agenda.

Conclusion:

The teachers engaged in more science talk that helped to support the children's learning of science, and asked more questions. They also taught the children and guided them in how to do certain things by instructing them. This is important because children's development of scientific concepts in classrooms is mediated through activities and oral language (Fleer, 2013), which is often in the form of the teacher explaining to the children. This means that, during play, the teacher could come in and support the children's learning with the questions they asked, teaching and directing them towards what they were supposed to be learning. The teachers also said that play freed up their time, so they could walk around, listen to what the children said and gain an idea of what they were thinking. Then they could support their learning to design the lessons that followed. Talk resulted in making part of what the children were thinking more visible than in a usual science lesson and allowed the teachers to identify the children's misconceptions and partial understandings. This is helpful because proper intervention and support will result in children's development in science (Gibbons, 2001).

From the discussions presented, the answers to research question 2 for teachers were: they were doing more science talk and they mainly questioned, taught and instructed the children. Next, the discussion proceeds to answer research question 3, about the children's perspectives on play in primary science.

8.3 Children's perspectives on play in primary science

Children's perceptions of play in science were that play is fun, motivating and a way for them to learn science. They also saw it as a place to experiment with ideas and sometimes to confirm what they already knew. However, some children saw it as a distraction from learning or considered themselves too old to play.

In this section, the findings from Chapter 6 (qualitative data) were integrated with the findings from the mixed-form data from Chapter 5 (quantitative data complemented with qualitative data). For most discussions, as the scientific play sessions were carried out during the science lessons, more emphasis will be placed on the science talk discussed in Chapter 5, rather than all talk. However, this does not mean that all talk will be ignored. In some areas, the data for all talk did support and contribute to the arguments in this section and will be used. The analysis and interpretation of these integrated data will be discussed here to show their convergence and divergence and answer research question 3 of this research study:

Q3. What are the children’s perspectives on play in primary science?

From Chapter 6, 19 themes were inductively coded and generated from the children's perspectives. They were classified using Falk and Dierking (2000)’s contextual model of learning (CML), which allows the personal context and sociocultural context to be discussed.

8.31 Play in the personal context

In the personal context, children’s motivations and expectations, prior knowledge, interests and experiences (KIE), and ‘choice and control’ are categories of the key factors from Falk and Dierking’s CML that are discussed here. Some of the earlier themes discussed in Chapter 6 are combined and discussed in the following sub-sections.

(a) *Play is enjoyable and acts as a reward for children to learn science*

Many children reported that play was a fun and enjoyable experience [see Section 6.11 (a)], which had led to learning. The children used words like “fun”, “nice”, “exciting” and “enjoyable” to describe their play [see Section 6.11 (a)]. The definitions given by the children are consistent with Meckley’s (2002) definition of play, where play is child-selected and is fun. Play was fun and pleasurable [see Section 6.11 (a)] for most of the children, in common with those in the study by Diamond et al. (2019).

Play is a biological urge (Brown & Vaughan, 2009) and a need that cannot be ignored. The children in this study reported that they were drawn to it [see Section 6.11 (a)]. The children voiced their need and right to play, in line with article 31 of the UN Convention on the Rights of the Child. The free play in this study created the space and freedom that the children needed to play. This is shown through the findings in the children’s group interviews. The children would revert to play when they felt it was necessary and found the appeal difficult to refuse [see Section 6.11 (a)], using comments such as “mind was thinking of the PS the whole time” (Aishah: 339), “never want to stop the play” (Audrey: 460–461) and “do it ten thousand times” (B2G3: 174) if he could restart time. The children’s perspectives show that their attitude to play was ‘spontaneous, voluntary, pleasurable, rewarding, reinforcing and autotelic’ according to Burghardt’s criteria for play (2011, p.10) [see Section 2.11]. This can be seen in the finding that the children could not offer any reasons for why they wanted to play. There were no reasons, but they still felt that need or urge, in common with Brown and Vaughan (2009). The children welcomed play as space, freedom and time factored and provided in the form of free play [see Section 6.13 (a)], in common with what Jamison (2004) proposed about play. The children also found themselves laughing during the scientific play sessions and highlighted that they had laughed more than they did in a usual science lesson. These positive affective behaviours of smiling and laughing were also found in McInnes et al.'s (2009) study when children were involved in play.

Play motivated the children and acted as a reward, where they were observed to have repeatedly played as displayed. This is what Athey (1990) describes as 'behaviour schemas' and Csikszentmihalyi and Hermanson (1995) describe as the 'flow of play'. The children strongly desired to engage in a highly enjoyable [see Section 6.11 (a)] and repeated activity. They were observed to be motivated to explore new materials and ideas [see Sections 6.13 (a) and (b)] quite confidently through the free play format and were seen to engage longer when they repeated their play activity, in common with Iverson (1982). An example would be Audrey, who said she felt less sleepy in a scientific play session than in a usual science lesson. She argued that there were "so many other magnets" that she could try (463) [see Section 6.11 (c)] that she did not want to stop playing (460–461), an indication that she was in the 'flow of play'. On the other hand, for some other children, play motivates them and helps them to escape from the usual lessons (e.g. Nurul) [see Section 6.11 (c)], which they might not like, while Li Min found play to be a form of reward [see Section 6.11 (d)] after all the writing and being tired in the class, but she could still enjoy play.

In Section 8.31 (a), there were five themes covering the motivational and expectational aspects of play in the personal context. The quantitative data that could be merged here would be the high frequency counts for the number of utterances for the two scientific play sessions: session 1 (7894), session 2 (7759), with a total of 15 653 counts of talk [see Table 5.1]. The children were engaged in play, and they talked continuously because they had enjoyed it. These two pieces of data from the scientific play sessions, when integrated with the themes of the children's perspectives in Chapter 6, confirm the integrated findings to be convergent. Play could be fun and enjoyable [see Section 6.11 (a)] and the children felt rewarded, resulting in such a high count of utterances.

(b) *Play can be limited by the adults' set of unwritten rules*

An interesting finding in this study was that play initially motivated the children to get involved, but the teacher's unexpected outcome and response had left the children puzzled [see Section 6.11 (f)]. In this example, the children's perspectives differed from the teachers' perspectives on play and confused the children. In this case, Maya dropped a magnet, and it became demagnetised. Seeing this, she became very excited and wanted to show it to her teacher for reassurance because she had managed to test and prove what she had learnt from the chapter on ways to demagnetise a magnet. However, she was shocked by the teacher's response. Instead of receiving praise, she was reprimanded by the teacher for 'spoiling' the magnet. This teacher's reaction confused her because she had thought that her teacher would be happy to see that she had understood demagnetisation, but this was not the case.

This was a good example of a discrepancy where an adult and a child differed, because they had perceived play and learning differently. This is in line with Pyle and Alaca's (2018) study. How the children defined their perceptions of play in the study differed from how an adult defined it (Fisher et al., 2008; Karrby,1989; Keating et al., 2000; Robson, 1993; Rothlein & Brett, 1987; Sommer et al., 2010). Therefore, for the data to be ecologically valid, Barnett (2013) recommended that children's perspectives should only be collected from the children themselves, and not from adults.

This study centred on children, and measures were put in place to ensure that it was children's perspectives that were collected, directly from the children. Listening to the children's perspectives via the group interviews without the presence of their teachers allowed them to be more comfortable and revealed to the researcher how they felt and thought. These interviews can then help us to understand more about the children and help to incorporate play into lessons to foster more active participation, which Miller and Kuhaneck (2008) promoted and Skamp (2012) argued can influence teaching practices.

Besides the conflicting perspectives on play observed between the children and their teachers, play could also be limited by other adults, their parents. Whether children are able to perceive play as motivating or not can be affected by their parents' perspectives [see Section 6.13 (g)]. The findings showed a mixture of varying views among the children's parents, ranging from being against it and stating that 'play is not learning' to parents who supported and encouraged their children to play to learn. Among parents who were working very hard for a living and had no time for their children, their children got to play a lot as they were unsupervised. However, the parents who were more interested in their children's studies tended to suppress play and kept asking them to study. The interesting part of these findings suggests that the parents who stopped or discouraged their children from playing were usually the mothers, while some fathers viewed play as critical and as having an impact on the children's learning and development, in common with what Gunnarsdottir (2014) argued. These fathers believed in science being fun because it involves many experiments and the children can "play a lot of things" (646–647). These fathers encouraged their children to learn science by doing experiments and playing.

In these findings from the children, they reported that the positivity and involvement of their fathers had directly influenced them, increasing their interest in science and making them more motivated in school. Although the intangible nature of play, which cannot be quantified, as reported as Fleer (2107), has masked the impact of play, any positive support such as that from the parents or teachers [see Section 6.13 (g)] could change adults' perceptions of play because play does motivate children.

In this section, Section 8.31 (b), this particular aspect of adults opposing their children's play could not be specifically accounted for through the transcripts of the group utterances. Integration of the findings was not possible here, and the findings were only on one plane that could not be confirmed or refuted.

(c) *Play is dependent on children's prior knowledge, interests and experiences (KIE)*

In this study, the findings showed that children's prior knowledge, interests and experiences (KIE) impacted upon their perspectives on play in primary science (see Section 6.12). The sources for children's KIE mainly come from school and other sources beyond school settings, such as science centres, books, media, home or the people they interact with, such as parents, siblings or peers outside class. Prior interests informing children's choice come from their cultural background, gender, interests and personal preferences. These findings coincide with Broadhead et al.'s (2010) argument that children bring with them different prior knowledge, exposures or experiences which are culturally influenced and informed by factors beyond school settings.

The two aspects of prior knowledge and experiences shared similar sources both in school and outside school. In school, what the children shared was standard and what happened during a standard science lesson was that they gained their knowledge from the teachers. An interesting example is where Li Min, having been taught a concept, was very sure of it [see Section 6.13 (c)] and remembered it well. What the teacher had taught in the class had an impact on her thinking process, and when unexpected things happened, she was able to stand firm on her feet and deduce from her observations that the horseshoe magnet she was using was faulty and had become demagnetised [see Section 6.13 (e)]. She was able to carry out a series of actions to test her hypothesis [see Section 6.13 (b)] and confirm her conclusion. This was made possible by the play she was engaging in, and her interactions with the materials helped to confirm her prior knowledge [see Section 6.12 (a)]. Play has some relationship to science. When Li Min first experienced play, it was a novelty to her, and she was trying to make sense of it and relate it to what she already knew about magnets. She was in an 'assimilation' process, in common with Scaife (2018). She observed the conflict between what she knew and what she observed and started to make sense of it. She went through 'accommodation' and finally concluded that she was right and learned something [see Section 6.13 (e)].

(i) *Play is informed by the children's prior knowledge*

In terms of children's prior knowledge [see Section 6.12 (a)], the nature of play was dependent on school and other sources outside the school setting. This could include books, the media, science centres, peers, siblings and parents. The interviewed children indicated how these sources had informed or taught them, and they used play to verify what they had read about [see Section 6.12 (a)], such as Kai Cheng, who shared how he had “tried the stroking method” (898–899) and the demagnetisation of magnets by smashing them (903–906) so that “the magnetism will go out” (907). The ‘emanating model’ proposed by Erickson (1994) was used here, where the magnet’s magnetism was perceived as being like energy emitting from the magnet. Although there was an alternative conception surfacing, such as the magnetism ‘going out’, the important thing was to provide the children in this study with the opportunity to see for themselves via an authentic first-hand science learning experience [see Section 6.13 (b)], to get them engaged as learners in the process first. This study achieved this, in common with Driver and Easley (1978) and Duit and Treagust (1998). The presence of the alternative conception was taken note of and dealt with later. With that in place, play had enabled the children to reflect upon their learning through scientific inquiry and to make sense of what they had read or learnt, engaging them as scientists [see Section 6.13 (a)], which is in common with Ashbrook (2010).

(ii) ***Play is informed by children’s prior interests***

In terms of prior interests [see Section 6.12 (b)], the children’s choices about how they played could be linked to the cultural environment where they were being brought up, their gender, specific interests (such as particular interest in a subject like chemistry) and personal preferences. These were generally linked to the children’s everyday lives and what they came into contact with in terms of cultural beliefs. The ways in which the children played were good representations of what informed their choices. For example, there was Mindy, who had the personal belief that she must show respect to the materials she was working with, making the statement that she should not *“*make fun of a magnet, or else it won’t work*”* (289). Next, there was Wei Ming, who engaged in an imaginary play and used the magnetic beads to make a monk’s prayer bracelet, which he claimed were ‘Buddha beads’ (346–355). His play involved creating a chain with unlike poles facing each other to cause them to attract and form the chain. Although his play did not look as though he had learned anything on the surface and was just ‘fooling around’, when questioned in the group interviews, he elaborated on what had informed his decision. How the child constructed knowledge, in this case, was complex and involved an interaction between his intuition and conscious elements of what he was familiar with, seeing it and linking what he knew before the play to the play itself. This is how Preston (2016) argued that children construct their knowledge.

As for gender-informed play, the children were spotted making things which they called ‘girly’ (e.g. a necklace) and ‘boyish’ things (e.g. toy cars). Some children were making things linked to their gender, although most could play in a gender-neutral way. Special care was put into ensuring that the play was examined carefully and equally (e.g. not gender biased), in common with Ailwood (2010), Blaise (2010) and Grieshaber and McArdle (2010).

Lastly, in terms of specific interests and personal preferences, the children were shown to have turned towards their personal interests, such as chemistry, to learn more [see Section 6.12 (b)] and to have approached play differently. Some children in the findings wanted ‘guaranteed fun’ with strong magnets, while others were more adventurous and tried all the different types of magnets [see Section 6.12 (c)]. Play was child-chosen and not fixed, as Meckley (2002) proposed. The children in the study were able to choose freely [see Section 6.13 (a)] and learned [see Section 6.13 (c)] in non-threatening surroundings, allowing them to try things out through trial and error [see Section 6.13 (a)], gaining insights into their learning, in common with Fatai et al. (2014).

(iii) ***Play is informed by children’s prior experiences***

Children’s prior experiences [see Section 6.12 (c)] can come from school, contexts out of school and from shared experiences. The findings show that children’s play was informed by prior experiences during previous science lessons in school. The children experienced things for themselves and remembered details like which were the strongest or the weakest magnets. They also remembered what the teachers had taught them about magnetism and other topics, such as closely related materials, and tried to apply them [see Section 6.12 (c)]. The findings show that children’s perspectives on prior experiences in contexts out of school came from home and science centres. The findings include the example of Sam, who had a change in conceptual understanding when he linked his play experiences at home [see Section 6.13 (f)] with school, learning about the concept of ‘repulsion’, and Mindy with her increased understanding and confidence spoke up and tried to negotiate with her mother to convince her to play at home [see Section 6.13 (g)], as endorsed by the school. Lastly, in terms of shared experiences, the children were found to have joint and shared memories accumulated from school science lessons or play episodes [see

Section 6.12 (c)], which, through gestures or simply encouraging their peers to recall, were tagged with emotions and fond memories. These actions taken by the children during their free play resulted in their affective domains being targeted, and this helped them to learn science because the affective domain is closely linked to the cognitive domain, as argued by Wellington and Ireson (2018).

Interpretation of the integrated findings [Sections 8.31 (c) (i) – (c) (iii)]

For the three parts [Section 8.31(c) (i) to Section 8.31 (c) (iii)] that were associated with play that was dependent on children's prior knowledge, interests and experiences (KIE), the integrated findings do not confirm the quantitative data. Children's recall (CR) was the twelfth most dominant type of talk in their science talk, at 0.9% [see Table 5.5], the sixth least dominant type of talk out of all 17 types. This could be due to how the children talked. When these children based their play on their prior KIE, they did not necessarily verbalise what was on their minds. Some children did verbalise it, and the data was captured, but this does not mean that not being captured indicates the absence of recall of their KIE. Therefore, if we just base our conclusion on the integrated findings, the findings were divergent. Next, the discussion moves on to the children's choice and control within the personal context.

(d) Choice and control of the child

From the findings in Chapter 6, children's perspectives on play in science were that play enables free-choice learning, play is a context that empowers children in the freedom of choice to explore and learn and play provides them with an authentic tactile experience [Section 8.31 (d) (i)] which enables the testing of ideas. For some children, play is learning or not learning [Section 8.31 (d) (ii)], and the nebulous structure causes some discomfort for some children [Section 8.31 (d) (iii)]. Play encourages creativity and builds children's problem-solving skills [Section 8.31 (d) (iv)]. Besides playing in school, play can also take place at home, where learning is extended [Section 8.31 (d) (v)].

(i) *Play is a context that empowers children in the freedom of choice to explore and learn and provides them with an authentic tactile experience*

Free play in this study provided learning contexts that enabled the children to exercise or affirm group or individual agency, as Wood (2014) proposed. The freedom of the child to choose how to play is an essential factor in its success and for it to be considered play by the children, as argued by Stone et al. (2019).

This study has shown that free play motivated the children to explore the new materials presented to them, in common with Henniger (1987). When given 15 minutes to interact with the materials, the children became substantially engaged with a task for much longer than 15 minutes, as discussed by Iverson (1982). In this study, the children were seen to be constructing knowledge [see Section 6.13 (c)] when they were inquisitive, explored using many senses, and interacted with the materials provided [see Section 6.13 (b)] and their peers [see Section 6.21 (a)]. They also discovered more about new things [see Section 6.13 (a)], in common with Braund and Reiss (2004), with their intuitive and conscious elements interacting at the same time, agreeing with Preston's (2016) argument. During free play, the children reported that their affective and cognitive domains were achieved when they said that they had enjoyed playing [see Section 6.11 (a)] and that play had allowed them to develop a deeper conceptual understanding of the topic [see Section 6.13 (c)]. Play targets the children's affective domains, and this often leads to the child being inquisitive. He or she will explore by using his or her senses and finding out more about new things or going deeper into a more complete conceptual understanding (Braund & Reiss, 2004) [see Section 6.13 (c)]. This is congruent with Wellington and Ireson's (2018) argument about what could be achieved through free play as the children became empowered.

Furthermore, one child commented that play in science means "extra, extra scientist fun" (497), and that play had allowed her and her peers "to explore science" (683). Hayden summed up play as "experimenting", "discovery, like having fun with those materials" that they were supposed to learn about (301–303). Play made learning more accessible, in line with Howard and Miles' (2008) behavioural threshold theory (BTT) and allowed the children to practice more within authentic contexts. Sarah commented that she preferred play and learning to be "merged together" (269–270). Exploratory play, which had no agenda in the children's free play, took place in this study and resulted in scientific development among these children as they explored (Johnston, 2014) through the playful elements afforded by play. Cognitive value in science was achieved by the children (Johnston, 2014; Stone et al., 2019).

The qualitative findings can be merged and integrated with the quantitative findings found in Chapter 5. Using the Primary Science Talk with Play Framework (PSTPF), there is a theme that codes for the choice of the child (COC), meaning that the child exercises choice and control. This theme talks about the empowerment of children and was trackable by the personal pronoun 'I' during their scientific play sessions. From the all talk findings in Chapter 5 [see Table 5.1], it can be seen that choice and control were less dominant than essential types of talk, such as questioning, observation and feedback. However, in the science talk, choice and control were more dominant. The findings in this study suggest that choice and control were one of the dominant types of science talk (the fourth most dominant type of talk at 1.9% if we combine both reasoned and non-reasoned questions) that were prominent after the children became used to their play and started exerting themselves [see Table 5.5]. When the children became inquisitive, they would try to discover more by using their senses, which could explain why observations were the most dominant type of science talk, at 6.0%, and questions were the second most dominant, at 2.0%. These quantitative findings merged with the qualitative findings and confirmed the integrated findings to be convergent, that play is a context that empowers the children.

(ii) ***Play is learning or not learning***

In this study, free play was planned [see Section 6.13 (b)], and the children interacted with the materials and their peers. They tried to make sense of what they were playing with and to find connections through their observations and questions. Play was a cumulative process by which the children were learning as they made meaning and found connections, in common with Falk and Dierking (2000). Children in this study were behaving like scientists when they engaged in the processes of making observations and asking questions [as shown in the findings in Section 6.21 a (iv)], a similarity drawn from Ashbrook (2010). The children reported that they had learnt [see Section 6.13 (c)] through observations, gestures and conversations with their peers, which is in line with Falk and Dierking (2000). Additionally, some children also thought of play as a tool to help them remember things better and answer questions in their tests.

According to Laszlo (2004) and Johnston (2014), science has some play elements, but this view was rejected by some children, who commented that play was not learning [see Section 6.13 (c)] and that when you played, you were not learning [see Section 6.11 (e)]. Some children, such as Emily, commented that, if she played, she would “do nothing” (459) [see Section 6.11 (e)], and Lydia was concerned about having less time to enjoy while playing because playing would result in less time to learn more things (79–80). Li Min felt that play was not learning [see Section 6.13 (c)] and she considered the time after playing to be the “time to learn”. Play provided freedom for the children and empowered them [see Section 6.13 (a)] to come up with ideas (C4G1S2: 342) on a safe platform (C4G1: 346). Therefore, the perspectives of these children would suggest that free play was not for them. We could apply Fisher et al.’s (2013) study (discussed in Section 2.31 ‘Guided Play’), where the findings indicated that some children learned more within the scaffolding provided by an adult in a playful context, rather than just free play alone [see Section 6.13 (d)]. Guided play, or purposeful play with ‘visible’ learning outcomes, might have encouraged these children in this study, in this cultural setting, to think that play was learning with something measurable to be seen (Fleer, 2017). This is consistent with what Gunnarsdottir (2014) described as the intangible nature of play, which masked the impact of children’s learning and development and why, sometimes, play was not implemented for some groups of people [see Section 7.21 (a)].

The children defended their point that they had learnt something in science [see Section 6.13 (c)] by giving evidence, such as Michael, who had experienced a conceptual change for the topic of magnetism [see Section 6.12 (c)]. Some children also shared their views that if they could go home and continue playing [see Section 6.13 (f)] as they did in school, asking and answering questions on the topic, this showed what they had learnt. The child’s autonomy and free-choice learning context in school, and extended back home [see Section 6.13 (f)], had helped to engage the child in “building larger conceptual structures and intuitive theories” and supporting higher-order generalisations (Sim & Xu, 2017, p.642). The explanations, accompanied by hand gestures, were examples suggesting that the children did understand what they had learnt in science [see Section 6.13 (c)] and were confident about demonstrating it. It was also the children's explanations of how they had come up with certain things that informed others that they had actually brainstormed and applied [see Section 6.12 (a)] what they had learnt from the topic to put it into action [see Section 6.13 (a)]. This finding is consistent with Stone et al.'s (2019) study, where the play group children were more engaged in the activities and were more confident in using the materials to demonstrate than the children who did not play. Free play was suitable for these children [see Section 7.21 (a)], and provided them with a high level of pleasure [see Section 6.11 (a)], which simultaneously motivated them to continue playing (Fronczek, 2009).

Children's perceptions of whether or not the session they were entering was play had an important impact on their behaviour threshold (Howard & Miles, 2008). The child would have his or her behaviour threshold (BT) decreased and found it easier to approach the tasks with confidence and more fluency if he or she perceived it as play (McInnes et al., 2009). In contrast, those children who disapproved of play and perceived the scientific play sessions as tasks rather than play, found it more difficult to enter. For example, Benjamin's interest dropped because he found the free play in science a bit difficult [see Section 6.13 (d)]. These children did not find play to be fun as the challenge of free play could be viewed as 'a task' to them. Because they were not open or used to the format, they struggled and boredom could set in, in common with Falk & Dierking's (2000) argument. Play is fun if the children can enter into it based on their prior knowledge [see Section 6.12 (a)] and the perception that it is play. The children will be self-motivated because they can exercise choice and control over their learning (Falk & Dierking, 2000). The findings revealed that the children who were pro-play were those who had perceived the scientific play sessions as play and had entered into it with the appropriate level of reduced BTT.

(iii) Play's nebulous structure causes discomfort for some children

The findings show that some children expressed disapproval of free choice and preferred things to be done in steps and be guided [see Section 6.13 (d)]. For example, Hayden claimed that he was not used to the method (free play) and initially resisted it because he was 'lost'. What some of these children wanted was guided play [see Section 6.21 (c)], where an adult would come in to provide some scaffolding or help.

The children could then begin their play to achieve what they perceived as the learning outcomes of the scientific play sessions, in common with Weisberg, Hirsh-Pasek and Golinkoff's study on guided play (2013). It is also probable that these children had perceived the scientific play sessions in the present study to be non-play (because it was conducted in a classroom or science laboratory) and had treated them as formal lessons with structured and guided steps. As in McInnes et al.'s (2013) study, there was a discrepancy between how children and adults classified play and non-play.

(iv) *Play encourages creativity and builds children's problem-solving skills*

If the children were set to believe that the scientific play session is play, they would be able to exercise free-choice learning, which empowers them to take more active ownership of their learning [see Section 6.13 (a)] and be creative in applying scientific concepts to their play (such as the 'Mario' car or the 'Snatch' game that the children came up with and designed [see Section 6.13 (e)]). Similarly to Fisher et al.'s (2013) study, the findings in this study showed that the children were full of creative ideas [see Section 6.13 (e)] and moved in and out of their imaginary play, creating stories and sound effects to play, as in Fleer's (2017) 'cultural-historical view of play'.

In this study, the findings showed that free play provided many opportunities for the children to be curious and to explore [see Section 6.13 (a)]. This excited them about their learning of science, which is in common with Johnson et al. (2005). There was a noticeable increase in interest in science among the children, who moved from 'hating science' to 'liking science' as they found more meaning in learning it and found it more manageable [see Section 6.13 (a)]. An example is Abigail, who had changed her mind from 'disliking science' to 'liking science' because she felt that "with that kind of thing" (like the PS in this study), science was "easier now" (748). This is a concern for science educators because these children had been learning science as a formal subject for less than a year (with a range of 6–9 months) and already we were losing them. The findings showed that some of these children were able to 'reverse' their decisions about 'hating science' to 'liking science' after being involved in the free scientific play sessions. In this study, free play promoted excitement [see Section 6.11 (a)] and engagement with science, in common with Saracho and Spodek (1994) and Smith (2010).

(v) *Play can allow the extension of learning at home*

As well as learning in school, the findings in the study show that some children had gone beyond school and continued their play at home [see Section 6.13(f)]. Some were lucky and had the materials to interact with, and there were also some who had the materials but chose not to play with them. Some were disadvantaged by the lack of materials at home. In this study, Madam Lee helped to bridge this disadvantage and gave all the children two magnets to take home to explore. There were examples of children who recalled their prior experiences in school and continued their investigations at home; for example, Mira. She went home and searched for some old Singapore coins and tested them. As she had been given the new Singapore coins to try in school, she was curious and investigated at home. That was when she realised that the old coins were not magnetic. These children went home to either play independently or demonstrate to their family members what they had learnt or discovered.

Interpretation of the integrated findings [Section 8.31 (d) (ii) – Section 8.31 (d) (v)]

In Section 8.31 (d), only part (i)'s qualitative data could be merged with the quantitative data. For the rest of the section – 8.31 (d) (ii) to 8.31 (d) (v) – there was no quantitative data that could be merged with the qualitative data to give us integrated findings. The question of whether play is learning or not could not be determined from the 17 types of talk. The discomfort with play, creativity, problem-solving and the extension of learning at home were intangible feelings that the quantitative data could not quantify. Therefore, for Section 8.31 (d), only the integrated findings for Section 8.31 (d) (i) confirm the findings to be convergent, and the rest did not have any corresponding quantitative parts to confirm or disconfirm their convergence or divergence. Next, the discussion moves on to play as a social activity within the sociocultural context.

8.32 Play within the sociocultural context

In this study, the findings showed that the children talked more than they were usually able to talk in a science class and were involved in group play most of the time, although they were not instructed to remain in their group to play. Conversations were heard during the scientific play sessions. These conversations are essential features of free-choice learning, and can make key contributions to the learning of science, according to Braund (2014). However, because the children started as a group, with a basket of shared materials, they kept to their group play due to prior experiences of repeated classroom norms. The children saw play as a form of social mediation by their peers [see Section 6.21 (a)] and building their social skills [see Section 6.21 (b)]. In their learning of science, the findings indicate that mediations were also conducted by their teachers [see Section 6.21 (c)] as the power relationship decreased with play.

(a) ***Play is a way for children to interact with their peers***

In the findings presented in Chapter 6, children reported that they were able to work in groups during the scientific play sessions and used play as a medium to explore, interact and communicate with their peers. Play worked as a platform where children could take on different roles and experiment with different perspectives (Bateson, 1955). These different roles were how the children managed to help their peers, such as: giving ideas, teaching them, finding companionship and asking questions [see Section 6.21 (a)]. The children learnt to be cooperative and get along with others through play, in common with Humphreys and Smith’s (1987) proposal. They started “to make friends” (Mandy: 158) and “learn more about each other” (161–162) in order to have companionship. This is what McInnes et al. (2009) argued about play and its relationship with behavioural threshold theory (BTT). Similarly, the children in this study were observed to be more on task, persistent in solving a problem and achieved fluency in their play as they worked in a group, and not alone.

The children were able to engage in what Gopnik (2012) described as a highly social endeavour where they got to mingle with real science, but in a play format. Through the social activity of play, the children spoke to one another using a variety of types of talk, in common with Scaife’s (2018) proposal. The children were engaged in free scientific play sessions and this, according to Wellington and Ireson (2018), is important for children’s learning in science. The children were motivated and their interest and engagement is shown through the cyclic conversation, observations and questioning shown in Chapter 5. They did report that they were able to work well with one another to have a common goal to build something [see Section 6.13 (a)] or problem-solve difficult situations [see Section 6.13 (e)], leading to a better learning experience. The children reported that most of them preferred to ask their peers when they encountered questions because they found them “explaining it easily” and “step by step” (C3G2S5: 359–360) through the group interviews. Peers offered these children opportunities to explore their ideas or raise questions during play, something which Galton et al. (1999) argued is limited in a typical science class. Next, the discussion moves from the roles of children’s peers to what play provides as a social activity.

The quantitative findings show that the children interacted and helped their peers by asking questions, giving ideas and teaching each other through the high-frequency counts of questions (6%), feedback (1.8%) and child teaching peers (2.0%) [see Table 5.5]. Through these three types of science talk, which were dominant (the first four most dominant types of science talk), the children talked during their scientific play to carry out mediation. Therefore, these integrated findings confirm the merged findings to be convergent and play as a way to achieve mediation by their peers.

(b) ***Play is a place where children build their social skills***

In this study, the children were reported to be very pleased with how play enabled them to work in a group and build positive peer relationships [see Section 6.21 (b)]. An example would be Carmen, who claimed that play was “actually teamwork” (187). These findings are consistent with the argument that Hartup (1993) and Rubin (1990) made about how play contributes to positive peer relationships.

However, there were cases where some children yearned for an independence that was denied during the scientific play sessions. This is because the free play setting in the class had caused them to perceive the scientific play sessions as group activities and they would always try to keep the whole group intact and not allow any members to wander away, in order to abide by the rules of the class routines. They were worried that they would be scolded by their teachers if they failed to abide by the rules and were unable to work in the group they had been assigned. This shows that the children were well trained on the procedures and routines of the classroom, and if instructions were absent, their prior knowledge of how it was usually done would be activated. The reasons the children reported for wanting to play alone were to avoid conflicts, fear of judgement by their peers and a desire for independence [see Section 6.21 (b)]. This notion of playing alone was viable and could be encouraged. The child should have the final say or the agency to decide how he or she wants to play as these children did not come to school or into a social activity like play as a blank slate (Pine, Messer & John, 2001). The children had come to the free scientific play sessions with a wide range of prior experiences [see Section 6.12 (c)] and prior interests [see Section 6.12 (b)]. These experiences could inform the children's ideas about science and enrich them with new experiences obtained from the free scientific play sessions. Play in this research study was a place where the children could play freely. Besides gaining knowledge and experiences, the children also built their social skills (Fatai et al., 2014). Next, the discussion moves from the children to the teachers, who were also involved in mediating the children.

In part (b), the children learnt to build social skills and worked in a group most of the time. Therefore, this act of the children holding their peers intact within a group format during play could account for the high percentage of utterances such as observing (6.0%), questioning (6%) and giving feedback (1.8%) in science talk, due to the cyclic conversation that took place [see Table 5.5]. Child teaching peers (2.0%) also scored highly, which could have contributed to how the children interacted with their peers. Based on these findings, it can be seen that the integrated findings confirm the findings and the outcome shows that the interpretation of the integrated findings was convergent, that play is a place where children build their social skills.

(c) ***Play offers opportunities for teachers to interact with children in reduced power relationships***

For this study, the power relationship between teachers and children in the class during play (Grieshaber & McArdle, 2010) and the distance of the teacher's table away from the children were reasons the children reported for why they did not ask the teacher for help while they were playing. The children explained that they feared asking questions because they would feel embarrassed if the teachers had already explained, and that they could not understand because the teachers were explaining too fast. Therefore, the children's choices were linked to 'conflict, negotiation, resistance and subversion' (Wood, 2014, p. 4), whereby the children had to go through an internal or external conflict to negotiate for what they wanted, accepting or resisting whatever came along the way. Their choices were reliant on the power relationships between their teachers and them (Wood, 2014).

On the other hand, some children preferred the scientific play sessions, explaining that the teachers were more accessible to them, in their vicinity when they needed them with the materials right in front of them. With a smaller audience present, they felt safer when asking questions and it was not so embarrassing to do so. This was an issue that is real in an Asian society, the issue of 'face'. The children expressed their confidence about asking more questions in a small group setting than a whole class setting. This finding is related to the cultural and historical context of the country, as Chin (2007) argued. To understand the children's perspectives, an awareness of their learning environment and contexts and the interplay between these and the cultural and historical aspects in that particular country is deemed essential.

The children reported that the roles of the teachers during scientific play sessions were to answer questions, ensure safety and provide scaffolding to help them achieve (such as offering guided play, as argued by Weisberg, Hirsh-Pasek and Golinkoff, 2013), which they needed to achieve in a purposeful play format. The teachers facilitated and asked questions to help the children learn more and encourage them. They could share their findings with their teachers and learn about the concepts covered in the lesson when the teachers explained it. The children were helped by their teachers and the teachers also got to know more about the children, their misconceptions and what they were thinking. In some groups, the teachers entered the children's play and became co-players or invited the children to seek reassurance from them. In this sociocultural context, play enabled the teachers to support the children's learning in the role of a teacher and the additional role of a co-player in this reduced power relationship.

For this section, there were many aspects of the quantitative findings from Chapter 5 [see Table 5.6] that merged well with the qualitative findings to inform the integrated findings. Although the teachers' roles were diminished in the free play settings, they still performed them well, with asking questions (12%), teaching the child (4.1%), instructing or guiding them (2.8%) and offering help to the child (2.4%) being the first four most dominant types of science talk. As the teachers tried to help the children, they also provided extra support to encourage (2.2%) and be part of the children's play by providing reassurance (2.0%), the fifth and sixth most dominant types of science talk to the children.

This strong presence in the data integrated well with the qualitative findings to point the whole discussion for part (c) towards a high convergence of both sets of data. The interpretation of these integrated findings confirms the findings to be highly convergent. In conclusion, all the integrated findings in the three subsections of play involving the sociocultural context were convergent.

Conclusion:

For Section 8.32, on play in the sociocultural context, it is possible to merge the qualitative and quantitative findings from all parts (a) to (c) to have an integrated findings' discussion. From these integrated findings, it can be seen that the children's perspectives mainly converged on play being enjoyable, empowering them, and that play is a social activity where the children are engaged in social mediation with their peers and their teachers, building their social skills (Hartup, 1993; Rubin, 1990). As prior knowledge, interest and experiences were intangible items that could not easily be quantified in the free play, these were the two data sets that failed to merge. The integrated findings support the theory that play is a social activity, enjoyable for the children (Diamond et al., 2019). They perceived play as play, found entering play easy and approached the tasks with confidence (McInnes et al., 2009), or demonstrated using the play materials (Stone et al., 2019). They were more engaged (Stone et al., 2019), and positive behaviours such as smiling and laughing were observed (McInnes et al., 2009) as well as being heard on the audio. The children also reported that they had laughed more in the scientific play sessions than in their usual science lessons. These positive behaviours were linked to the behavioural threshold of play (Howard & Miles, 2008).

The discussions presented here have answered research question 3 from the children's perspectives by the themes that were generated and classified under the personal and sociocultural contexts. For a minority of children, play could bring about some discomfort due to the nebulous structure and they did not consider it to be learning because they perceived play to be a task. This resulted in them not being able to enter play easily. Moreover, these children also perceived play as a waste of time, or that it was only for young children. In contrast to most of the other children, play is enjoyable and acts as a reward to the children. Play might be limited by the adults and can be dependent on children's prior KIE. Play sets up many contexts for the children to be empowered, learn and be creative. Play can allow learning to continue at home and be socially mediated in schools by the children's peers and teachers. The children's perspectives were critical to allow their voices to be heard in this section and for research question 3. Once they did not perceive the play as play, access to it would be denied, and they might find play daunting.

8.33 Integrated findings informed by theory and practice: Children's perspectives

These integrated findings inform practice greatly because from these data, it reconfirmed that scientific play is free play (Lim, 2010) and that play is enjoyable for children, even in middle childhood. Although some children commented that play was for young children, they could not explain why they were attracted to it. Play can be for all ages and used throughout life (Else, 2009). It is a plausible pedagogy to be used by practitioners due to the many advantages that come with it. Free play is best designed with children's perspectives in mind (Pyle & Alaca, 2018). Free play provides rich contexts in which children can be empowered to become involved in the high engagement of scientific processing skills such as critical thinking, problem-solving, inquiring, discovering and comparing (Stone et al., 2019).

For practice, time could be set aside during science lessons to use free play to allow children to start talking and exploring science. This adaptation of play within a formal setting in this research study has shown that play is beneficial and feasible in school contexts. The power of play shows the shift in the children's mindset and perspectives and their firm belief that their teachers were more approachable during play. The reduced power relationship between the children and the teachers in a science classroom influenced them and made them think that getting mediation from the teachers became much easier through play, despite the integrated data showing that they were in fact helped more by their peers. The student–teacher relationship was improved by play and could attribute to the children's learning, as argued in Hattie's (2009) meta-analysis of 800 studies. The teachers were readily accepted as co-players, and this acceptance opened up an excellent opportunity for the teachers to discover what the children were thinking, thus gaining valuable information to identify any misconceptions or areas for improvement. Hence, the above strongly suggests that play is feasible and has its place in an educational institution, even in an Asian classroom.

Below, the discussion proceeds to the next section, where teachers' perspectives are considered in order to answer research question 4.

8.4 Teachers' perspectives on play in primary science

In this section, the findings from Chapter 7 (teachers' qualitative data) are integrated with findings from the mixed-form data from Chapter 5 (quantitative data complemented with qualitative data for both teachers and children). Both teachers' and children's quantitative data were merged with teachers' qualitative data because the teachers' perspectives were closely related to how the children talked and played. The frequency of the types of talk on how the children got involved in the talk was able to shed light on what they were doing and supported the teachers' perspectives. Similarly to the children's perspectives, more emphasis will be placed on the teachers' science talk discussed in Chapter 5, with some findings quoted from all talk to support the arguments in this section. The analysis and interpretation of these integrated data will be discussed only after the discussion on teachers' perspectives to show its convergence and/or divergence and answer research question 4 of this research study:

Q4. What are the teachers' perspectives on play in primary science?

To answer this research question, the discussion in this section 8.4 will look at the teachers' perspectives on play in primary science first, before the discussion on the integrated findings.

From the teachers' individual interviews before and after the scientific play sessions, a range of teachers' perceptions of play in science were found. The teachers' perspectives on play were found to be made up of 14 themes [see Table 7.1], classified and held together by Falk and Dierking's (2000) Contextual Model of Learning (CML) under two contexts: Personal and Sociocultural Contexts. For the Personal Context, themes were identified such as: Play is open-ended or self-differentiating, which is enjoyable for children; Play is a context for the application of knowledge and scientific language, which generates curiosity; Play is a way to provide tactile experience in school, which is a distraction from practising/ drilling for exams or conflicts with learning; Play is also challenging to parental perceptions of school science. In the sociocultural context, the categories are: Play is suitable for some classes and better for some groups than others; Play is a place for developing social skills, an opportunity for children to learn from one another; Play is a way to find out what children think and at the same time a cause of behaviour management problems and a place for conflict if there is no synergy in the group. As some of these views overlap, they will be combined and discussed in seven sub-sections below.

8.41 Personal context

(a) *Play is open-ended or self-differentiating, which is enjoyable for children*

In this study, free play was encouraged, and teachers reported play as open-ended or self-differentiating [see Section 7.13 (a)]. Free play emphasised children's freedom, in contrast with the standard practical sessions during a usual science lesson. The teachers reported that play was a novelty to the children and was resource-rich (Wood, 2013) to allow differentiation [see Section 7.13 (a)]. The teachers' perception of play was consistent with Hewes' (2014, p.286) definition of free play, where the characteristics of control (from the child's decision-making), uncertainty (due to the open-ended format), flexibility (they could do anything they wanted), novelty (given a large basket of things in great quantity as well as things they had not handled before), and non-productivity (as there was no worksheets to complete at the end of the scientific play session). Wood (2013) argued that play must be resource-rich to let the children play, which the design of the setup took care of.

Madam Lee remarked on how free-choice learning had affected her children. She recalled that she was surprised by the positive change in the children's attitudes when they were doing what they wanted to do. The children were more engaged than before, and they worked much better than when they were being instructed. This finding is consistent with Bulunuz's (2013) study, where children in the experimental group displayed more significant positive behaviour changes than the comparison group in making and testing predictions and explaining and reflecting on their observations. Play was self-differentiating [see Section 7.13 (a)], too, because it allowed learners at various levels to enter without any problems, although some considerations needed to be put in place to cater to the children's skill levels, as proposed by Falk and Dierking

(2000). The play experience was unique to the children, and a multitude of factors determined that every group's play experience was different, which attracted the children to be more willing to participate and join in the play. This is consistent with Howard and Miles' (2008) 'behavioural threshold of play', with the threshold of the children in this study being lowered because they perceived the activity as play and were more willing to participate as they approached play with confidence.

For the personal context, the teachers' perspectives were classified under four themes, and each theme will be interpreted with the integrated data, combined and discussed below.

For this section, play means open-ended free play, and the teachers' perceptions were in line with Hewes' (2014) definition that children are able to self-differentiate and exercise control in their decision-making. This decision-making move by the children could be seen through the codes [see Table 5.5] for 'Child's Own Choice' (COC), 'Child's Observation' (CO), 'Child's Question' (QN) and 'Child's Feedback' (CF). A possible scenario that was observed during the scientific play sessions that could account for the open-ended nature of free play occurred when a child tried to make a decision (COC). What he or she could do was to make some observations of what was happening (CO), ask some questions (QN) and possibly answer or just talk (giving feedback – CF), as per usual. He or she could also ask questions and, finally, decide what he or she wanted to do by COC, expressing his or her choice using the pronoun 'I'. Teachers argued that, since play is open-ended, the children could enter at multiple points and play. Observation was high at 6.0%, with the children describing what they had observed, possibly being made curious by the play, and started asking questions, which was also high, at 2.0%. These were the two most dominant types of science talk that the children engaged in. Next, the children could respond to their peers (1.8%) and express their choices (1.9%). These were the fourth and fifth most dominant types of science talk by children. Children at play could also seek reassurance (CSR) and keep repeating what they were doing or a fact they had just learnt, with CSR being the seventh most dominant type of science talk, at 1.5%. These findings support the teachers' perspective that play is open-ended for the children. These figures are for the children's science talk, but the teachers were also involved.

For teachers [see Table 5.7], being a facilitator during the scientific play sessions due to the open-ended format, they might support the children's play by asking questions (QN^T 12.0%), teaching the children (TTC 4.1%), offering help (TOH 2.4%), giving reassurance (TGR 2.0%) to encourage (TE 2.2%) them to continue and responding by giving feedback (TF 0.9%). Five of these types of science talk were among the first six most dominant, with TF being the eighth most dominant. The above interpretation of the integrated findings shows that the integrated data confirm one another and were convergent. Teachers' perspectives on play being open-ended were verified. Next, the discussion moves on to part (b).

(b) *Play is a context for the application of knowledge and scientific language, which generates curiosity*

The teachers reported that they had seen many examples of the application of knowledge by the children [see section 7.12 (a)] through their daily interactions with the children both during and after the scientific play sessions. Their perspectives were that play was good, and set up contexts for the children to interact and apply their knowledge to their daily lives. They gave examples of children coming up with games that used the concepts from the chapter on magnetism called 'magic tricks'. The children also started to question the teachers about observations they had made in class, where the compass given to them was not waterproof. These were two instances where the children applied what they had learnt in science to their daily lives [see section 7.12 (a)]. To develop the game, the children needed to have the scientific knowledge that like poles repel and how a compass works [see section 7.12 (a)]. It was an ironic situation when the child questioned why a compass [see Section 7.11 (a)], which was often used in tracking, was not waterproof and what would happen on a rainy day. This child's question clearly showed what he was thinking [see Section 7.21 (c)].

Play provided a platform, a context for talk and hands-on experience enabling science learning to occur [see Section 7.11 (c)]. The children in this study have been shown to use talk that promoted reasoning and they were able to go on to build their scientific arguments [see Section 7.12 (a)], which is in common with Kuhn (1993), Snow (2010) and Wellington and Osborne (2001). In this study, free play afforded children the opportunity and space to articulate their ideas during play and peer collaboration and showed through the application of the relevant scientific concepts [see Section 7.12 (a)] that it was a positive contribution to the children's conceptual understanding of science (Howe et al., 2005; Howe et al., 2000; Mercer et al., 2004; Snow, 2010). With free play, children were given authentic experiences to interact with the materials [see Section 7.11 (c)] and make meaning. The children in this study were able to retain the scientific concepts when they had successfully attached meaning to them and were able to apply them [see Section 7.12 (a)], in common with Snow's (2010) proposal. The following paragraph will present some examples of the teachers' observations that were consistent with what Snow (2010) proposed.

There were more instances recounted by the teachers where the children started asking questions that were not shallow or superficial [see Section 7.11 (a)]. The questions they asked reflected what the children were thinking, and they revealed some deep thoughts. The children were asking more questions than usual about things they had observed and experienced, and were curious to know more [see Section 7.11 (a)]. The teachers were intrigued by this deeper thinking. This finding is consistent with Braund and Reiss' (2004) and Johnston's (2011) argument that the affective domains of the children were triggered, and the children became curious [see Section 7.11 (a)] and delved deeper into their conceptual understanding of science [see Section 7.12 (a)].The teachers were also pleased to see them apply what they had learnt through the free exploratory play into examination-style questions [see Section 7.12 (a)] that consisted of higher-order thinking questions. In this study, play made learning impactful for most children, and the impact was long-lasting as the children were still able to recall what they had done after a couple of months and applied their knowledge correctly [see Section 7.12 (a)].

Teachers recounted the positive behaviours they had noticed in the children, such as a sudden rejuvenation of energy from a sleepy mode to attentive mode whenever the word 'magnet' was mentioned and the grins they had on their faces, looking at their peers in a non-verbal manner, recalling the common, shared and life-enhancing experiences they had gone through. These positive affective behaviours were also noticed as being displayed by children during play in McInnes et al.'s (2009) study. Attendance at school improved for some children, and one child revealed that she would ensure that she turned up for school much earlier to discuss what she would try to do with her friends later on in the sessions [see Section 6.11 (d)]. It was not the same anymore, recalled Madam Geetha when she compared her children's attitudes to other topics and classes. These findings are consistent with what Braund and Reiss (2004) argued on the personal context in the CML model.

The visible outcomes that the teachers reported seeing in their children after the scientific play sessions helped to encourage the teachers to choose play in science classes. Some teachers were reluctant to use play initially because they were unsure what it could bring about and had preconceptions that it was a distraction from practising and drilling for examinations [see Section 7.11 (d)]. However, when they noticed the visible shifts in motivation and attitudes among the children, they also underwent visible shifts themselves. In the end, all five teachers agreed that play has its place in the learning of science, and said they will use it more often. Mr Wong supported the plan and commented that he would like to use play as pedagogy because he argued that play was "an engagement" (Post-Play: 741) and a type of "unconscious learning" (Post-Play: 741).

In this section, scientific language was spoken by the children during their scientific play sessions. Although most talk was not science talk, they still managed to speak about science for at least 24.7% of all talk. For scientific knowledge, the quantitative data that can be merged and integrated with the qualitative were as follows. In terms of scientific knowledge, play set up contexts for both the teachers and children to apply. Both could be teaching the children science knowledge (TTC 4.1%, CTP 2.0%), questioning (QN^T 12.0%, QN 2.0%), setting up contexts for scientific arguments (TA 1.1%, CA 1.0%) and answering them (TF 0.9%, CF 1.8%). Similarly to part (a), the teachers and children also encouraged the children (TE 2.2%, CE 1.4%) and gave reassurance (TGR 2.0%, CSR 1.5%). One can see that the percentages for teachers were much higher than expected because the teachers, being the more knowledgeable ones, carried on with their roles as teachers, questioning, teaching and instructing (TIC 2.8%), and supporting the children's learning by offering help (TOH 2.4%) and encouragement. For the teachers, these eight types of science talk were the first eight most dominant types of talk and, in the application of scientific knowledge, the teachers' roles in free play could be seen as such. The only additional science talk that was different from part (a) is Child's Recall (CR 0.9%), requiring the child to tap into their prior knowledge in order to apply his/her knowledge.

Based on the interpretation of the integrated findings, part (b) sees more of the teachers' presence in science talk than the children since the teachers used more science talk (29.1% for teachers compared to 24.7% for children). The integrated findings confirm that the data were convergent towards play as a context for the application of scientific knowledge. Next, the discussion will move on to part (c), on play as a way to provide tactile experiences.

(c) ***Play is a way to provide tactile experiences in school, which is a distraction from practising/ drilling for examinations or conflicts with learning***

Ms Koh commented that play was advantageous for physical science because the children would gain tactile experience [see Section 7.11 (c)], allowing them to use their senses to see and explore in real life. This finding agrees with what Wellington and Ireson (2018) proposed, as science is both a practical and a theoretical subject; both hands-on and mind-on approaches are beneficial to the children. With the hands-on in the free scientific play sessions [see Section 7.11 (c)], teachers in this study recalled how the children were able to explore the materials with freedom, utilising their senses (Braund, 2004) and attaching meaning to their experiences, which would then be retained (Snow, 2010) in the children's memories as part of their science learning.
Mr Wong said that play was very engaging and, even though he had signed up for this study voluntarily, he still had some reservations about play because it conflicted with learning [see Section 7.11 (d)]. He found play to be 'a risk' because it might not have any tangible returns, as compared to traditional pen-and-paper assessment. Like Meckley's (2000) definition of play, play is child-chosen and emphasises the process, not a product. Mr Wong was apprehensive as to whether play would measure up to the safe and tested path to 'success' of doing drills and practice [see Section 7.11 (d)] because play does not exhibit any visible or concrete evidence to quantify the children's learning and cannot be captured on paper and assessment, which he would be accountable for as a teacher. Mr Wong's dilemma about whether or not to use play was a genuine issue in teaching because there was what Wood (2013, p.14) called the strain between the 'rhetoric and reality of play'; whereby teachers had to decide

between the educational and policy-centred versions of science lessons and the 'ideological versions of free play and free choice' [see Section 7.11 (d)].

Madam Lee added that whether or not play could be implemented was "teacher dependent" on the "nature" and "character" of the teacher delivering the lesson. The teacher's comfort level in allowing the children to play was also an important factor in play being successful when introduced as a pedagogy.

For this section, the tactile experiences captured were by the teachers because they were the ones who would set up the materials. For tactile experiences, the types of science talk were similar (QN^T, TTC, TIC, TOH, TE, TGR, TA and TF) to those in part (b), except without the child's recall. What may be additional here is the teacher's story and character (TS 0.2%). Here, the teachers would question, teach, instruct, offer help, encourage, give reassurance, set up contexts for argument, and give feedback to help the children create the proper contexts that supported tactile experiences. The tactile experiences set up for the children were created through careful planning by the teachers and included the right opportunities for them to intervene and support the children's learning. The possibility of the teacher creating story and character could make the relevance of the children's play experiences clear to them. Science talk for TS was the second least dominant type of talk because it was not easy for the teachers to introduce it without a proper context and shared background with the children. However, this fact did not stop some teachers from using it in their science talk.

Based on the interpretation of the integrated findings, part (c) relies a lot on the teachers because they set up the contexts for learning. The integrated findings support and confirm the data that they were convergent towards play as a way of providing tactile experiences. Next, the discussion will move on to part (d), on play as challenging to parental perceptions.

(d) ***Play is challenging to parental perceptions of school science***

Although this sub-section is about parental perceptions, parents – the children's stakeholders – also play active roles in influencing their children positively. Teaching is challenging, and when there are more parents who can understand and know more about play, it does help teachers to implement play more easily in class. The teachers' choices about whether to try may be directly or indirectly affected by parental perceptions of play. Parents had varied views about their children's involvement in play. Some parents were for the implementation of play, while others were against it [see Section 7.13 (b)]. Ms Geetha talked about getting parents' support to help extend their children's learning beyond the school context as the children did spend a considerable amount of time back home. Ms Geetha argued that active parental involvement is something that keeps children's interest in science going. Parental involvement had an impact on their children as they could have more hands-on experience.

On the other hand, some parents were against play due to mistrust and would often comment, "you're going to study, not to play" as recalled by Mr Wong (Post-Play: 732–733). This dichotomy of play that was present when these parents perceived play and learning to be mutually exclusive and not congruent was primarily due to the "mistrust of play" raised by Wood (2013, p.19). This mistrust was due to the lack of a precise operational definition of play and the persistent view that play is the opposite of work. It could also be due to these parents' historical and cultural heritage, if they had the traditional mindsets and reacted this way, with a preference for worksheets to account for their children's learning. Having a good relationship and proper communication between teachers and parents may help to convince the parents that their children's hands-on experience in school through free play will help to develop their scientific conceptual development. Regular updating on the topics covered or things done in school would help to keep the parents informed. Teachers also fed back that there were visible differences in the children's attitudes and that, hopefully, parental perceptions of play would change in the long run, once they were convinced by empirical evidence that they could witness from their children. This finding in the present study is consistent with Hyson et al.'s (1991) study, in which they found that children who had attended more academic pre-schools were less creative and less positive about their school experiences. Therefore, the findings show that parental perceptions of play are important in determining the type of schools their children attend and their stance on allowing play in their children's lives. Being in an Asian context, the dominance of "trusted authority figures" (Iyengar & Lepper, 1999) still speaks volumes as the choices were still predominantly made by the parents. Play is challenging to parental perceptions because parents exert their authority over their children's choices.

For this section, there was no quantitative data on all talk or science talk, which could pinpoint the impact on the teachers' and children's talk. Therefore, there is only qualitative data to support the theme that play is challenging to parental perceptions of school science. This theme is valid because it is also listed as one of the themes discussed by the children in their group interviews, where the children were concerned about their teachers and parents who might not be keen to allow them to play, for many reasons.

In summary, the integrated data converged for three out of the four themes generated for the teachers' perspectives in the personal contexts. The last theme could not be integrated but does stand because the qualitative findings point to play being challenging to parental perceptions of school science.

8.42 Sociocultural context

(a) *Play is suitable for some classes and better for some groups than others*

Before the scientific play sessions, Ms Koh believed that play was more suitable for some groups than others. She reported:

> *My, this class is very kinaesthetic, so anything that requires movement bringing them around the school for bio-related, things and, animals and plants, er … they remembered it a lot better, […] letting them see, move and touch, is a lot better for this class, compared to my other classes, yah! I've, I've used to have one that is a lot more about writing, so they prefer like you know, those crossword puzzle [sic] that kind of thing, they like.*
>
> Ms Koh (Pre-Play: 502–508)

Teachers' perceptions of play varied according to the group they were teaching. In some schools in Singapore, children are grouped by prior attainment in their previous school year. In this study, teachers described these as broad categories: "low-ability/ low-progress", "middle-ability/ middle-progress" and "high-ability/ high-progress".

Some teachers felt that play worked well for particular groups of children and less well for other groups [see Section 7.21 (b)]. Madam Lee felt that play would be "good for the mid-ability to the high-ability children" (Post-play: 50) but doubted its benefits for the "low-progress children" (Post-play: 51). She pointed out that "with so many materials", the context was too open-ended that "low-progress children" would not "even know what to do" (Post-play: 50–52). Mr Wong agreed with this.

The challenges that the teachers faced in class were many, and they were often advised to make time to listen, observe, reflect upon and analyse the children's play in order to better understand the children's perspectives (Chesworth, 2015). Although different classes and different groups could affect how much time the teachers would have in class, generally, the teachers gave feedback in the interviews that they were surprised how play had freed them up compared to a regular practical class. They could move around more freely in the class during the free scientific play sessions to determine what the children were thinking [see Section 7.21 (c)]. Therefore, using play in this research study had allowed the teachers to take a step back, observe and reflect upon what they could do to help the children understand science, and build their social skills. This creation of a reflective space for all teachers was evident because play took place simultaneously for all groups.

For the sociocultural context, the teachers' perspectives were classified under three themes, and each theme will be interpreted with the integrated data, combined and discussed below.

For part (a), the quantitative data in Chapter 5 could not be merged and integrated with this theme to analyse whether it was suitable for some classes. This is because the data presented were all collated data summed together from the five classes. However, if one were to track down the individual classes or groups, it could be done and analysed. What one could see would be the frequency of types of science talk such as Questioning (QN^T 12.0%), Teacher Offering Help (TOH 2.4%), Teacher Teaching Children (TTC 4.1%), Teacher Instructing Child (TIC 2.8%), Teacher Giving Reassurance (TGR 2.0%) and Teacher's Feedback (TF 0.9%).

A high frequency of questioning could indicate two sides of the coin. Either the teacher asked many questions to support the children's learning during play, which means they were weaker in understanding science, or the teacher asked more questions to challenge or asked thought-provoking questions of those children with a stronger understanding of science. TTC, TIC, TOH and TGR are the four codes that are indicative of class profiles where support was needed. From the much higher frequency of questioning and a much lower frequency for the other four codes, the quantitative findings indicate that the group of children were better in their understanding of science. As they were better at learning science, they did not need the teachers to instruct, teach, support or answer so much.

The integrated findings here were only able to show the overall profile of the children studied in this research but could not differentiate or compare. Therefore, the integrated findings did not conclusively support the teachers' perspective that play is more suitable for some classes than others.

(b) *Play is a place for developing social skills, an opportunity for children to learn from one another*

The findings show that the teachers felt that play was a social activity that would act as a place or context for developing social skills [see Section 7.21 (f)], where children could learn from one another [see Section 7.21 (d)]. In this research study, most teachers specifically planned to allocate the groupings of children in the class. This planning was evident because at least four teachers made it known during the interviews what they had planned to do and what did not work out for them.

For example, Ms Koh talked about having a mixture of "high ability" (HA), "middle ability" (MA) and "low ability" (LA) girls in the scientific play sessions [see Section 7.21 (b)]. She planned to have "higher ability" girls who were "using the better terminology" (Post-Play: 406) to lead the group, but this did not work out in some groups because the "HA" girls happened to be quieter ones and did not manage to get their communication across [see Section 7.21 (c)]. Although it did not work, Ms Koh still firmly believed that the girls did learn from one another [see Section 7.21 (d)]. Similarly, Madam Lee planned but failed to get two groups to work cohesively together [see Section 7.21 (g)]. She added that she guessed the scientific play sessions would ultimately enable these children to learn that they would not always get to work with people they liked and had to learn to work with one another [see Section 7.21 (f)]. On the other hand, Madam Bhavani was successful in purposefully placing two vocal children together:

> *Somehow, he puts her in place, because no one [else will], if you are too quiet, you won't put her in place.*
>
> Madam Bhavani

The teachers agreed that play was a place for developing social skills [see Section 7.21 (f)]. Likewise, in this study, play enabled the children to learn from one another [see Section 7.21 (d)] and from the people around them (Else, 2009; Fatai et al., 2014; Groos, 1920) and helped them to build up their social skills [see Section 7.21 (f)] (Fatai et al., 2014; Fleer, 2007; Malone & Tranter, 2003; Robson, 2010; Singer, 2006; Smilansky & Shefatya, 1990; Weisberg, Hirsh-Pasek, Golinkoff, Kittredge & Klahr, 2016).

For part (b), this section will use the quantitative findings from the children instead of the teachers. Play is a social activity, and for it to take place, there were particular types of science talk that the children could be involved in. Children could develop social skills when they tried to teach their peers (CTP 2.0%), expressed their intentions (COC 1.9%) to their peers while playing, answered their peers (CF 1.8%) and lastly when they sought reassurance (CSR 1.5%) from their peers to show what they were doing. They also needed to negotiate materials from their peers (CNM 0.8%) by asking them nicely to lend them the materials.

The quantitative data showed that the types of science talk used were the second (CTP), fourth (COC), fifth (CF), seventh (CSR) and fourteenth (CNM) most dominant types of talk. The children were doing more science talk in teaching their peers and expressing their actions, pivoting more on the individual self than on others in a group format. At the same time, the children were nice enough to respond to their peers with feedback as a priority over their own need for reassurance, which was ranked seventh. Lastly, the findings also show that the children might have avoided negotiating for materials because this was the fourth least used type of science talk. They avoided conflict and could be flexible about playing with other things first while waiting for their turn. This finding could indicate that the children were able to develop their social skills to get along well with their peers during their scientific play sessions. Therefore, these interpretations of the merged and integrated findings confirm this theme of the teachers' perspectives that play is a place to develop social skills. The integrated findings were convergent.

(c) ***Play is a way to discover what children think and at the same time a cause of behaviour management problems as well as a place for conflict***

The findings show that most teachers in the study were reflective and walked around the groups during the scientific play sessions, thus picking up vital information about the children. The sensing of the grounds for what the children were thinking [see Section 7.21 (c)] was evident in the teachers' follow-up lessons and helped to inform them of what needed to be done. For example, the information that the teachers picked up could be group synergy or alternative conceptions of the topic. The teachers were able to hear or witness how some very quiet children started to speak for the first time in the group (some of the teachers were subject teachers who only saw the class for science). The findings show that some teachers could 'tap into' an in-depth understanding of the children's thinking [see Section 7.21 (c)] and what informed their choices in play. The teachers commented that they had managed to access or tactfully enter the children's play upon invitation with the relevant skills, relinquishing their usual control over a science class. The ultimate control was finally returned to the learners – the children. The teachers were seen as co-players in the children's play. This finding is consistent with what Singer et al. (2006) argue about entering the child's play without overriding the right to learning of the children.

Some groups were enthusiastic and worked as a group, while others could not work as a group. Madam Bhavani reported fewer discipline problems [see Section 7.21 (g)] as the children were gainfully engaged. Madam Lee learnt who could not work well in a group and that she needed to "play around" with the different combinations of children to help them work together. She talked about "conflict management" (which was the difficult part of the scientific play sessions) [see Section 7.21 (g)] and the class management skills needed to help the groups move. She also admitted that, even after doing all the planning, she still ended up with at least two groups who somehow did "not work out as well" as she had expected. For some teachers, play was indeed a place of conflict within the groups [see Section 7.21 (g)] who did not work well in the class. As free-choice learning through play was encouraged in this study, conflicts were inevitable and did arise due to the frictions and interactions between children with different personalities. Next, the discussion proceeds to discuss how the integration of data informed theory and practice.

For part (c), this theme is approached in two ways: the teachers' and children's science talk. The teachers commented that they could sense the groups' synergy and understanding by asking questions (QN^T 12.0%) and setting up contexts for scientific arguments (TA 1.1%). In terms of behaviour management, the teachers offered help to mediate any conflict (TOH: non-science 0.2%), instructing them (TIC: non-science talk 43.6%) and giving feedback (TF: non-science talk 5.1%). Meanwhile, the children could be involved in many more types of science and non-science talk. The children could be deemed to be thinking if they asked questions (QN 2.0%) and became involved in a scientific argument session (CA 1.0%). When it came to behaviour and conflict management, the types of talk involved could be all talk [see Table 5.1] for child's feedback (CF 35.2%) replying or responding to their peers, child instructing peers, telling them what to do (CIP 8.4%), child advising peers to abide by the class rules (CAR 1.2%), child interacting with peers from another group (CIA 1.1%) and child's own choice (COC 7.1%).

From the interpretations of the integrated data, the most dominant type of science talk, questioning for teachers, shows that the teachers asked many questions to determine what the children were doing or thinking. The tendency of the teachers to set up contexts for scientific arguments was not very high, as TA was only the seventh most dominant type of science talk. This lower dominance of talk could be due to the difficulty of setting up such contexts, and the children involved needed to be skilled to a certain extent to be able to participate. In terms of behaviour, the teachers spent most of their time instructing them what to do. However, if one looks at the teachers' instructions, one realises that they were just procedural instructions about how to start and end their play. The low frequency of the teachers instructing them to behave was not there. This data is further confirmed by the very low frequency of TOH, where teachers needed to offer help, and 5.1% of the feedback to reply to children. Therefore, for teachers, the conclusions are that the integrated findings point towards and converge on their perspectives that play is a way to determine what the children are thinking. However, from the low frequency of TOH and TF, the integrated findings show that, although there was a possibility of children's conflict and misbehaviour in play, it was not high enough for it to be a significant cause, refuting the integrated findings.

In terms of the interpretations of the integrated children's data, the high dominance of asking questions shows what they were curious about and that they were thinking about what they were doing. CA was lower because it was not easy for most children to enter into this without the appropriate level of ability to sustain the scientific level. As for behaviour and conflict issues, the quantitative data indicate that the children were involved in their play, with feedback being the most dominant type of talk, with a high percentage. As well as feedback, 8.4% (CIP) and 7.1% (COC) showed the children's desire for agency and that they could instruct peers and do things their way. These three data sets indicate a high volume of talk in these areas, which might contribute to conflict and behavioural problems. However, the low frequency count of CAR (1.2%) and CIA (1.1%) would indicate that the children generally abided by the class rules and did not move away from their groups to create behavioural problems in another group.

Therefore, from the children's data, the interpretation of the integrated findings confirms the findings to be convergent and that play is a way to discover what children are thinking. However, for the behavioural and conflict problems, similarly to the teachers' data, the integrated findings are refuted, indicating that, although play might result in some behavioural and conflict problems, it was not a cause of them. The integrated findings lead to the conclusion that they were divergent and play might not have caused behavioural or conflict problems.

8.43 Theory and practice informed by the integrated findings: Teachers' perspectives

For the teachers' perspectives, the integrated findings were discussed under both personal and sociocultural contexts. The integrated findings show that almost all themes, apart from two, were not convergent. These two themes are the parental perception of play in school science, and that play is suitable for some classes. This section is on teachers' perspectives, and when they were interviewed, they had assumed the role of teachers. The teachers reported through an educational lens, mainly from an adult's perspective (Rogers, 2013), on the scientific play sessions.

In the personal context, play is open-ended, and the integrated findings in Section 8.4 show the first six most dominant types of science talk that the teachers were involved in. One of the interesting integrated findings for teachers' perspectives is that, even though the role of the teachers seemed to diminish during the free play, both children and teachers reported that teachers were still essential and the teachers' role was always there, deep-rooted within the children, even in the free play setting. Teachers still play essential roles to engage in mediation with the children's learning by setting up relevant physical and verbal contexts for them to engage with. In theory, the better the teachers' professional content knowledge and understanding of the children's development, particularly for free play, the better support they can render to the children (Chesworth, 2015). Teachers were often encouraged to set aside time to observe, listen and reflect in order to understand what the children were thinking from their perspectives (Chesworth, 2015). In fact, with the reduced power relationship between them, the teachers' role in engaging in social mediation with the children increased.

Future recommendations for practice are that practitioners and teachers can make full use of the PSTP created, study the types of talk in their science classrooms and be aware of these types of talk, in order to support the children's learning. The availability of the teachers to ask guiding questions, teach and guide the children is equally crucial to the children in the free play setting. Therefore, science teachers should be adequately trained to equip them with the relevant knowledge of what free play entails and how to support the children's explorations and learning, rather than overriding their decisions or exerting the teacher's outcomes [see Section 2.5]. Teachers could be taught how to plan and design their science lessons to help children acquire and learn the necessary science content and science skills needed at primary level (Pyle & Alaca, 2018). Teachers could also be taught how to frame and ask good science questions. This training could be part of their professional development to allow them to gain better mastery of play and be able to have the skill to enter and leave play without disrupting it or taking over control from the children. With that skill in place, teachers can try to factor in some free play during their science lessons so that children have opportunities to talk freely and have hands-on experience.

The teachers were important role models, providing examples for the children to follow as they were the ones who did more science talk. The children could pick up science vocabulary and ask questions or respond to their peers through their interactions with their teachers in class, or from previous lessons. This is important because feedback and asking questions were the most dominant types of talk for all talk and the second most dominant for science talk among children. With the relevant skills being learned, the children will become more confident about engaging in more science talk. Practitioners can learn to brainstorm and set up contexts and tactile experiences with abundant materials (Wood, 2013) for the children to interact withand apply their knowledge. This is confirmed by the integrated findings in Section 8.4, through free play.

Moreover, more research can be done on children in middle childhood during the transition years, as play is known to release stress in the emotional part of children and useful in the learning of science. Furthermore, from a perspective, play could be scrutinised to ensure that gender equality is put into action through the abundance of play materials (Wood, 2013) provided and how play is facilitated by a practitioner (Ailwood, 2010; Blaise, 2010; Grieshaber & McArdle, 2010).

Next, a significant concern brought up by both the children and teachers was how the adults (teachers and parents) would look at play and school science. Although there was no quantitative data to merge with the qualitative data, this point is vital for future play implementation as a pedagogy. In theory, although play has a rich history and has been studied for more than a century (Bateson, 2011; Gordon, 2009), there have always been problems implementing it due to the lack of a definitive agreed definition in the literature (Reed & Brown, 2000). In practice, teachers and some children [see Section 6.11 (b)] initially struggled with what play could promise and rejected it. We need to acknowledge this discomfort that play brings about in order to encourage both teachers and children. Play is a new area for teachers, who may be very accustomed to traditional forms of class teaching. Through their participation in this research study, the teachers were surprised that they were left with more time to observe and walk around the class a few times while the children were doing the free play. Free play had freed them up, and they were able to walk around the class much more than usual to pick up misconceptions or help enrich the talk by asking prompting questions. This is vital in practice because misconceptions retained for a long time can be difficult to remove [see Section 2.2]. Play provided a rich context for the children to explore and ask higher-order thinking questions. The teachers reflected more upon the play sessions and planned to extend or continue them in the next lesson as a follow-up. The power of play and the children's motivational level amazed most of them, and they were convinced to try it, even though they might not have been supportive initially. Play has become a teaching repertoire for these teachers as they have personally gone through it and witnessed what play could do for the children they were teaching. All five teachers agreed at the end that play is powerful, and they were all willing to try free play with other classes or the whole level the following year. It was a struggle initially for play to be accepted by most teachers, who were trying hard to meet the demanding curriculum standards (Pyle & Alaca, 2018) and unsure of what play could bring about. Therefore, in practice, it is imperative that teachers give play a try. This is because, only when they have personally tried and witnessed it will they understand how play works and its pros and cons, allowing them to be more receptive to the approach. Teachers can use play to tap into its potential accordingly and use it to enhance the acquisition of science skills (observing, asking questions and having scientific arguments), as informed by the interpretation of the integrated findings.

For the sociocultural context, children's social skills and agency were being investigated. The convergence of the data indicates that play is a place for learning social skills. In this study, the data shows that the children could work well in the group setting. This was evident in feedback being the most dominant type of talk for all talk, with children being able to respond to others with a sound, word or phrases to continue the conversation. This was visible in the cyclic conversations [see Section 5.21, Figure 5.1], where children took turns to talk about something. The conversation continued until all group members had 'checked in' to the conversation.

Teachers were able to set up play situations for the children to take part in. As play is a social activity, the more the children get to play, the more they will copy the behaviour of the peers around them (Else, 2009; Fatai et al., 2014; Groos, 1985) and build up their social skills (Fatai et al., 2014; Fleer, 2007; Malone & Tranter, 2003; Robson, 2010; Singer, 2006; Smilansky & Shefatya, 1990; Weisberg et al., 2016). Therefore, for practice, teachers can set up different and abundant play materials (Wood, 2013) to tap into the potentialities of play, and allow exploratory talk for social skills to develop. Alternatively, one can also provide limited materials so that children must learn to acquire social skills in order to negotiate for materials.

The integrated findings show that, although teachers did mention conflicts and misbehaviour due to play during the interviews, the quantitative data show that instances of teachers offering their help or children seeking help from the teachers to resolve conflicts were rare and this was one of the least dominant types of talk. Teachers did not need to give feedback to stop the conflict. Although conflicts and misbehaviour were present, most teachers were not concerned about them because most groups played well. Three out of five teachers commented that they were shocked to have developed different perceptions of play, and that their experiences contrasted greatly with what they had expected to take place before entering the play. Instead of the anticipated increase in discipline problems and time bogged down by settling disputes and explaining some of the science procedures in this ‘practical’ replaced by scientific play sessions, the teachers had found reduced discipline problems and the sudden freeing up of time for reflective space. The teachers felt different and empowered by this space because they could walk around freely to see and hear what the children were talking about. They could find good timing to help struggling groups without overwriting what they had started off to do and joined the groups as co-players, entirely accepted by the children. They had found these two impacts to be very powerful.

The integrated findings confirm the theme that play is a place for teachers to see how the children think as the children made observations, asked questions, taught their peers and exercised their own choices. These were the first four most dominant types of science talk that the children were involved in. This is important for the children’s agency because talk in science class is vital for children to develop science and reasoning skills and is often missing in normal science classes (Lemke, 1990; Newton, Driver, & Osborne, 1999). Therefore, play can provide a rich context for children to practise having such exchanges in order to learn science and build scientific arguments (Kuhn, 1993; Snow, 2010; Wellington & Osborne, 2001). Time could be set aside for teachers to try out free play and allow it to take place.

From the findings of this study, it was observed that, when free play and sufficient materials were given, the chances of friction among the children were readily reduced. Therefore, to minimise conflicts, they should have enough materials to have hands-on experience and allow freedom of choice in their play, then they will not get into many problems with others.

8.5 Conclusion

Play is multi-faceted and can cause discomfort and anxiety for both teachers and some children (who are not used to it) because the impact on the children's learning of science is intangible (Gunnarsdottir, 2014). However, from this study, it can be seen that the substantial evidence has answered the four research questions and indicates that play did afford many opportunities to increase both all talk and science talk. These types of talk help to promote reasoning (Alexander, 2005), which is often absent or rarely talked about in science class (Lemke, 1990; Newton, Driver, & Osborne, 1999).

The convergence of most of the integrated findings in the discussions indicates that play has its benefits and that teachers need to try to experience and manage play. The nature and dominant types of talk on the extent of science does show that play creates links for children to learn science through the scientific skills embedded in science, observing, thinking, analysing and teaching others when they have acquired the knowledge.

From the children's perspectives, it was an achievement for them to have the agency to voice what they thought about play in primary science. This was vital because they were the ones who mainly played (Einarsdottir, 2005; Nothard et al., 2015). It is argued that, with the experiences of the teachers exposed to free play, this rhetorical nature of play would be readily reduced, and they would become empowered to make evidence-informed decisions about using their "ideological versions of free play and free choice" (Wood, 2013, p.14) in the primary science classroom. Lastly, the emphasis on understanding the children's perspectives will also help and is vital because play is for the children, and there is a known disparity between adults and children on how children define their perceptions of play (Fisher et al., 2008; Karrby,1989; Keating et al., 2000; Robson, 1993; Rothlein & Brett, 1987; Sommer, Samuelsson, & Hundeide, 2010). What play means to children may not be congruent with an adult's perspective. This is important because, when play is no longer play to the children, entry to the activity will be compromised. Understanding more about children can help to guide policy and enhance practice so that adults are better equipped to support their well-being (Waldman-Levi & Bundy, 2016). This is because, when children's voices were compared with teachers, their voices were often seen as inferior, ignored and dismissed (Colliver & Fleer, 2016). Children's voices are important for the successful implementation of play in the learning of primary science.

From the teachers' perspectives, all five teachers finally indicated an acceptance of play as a learning tool and a pedagogy. A common theme found in both the children's and the teachers' minds were parental perceptions of school science. This has a huge bearing on both groups and does affect or determine whether to use play or not. This rhetorical nature and reality of play (Wood, 2013) is not easy to manage in school.

The empirical findings in this study have answered the four research questions using multi-methods methodology, and the integration of findings from varied sources has helped triangulate the data to indicate the nature and dominant types of all talk and science talk among both the children and the teachers, as well as the children's and teachers' perspectives on play in primary science. Play can be suitable for children in middle childhood. The contribution of this research study will be further explained in the next chapter.

Chapter 9 Conclusion

9.0 Introduction

The main aim of this research study was to explore children's and teachers' experiences and perspectives on play in primary science in Singapore. In this study, many contributions to knowledge were made, and in this chapter the three most important areas are discussed. They are: (a) the creation of a new Primary Science Talk Framework for Play (PSTFP) to study the nature of all talk and science talk during free play, (b) the focus on children's voices and agency that is enabled through play and (c) the contribution of empirical data about using play to learn science in an Asian context for children in middle childhood. These contributions helped to answer all four research questions set up for this study. The findings of this study show that the children were doing a lot more talking than the teachers during the scientific play sessions for all talk, but that the teachers were doing more science talk, which was linked to their role of teacher.

In this chapter, the integrated findings from Chapter 8 are used in this summary of findings to answer the four research questions. The chapter is divided into six sections (sections 9.1–9.6). Section 9.1 presents the summarised answers to the research questions set out for this research study, while Section 9.2 discusses my contribution to knowledge. Section 9.3 presents a critique of the study, discussing its strengths and weaknesses. Section 9.4 presents the implications of the study for policy, practice and research, and Section 9.5 makes recommendations for further research. Section 9.6 presents the concluding comments of this thesis.

9.1 Answers to the research questions

This section addresses the research questions by providing the answers that were found during the study, highlighting all the summarised findings from Chapters 5 to 7, as well as the integrated findings from Chapter 8.

9.11 The nature and dominant types of talk among children

Q1(a). What are the nature and dominant types of talk among children during the scientific play sessions?

The children did a lot more talking than the teachers and they mainly gave feedback to their peers to continue their conversations. This act demonstrates the social skills of the children as they continued conversations their peers had started. The children also questioned a lot and made observations about what they saw during the scientific play sessions. There was no significant difference in the types of talk used by different group types of children assigned by the teachers.

Most of the integrated findings converged towards both sets of findings. However, the quantitative findings from Chapter 5 showed that more questions were posed by the children to their peers than to their teachers. The integrated findings also provide some insights into how some Asian children behave when free play is offered during scientific play. Their prior experiences both within and outside the children's class played a massive role in informing their behaviours. When free play was given with no instructions, the children comfortably fell back on the class routines or the rules they were used to, and used them to carry out their play. The setting where they started the play was important because, if they started in groups, they would hold those groups together during their play, not allowing much solo play. In this study, the children made use of their senses to explore scientific phenomena (Johnston, 2014) by means of exploratory play, which is without agenda or structure. The third most dominant type of talk is observations (9.2%), indicating that exploratory play did take place to explore science, and that these playful elements helped to achieve some cognitive value (Johnston, 2014; Stone et al., 2019). Play is a place for children to learn social skills and they tried to co-exist well together, with feedback (35.2%) being used the most frequently, to continue the conversation. These conversations were essential to the children because play provided them with many contexts to have authentic, hands-on experience to explore and generate interest in science as they tried to put things together and learn from one another. This suggests that play is relevant to the learning of science.

9.12 The nature and dominant types of talk among teachers

Q1(b). What are the nature and dominant types of talk among teachers during the scientific play sessions?

The teachers talked much less than the children because they followed the play protocol. In all talk, their talk was mainly linked to the role of a teacher, giving instructions to start and end the scientific play sessions. They also asked questions and answered the questions posed by the children. The teachers were observed to be encouraging the children as they supported them by encouraging and reassuring them to continue to explore during their scientific play. There were not many significant differences between the different teachers.

From the interpretation of the integrated findings, the nature and type of talk that the teachers utilised during a scientific play session were similar to the quantitative data in Chapter 5. One of the integrated findings shows that the teachers who were still adjusting to the new play settings [see Section 7.2 (g)] were likely restrict their repertoire of teaching to initiation, response and feedback (IRF), as in Lemke's study (1990). This was confirmed with the three types of talk that were the first three most dominant types of talk. Besides these three types of talk, the integrated findings highlight the point that teacher teaching child (TTC) was less frequent than in a regular science class. TTC was a less dominant type of talk here because free play was offered, and the teachers were adhering to the fidelity of the play protocol. Another possible reason could be that the children were learning on their own by exploring and learning from their peers through play, so the teachers did not need to teach them so frequently.

9.13 The extent to which children talk about science

Q2. To what extent do children and teachers talk about science during scientific play? (Focus here is on children.)

The findings showed that, mainly, children did not talk about science while they were in a scientific play session. However, the dominant types of science talk that the children were involved in were linked to some science skills carried out by the children, such as observing and questioning. They were teaching their peers too. In addition, the children reported that they had found it easy to talk in the contexts that play provided, with a lower behavioural threshold. The children's science talk revealed their types of learning theories for learning about magnets and allowed the teachers to pick up on misconceptions and how much they had learnt. There were no statistically significant differences between different groups of children for science talk.

Four integrated findings are discussed here. Firstly, the findings indicate that the children were involved in non-science talk most of the time. This integrated finding is consistent with the children's perspectives [see Section 6.13 (g)] that play is challenging for parents and teachers. Because the children did not talk about science most of the time, parents and teachers were apprehensive about what play could do to help their children in their learning of primary science. Therefore, the findings may discourage them from using play more willingly. Secondly, the two-letter-coded types of talk were more dominant than the three-letter-coded types. The children were involved in talk classified under children's motivations and expectations [see Section 6.11], together with their prior knowledge, experiences and interests [refer to Section 6.12] more frequently than the 'choice and control' [see Section 6.13] of Falk and Dierking's (2000) CML. The children were able to practice some science skills through their science talk and were engaged in science exploratory talk (Mercer et al., 1999).

Through the contexts that the children were immersed in while engaged in their scientific play, they were able to acquire science words that were imbued with meaning and experiences (Snow, 2010). Thirdly, children's science talk revealed their types of learning theories for learning about magnets. There were two types of these that were observed in this research study: the terminology-based explanation and chemical composition. These learning theories were seen through the seven types of science talk, from observation (6.0%), questions (2.0%), child teaching peers (2.0%), child's own choice (1.9%), feedback (reasoned 1.8%), argumentation (1.0%) and recall (0.9%). The utterances depicting their learning theories about magnets were primarily visible and could be captured to confirm the integrated findings to be convergent.

However, the fourth integrated finding was divergent because, from the children's perspectives on play, play was nebulous and caused discomfort to some children [see Section 6.13 (d)]. Despite this discomfort, it did not inhibit the children in the actual findings, and they were shown to have talked more. The children were able to adjust to the demands of play and entered into it because they perceived scientific play as play and enjoyed themselves. The children found it easier to talk due to the reduced behavioural threshold (Howard & Miles, 2008), making play easier to access. Therefore, the extent to which the children talked about science was largely convergent, except for the ease of talking in play.

9.14 The extent to which teachers talk about science

Q2. To what extent do children and teachers talk about science during the scientific play sessions? (Focus here is on teachers.)

The findings show that the teachers were doing more science talk than the children. Teachers tended to use more science talk in this study to ask questions and teach the children. There was a reduction in the dominance of talk instructing the children when the teachers needed to use science talk. There was a small statistically significant difference between different teachers for science talk.

From the integrated findings, it has been shown that teachers' confidence in trying out play increased when science talk increased from 21.2% (PS1) to 39.1% (PS2), with more questions being asked, increasing from 9.2% (PS1) to 15.5% (PS2), a 6.3% increase. This helped the teachers to enter the children's play as co-players, to scaffold their learning or to obtain useful information about what they were thinking. This could be used in subsequent lessons.

9.15 Children's perspectives on play in primary science

Q3. What are the children's perspectives on play in primary science?

The children reported that they had found play to be fun and enjoyable. It motivated and rewarded them by setting up many contexts for them to explore in a few authentic play settings. The play was informed by their prior knowledge, interests and experiences. Their peers and teachers provided social mediations to them through play. However, they were influenced by how their parents and teachers perceived play, and this resulted in some children claiming that they were too old to play and that it was a waste of time if nothing tangible was gained when they played.

The findings show that the children's perspectives could be mapped to two contexts in Falk and Dierking's (2000) CML model, personal and sociocultural contexts. The 19 themes originally generated in Chapter 6 were combined into 13 themes during the final stage, which were discussed in the last integrated findings.

(a) Personal context

Free-choice play was perceived to support learning by creating opportunities to:

- Use children's motivations and expectations of using play in learning science,
- Play is dependent on children's prior knowledge, interests and experiences (KIE), and
- Choice and control of the child.

Play was perceived to be enjoyable and to act as a reward for children to learn science. Play can be limited by the adults' set of set of unwritten rules. For example, when the children were told they had the freedom to do anything they wanted to do during the scientific play sessions, they were stopped from doing so due to the different perceptions of some items. Children who tried demagnetising the magnets were frowned upon by some teachers because this means that fewer working magnets will be available in the science laboratory. Play is informed by children's prior knowledge, interests and experiences (KIE). Finally, play is a context to empower children in the freedom of choice to explore and learn, and provides an authentic tactile experience. Play can involve learning or not learning. Play's nebulous structure causes discomfort to some children. Play allows creativity and builds children's problem-solving skills. It can also allow the extension of learning at home.

The integrated findings for the first subheading show that play is enjoyable, and this is confirmed by the high number of children's utterances. However, the idea that play can be limited by the adults' set of unwritten rules could not be confirmed by the integrated findings as there was no tangible data to be merged with the qualitative data. As for the second subheading, that play is informed by children's prior knowledge, interests and experiences (KIE), the type of integrated findings did not have many data points to support it, except the recall talk carried out by the children, which refuted the theme. Lastly, for the third subheading, only one out of five themes could be merged to confirm the theme.

(b) Sociocultural context

In this context, play is a way to engage in social mediation with their peers. In addition, play is a place where children build their social skills. Play offers opportunities for teachers to interact with the children in reduced power relationships.

From the integrated findings, all three themes were convergent and were all confirmed. The children engaged in social mediation with their peers by asking questions (6%), giving ideas (1.8%) and teaching peers (2.0%) [see Table 5.6]. In terms of social skills, high numbers of utterances such as observing (6.0%), questioning (6%), child teaching peers (2.0%) and giving feedback (1.8%) in science talk were examples of science talk that helped to develop social skills [see Table 5.6]. For the last theme, the integrated findings came from the teachers' quantitative data and utterances such as asking questions (12%), teaching the child (4.1%), instructing or guiding the child (2.8%) and offering help to the child (2.4%), were the dominant types of science talk, indicating how the teachers helped to engage the children in social mediation in the reduced power relationship. There was also additional support rendered by the teachers to encourage (2.2%) and provide reassurance (2.0%) to the children.

9.16 Teachers' perspectives on play in primary science

Q4. What are the teachers' perspectives on play in primary science?

From the teachers' perspectives, play is self-differentiating and offers many rich contexts for the children to become immersed in and to be empowered to explore and learn. Play allows teachers to be able to access the children's thinking and understand their learning theories about magnets. Although the teachers had initial apprehensions before the study about what play could do to help the children in their learning in primary science, they discovered that there were fewer behavioural management issues occurring and they found space and time to walk around, listening to what they were talking and thinking about, and identifying misconceptions. The common theme that play is challenging to parental perceptions of school science was also present and influenced their take-up rate in using play to learn primary science.

The findings show that the teachers' perspectives could be mapped to two contexts in Falk and Dierking's (2000) CML model: personal and sociocultural contexts. The 14 themes initially generated in Chapter 7 were combined into seven themes during the final stage, which are discussed in the last integrated findings.

(a) Personal context

For the personal context, play can be seen as open-ended or self-differentiating, which is enjoyable for children. Play is a context for the application of knowledge and scientific language, which generates curiosity. Play is a way of providing tactile experience in school, which is a distraction from practising or drilling for exams, or conflicts with learning. Play is challenging to parental perceptions of school science.

From the integrated findings, three of the four themes were convergent and confirmed the themes. For the first theme, both children's and teachers' data supported through the dominance of talk the idea that play is open-ended or self-differentiating. The observations and laughter heard in the audio recordings also indicated that the theme was convergent. For the second theme, the application of knowledge, both children and teachers were seen to be teaching children science knowledge. The findings showing that the teachers do more science talk also indicate that teachers were the ones who could set up the contexts for the application of knowledge and scientific language. The high frequency count for questions asked by both children and teachers also showed that play did stimulate curiosity. The children also reported some recall whereby they recalled their prior knowledge and were able to apply it. For the third theme, teachers questioning, teaching, instructing, offering help, providing reassurance, setting up contexts for argument, and giving feedback were the types of talk most frequently present in the scientific play to help create proper contexts that supported tactile experiences. It was the last theme that could not be integrated to indicate convergence. However, this theme was reported by both children and teachers and shows that play does have some weight in influencing parental perceptions of school science.

(b) Sociocultural context

In this context, play is seen as more suitable for some classes, and better for some groups, than others. Play is a place for developing social skills, an opportunity for children to learn from one another. It is a way to find out what children think and at the same time it is a cause of behaviour management problems and a place for conflict.

From the integrated findings, two out of three themes were convergent and confirmed these two themes. The first theme could not be matched with the findings collected quantitatively and could not be confirmed or refuted. The other two themes were convergent. Children were trying to teach their peers in their science talk and giving feedback when they engaged with them. Children were seen to become involved in cyclic conversations and would always try to respond with feedback to allow the conversation to continue, an indication that they were developing their social skills. In the last theme, play is a way to discover what children are thinking, the teachers were reported to have asked a lot of questions as their most dominant type of talk. The low frequency count of children seeking help, the low incidence of teachers advising or correcting behaviour in feedback and the record of instructions given to start or end the scientific play sessions indicate that behaviour management, although present, was not a pressing problem. In the sociocultural context, the themes reflect the social interactions that were in place when the children and teachers interacted with one another during the scientific play sessions. This was linked with the development of social skills and conflict management due to the interactions in the social context of a classroom.

Teachers' perspectives were important in this research. Their awareness of how play fitted the different groups of children, and the experiences they had with the actual carrying out of the play, equipped them with the content knowledge of how play fits into a science class. This will be important if play is to be implemented, because it provides recommendations of real field experiences and empirical findings to contribute to knowledge.

In conclusion, the integrated findings and the findings from Chapters 5–8 have helped to address the main aim of this study, answering all four research questions.

9.2 Contributions to knowledge

This study contributes to many aspects of play in primary science, but this section will focus on the three most important contributions to knowledge.

Contribution 1:

This study is the first of its kind to create a new observation schedule based on a frequency count of both children's and teachers' utterances to study all talk and science talk in a scientific play setting. The Primary Science Talk Framework for Play (PSTFP) was specially created by the researcher in this study by combining two conceptual frameworks: Simon et al.'s (2008) discourse analysis and Falk and Dierking's (2000) Contextual Model of Learning (CML). This new framework is unique and can be used to study the nature of utterances of all talk and science talk among primary school children in science, with a new section addressing 'Choice and Control'. The PSTFP is a flexible and versatile framework that can be used to code and count the frequency of different types of talk in a selected excerpt of classroom talk or, as in this study, it can be used to analyse the entire duration of children's and teachers' utterances. The full transcripts used in this study gave a complete picture of what had happened while the children played in class with their peers and teachers, and not just a selected section of it. The PSTFP can indicate the nature and dominant types of talk that take place during children's play and allow practitioners to gain a better understanding of the children, and of themselves, in order to support the children's learning.

Contribution 2:

Children's voices and agency were highlighted in this study, and they contributed to knowledge about how children think. As play is a child-chosen (Meckley, 2002) and child-centred (Coughlin, Hansen, Heller, Kaufman, Stolberg & Walsh, 2000) activity, children's perspectives on play in primary science are vital to allow children's voices and agency to be heard. Through the design of the free play scientific sessions and the research question exploring the children's perspectives, children's voices could be heard. This is important because children's voices and agency are usually under-researched and, with increasing adult control over children both in play and in children's daily lives, play opportunities have been significantly reduced and teachers have taken control. The idea of simply listening to children's voices is a way forward in interpreting the aspects of their lives and their childhoods (Birbeck & Drummond, 2005) that are particularly important in play. This is because what children report about what they see as important is not always congruent with adult interpretations (Birbeck & Drummond, 2005). If the teachers had steered the children's play towards their intended learning outcomes, this would have resulted in the intended activity losing its playfulness and being perceived by the children not as play but as a task. This would result in the children staying away from the task and decreasing their access to play. Therefore, children's voices are "the best sources of information about themselves" (Docherty & Sandelowski, 1999, p.177). When children's voices are heard, they will feel safe, supported and valued (Birbeck & Drummond, 2005) and enter play easily because they perceive it as play and not a task. From the findings of this study, play frees up time for the teachers to walk around during the scientific play and provides them with reflective spaces and time to observe the children. With the play protocol being created to suppress teachers' talk and encourage more children's talk, allowing the children to verbalise more in spoken language, their voices will enable the teachers to discover what the children are thinking. Children's voices allow teachers to be more aware of the children's play and not overstep the children's play boundary to make play not play. This helps to improve the quality of both learning and teaching (McIntyre, Pedder & Rudduck, 2005).

In this study, it could be seen that, even though these children were 8–9 years old, they took ownership of their own learning in this free-choice scientific play and nurtured a strong sense of agency through exerting the Child's Own Choice (COC) using the PSTFP. The children were aware of what they were doing and their ability to play and talk here was an indication that they were exerting more agency and wanted to be trusted to learn (McIntyre et al., 2005). Listening to children's voices could inform that. From the children's perspectives on what they perceived to be play and how they played in the play sessions, these findings will help inform practitioners or educators and enable them to develop and plan a more appropriate play context, respecting the actual players in the play settings. The richness of the naturalistic data collected, with the children's voices taken into consideration in this research study, can help to build on Stone et al.'s (2019) study on the role of free play primary science. In contrast with Stone et al.'s (2019) study, no assessment was undertaken and nobody was staring at them while they played. This helped to allow children's voices to surface more and be heard. The children in this study were more at ease and their free play was uninterrupted. Free-choice play or free play had enabled the children to have their voices heard and gave them the agency to carry out their play. Children's voices are an important source of information about how children interact and learn.

Contribution 3:

Although much research has been conducted on pre-schoolers using play as a medium for language arts, this study focuses on 'older children', who are in middle childhood. It also helps to contribute empirical data about using play to learn science in an Asian context. From the findings of this study, it can be seen that the children were not able to participate very well in a normal science classroom setting, feeling withdrawn and unable to ask many questions, for fear of losing 'face', and feeling conscious of their weaknesses. However, when play was used, the children found themselves able to ask the teachers more as the power relationship had been reduced by play. They could also ask their peers when they encountered problems.

The study also showed that the children were very well trained and would always fall back on the usual class routines, which were ingrained in them. They abided by the authority and always tried to keep the group together as a whole during their play, even though no instructions were given to them on how to play. The weighing in of parental (Lam & Ducreux, 2013) and teachers' perceptions of school science are major concerns that were raised by both children and teachers when they were asked about implementing play in their science lessons in an Asian context. The issues of assessment and the obsession with results were linked to the "rhetoric and reality of play", that parents and teachers are faced with in Asia when they are asked to decide if they will support play in schools or at home. This study has contributed insights into some dimensions of play in an Asian context.

In conclusion, the three main contributions to knowledge made by this study are: the creation of a new observation schedule, the PSTFP, which enables frequency counts of the types of talk in all talk and science talk; the increased importance of children's voices and agency through the design of the study and the targeted research questions; and, lastly, the contribution of empirical data of using play in science for middle childhood children in an Asian context. This will lead to the next section, where the critique of the study will be discussed.

9.3 A critique of the study

The limitations of the study will be presented in this section. This research study was conducted in three schools with five teachers and five classes. The findings were thus based on the small sample size case study of the three schools involved and might not give a full picture of all schools in Singapore. However, these three schools were representative of most schools in Singapore, with only an all-boys school missing and not represented. The rest of the schools were a co-educational government school, a co-educational mission aided school and an all-girls school. Most schools in Singapore are co-educational government schools. Although a case study can have a small sample size, a larger sample size including different types of schools could help paint a broader picture of how free play can be used in a science classroom in different schools. This study started with a list of intended schools in mind for recruitment: one all-girls, one all-boys, one co-education government school and one co-education mission school. However, unfortunately, different schools taught magnets, the targeted topic, in different years and at different times of the year. The targeted group of children needed to be in Primary 3, but some schools taught this topic in Primary 4 (P4). The original plan was to recruit at least one all-boys school to this study, but this failed because there are only nine all-boys schools in Singapore, and after removing those schools that were teaching the topic in P4 and those that were not willing to participate, there were none left.

In terms of the type of teachers participating in this study, there were schools with teachers who were more disposed to play and more likely to participate and others who were less disposed to play. Possible different conclusions about perceptions or level of participation could then result.

Next, the topic of this research, play, also met some problems when schools were approached. Play is complex and nebulous; it is difficult to operationalise to bring any returns, so many schools turned down the request to participate in this study when approached. This is mainly due to their mistrust of play, leading to little or no free play time being given to older children (Stone et al., 2019). In addition, societal indifference to play on the part of teachers and parents (IPA, 2014) means that play is avoided or not implemented because it is associated with a "waste of instructional time with no clear benefits for high-priority cognitive outcomes" (Christie & Roskos, 2006, p.57). Furthermore, some school leaders even questioned the value of play and wanted a guaranteed return in the form of children's learning from this study. Unfortunately, such a guarantee could not be given. Significant difficulties were faced in finding schools that were willing to take part in this study. In the end, the study managed to achieve most of the desired list of targeted schools, apart from the unavailability of an all-boys school. The inclusion of such a school would make this study even richer, looking at another factor of gender.

In the end, the schools that participated in this study were recruited through close contacts. These schools happened to be the researcher's ex-school, and the workplaces of an ex-colleague in another school and her ex-laboratory mate at the university. This brings us to the next point, which is the limitation of the sources of contact. Contact was an essential issue because, without it, the chances of schools being willing to participate in such a research study were extremely low. As the researcher knew all three of them, for the study to be credible and reliable, her request to the school was that these particular teachers would not participate in the study but that other teachers would be assigned. At the researcher's ex-school, the children in the study did not know her because she had already left for her postgraduate study before they entered the school. As an insider at one of the schools, familiarity with the classrooms, norms and types of materials that were likely to be interesting to play with and also relevant to the topic were some advantages that the researcher had in the study.

However, on reflection, as the researcher used to work at one of the participating schools, she would know the teacher well, and the issue of the degree of reciprocity (Hitchcock & Hughes, 1989) might arise. This was despite the fact that the teacher was assigned by the school leaders. The interviewee may potentially give answers that they think the researcher might want (Hitchcock & Hughes, 1989). Perhaps in the future, what could be done in such a context is to have two interviewers to conduct the interviews (Walford, 1994). An interview is not exclusively a data-collection situation but also a social and sometimes a political situation (Cohen, Manion & Morrison, 2018). Asymmetrical power relationships (Kvale, 1996) do exist because there is a fine line between the balance between the interviewer and interviewees. Although the interviewer may appear to hold more power to define the situation, the topics and the course of the interview (Kvale, 1996), the findings in this study are dependent on what the interviewees wanted to reveal, and they have the ultimate power to withhold or release such data (Cohen, Manion & Morrison, 2018).

The presentation of the findings in this study may be limited because they are an interpretation of social situations (Lee, 1993; Kvale, 1996). An interviewer's neutrality is a chimera (Denscombe, 1995, 2014) and is not possible in reality. In this study. researcher bias has been minimised (Maxwell, 2005) by returning the transcripts to the teachers for member checking (Guba & Lincoln 1989; Miles & Huberman 1994) to verify that what was transcribed in the research matched what they wanted to say or convey.

The study's primary data collection for research questions 1 and 2 primarily consisted of audio recording in the class. Although video recordings were collected, they were mainly used to verify the contexts of the audio recordings. This was a limitation because, although audio recording could pick up what was heard in order to tell us what was happening in the class, it was not exhaustive. From the field observations, it was seen that, when some groups were very absorbed in their play and in the flow of play (Csikszentmihalyi, 1991; Hewes, 2014), silence could descend. The children would continue playing in groups or alone for quite some time using silent gestures and without any conversation. This does not indicate that they were not thinking or learning, but such play is difficult to study or quantify. As defined by Meckley's (2002) definition of play, play is focused on the doing, the process and not the product. Therefore, the silence during their play could not be fully interpreted or accounted for what was happening with the children. The findings in this research were based on what was spoken and thus may be limited because the silent play could not be picked up by the audio recordings in this study. Therefore, reflecting on this issue, this was a limitation of the audio data and a possible suggestion for future research could include more video data to capture both verbal talk and silent actions during their play, adding a different dimension to the study.

Although it was intended that the children would be offered free play, the group setting that they were placed in to record their utterances during the scientific play sessions resulted in a different observation being made. The children were observed to be playing in groups that strove to keep all the members intact while playing, despite the fact that free play was offered to them. The children were abiding by their usual class routines and independent free play was challenging for some children because, within seconds, other children would come along and join them in their play. In this study, the children were free to roam around the classroom, but only a handful of children chose to do so and interact with other groups, for example negotiating for materials from another group or walking around to observe and bring back ideas to their group. Moreover, although the context was planned from the free play perspective, the setting of a classroom and the nature of the science lesson that took place immediately before the scientific play did push some children's play to a certain extent in the direction of purposeful play.

Lastly, the nature of the subjects taught in science causes play to be better suited and easier to implement for physical science topics such as magnets, rather than biological sciences. However, despite this shortcoming, play can still be used and implemented for biological sciences. The materials chosen for the scientific play sessions were carefully picked to ensure that they did not dominate or dictate play patterns (Stone et al., 2019). The materials were non-gender-biased to allow children of either sex to play with them. Although play seems to be more suitable for learning physical topics, this perception does not stop anyone from using play for biological topics.

9.4 Implications of the research for policy, practice and research

In terms of the implications for policy, the findings from this study help to build up empirical evidence for stakeholders such as policymakers, practitioners, researchers, parents and even the public on what free-choice play can offer children in science lessons in Asian classrooms. Although Singapore makes a "holistic" effort to include multiple stakeholders and agencies in order to offer a great variety of science, technology, engineering and mathematics (STEM) programmes (Teo, 2019), she also faces problems brought about by the declining number of graduates in STEM disciplines (Quek, 2019). A State of Science Index survey that polled more than 14,000 people across 14 countries, including China, Germany and the United States, conducted by global science firm 3M, showed that only 9–18 % of the Singaporean respondents had described careers in STEM as satisfying (Begum, 2019). This lack of interest in science has resulted in fewer individuals going into STEM fields (Jocz, Zhai & Tan, 2014). Therefore, the findings of this study, which showed an increased interest in school science from the children's perspectives, suggest that play could be implemented in policy to develop children's interest in science if the right teaching approaches are employed at the right time, as seen in this study.

The insights gained from this study include children's perspectives on play, and the teachers who took part in the study could be useful agents to share with the rest of the teaching fraternity how play can or cannot be used in the teaching of science. Sharing the teachers' perspectives on play and their experiences during the study could contribute to the evidence-informed teaching pedagogies that teachers can use in school. The policy can be enacted to try play as a teaching pedagogy for older children, and support on the ground from the schools can be improved in order to support Singapore's children in their learning, rekindling their interest in science.

Initially, schools can start small and engage in professional development to share how play can be carried out in science classes. The findings from this study show that children do not always get to talk in class during their science lessons. The findings also suggest that, if the ownership of learning is returned to children, they can engage in much more talk than the teacher in a free play context. Handholding of teachers new to play by another experienced teacher who has some experiences with play can help to reduce the fear and discomfort that comes initially when one introduces play in class. This study shows that this is important, because if the teachers never immerse themselves and try play, they will not be able to experience and try it during the scientific play sessions. The time freed up by free-choice play experienced by most teachers in this study was an important aspect and helped teachers to better understand what the children were thinking, as well as providing a space for the teachers to reflect and craft better questions to support the children's learning. As teachers become used to how play works, it will be easier for them to gain subject mastery over play and become confident to enter and exit the children's play without taking over control, and yet be able to make use of play to provide valuable insights into what the children are thinking, their alternative concepts and the gaps in their learning. As play is resource-rich (Wood, 2013), support from experienced teachers in preparing the materials in school will help the teachers a lot with the logistics and encourage them to try.

In terms of research, the study's findings can contribute to the empirical findings about play in a science class on magnets for middle childhood children in an Asian classroom. These findings could be significant as very few studies have been conducted on play and on magnets in primary science for older children. Children's conceptual understanding of magnetism is an under-researched field (Driver et al., 1994; Hickey & Schibeci, 1999; Preston, 2016; Van Hook & Huziak-Clark, 2007) and, from the findings of this study, they showed that their understanding of magnets includes the 'pulling model', the 'emanating model' and the 'enclosing model'. Alongside these findings, this study also focuses on quasi-free play learning in an informal setup within the formal setting of a classroom. The contribution of the new PSTFP framework could help future researchers interested in similar settings to study the types of talk that children engage in. Findings can be scrutinised and studied in-depth and lead to a better understanding of the nature of all talk and science talk that children engage in when they learn science. Different methodologies can be used to triangulate the data obtained and build on the available data so it can be shared with the research community.

9.5 Recommendations for further research

The current study was conducted in Singapore, an Asian country, and it would be interesting if a comparative study could be carried out in a western country that has different perceptions of play in its culture. As well as a western country, more research could also be carried out in other countries to build up the empirical findings on play perceived by children all over the world, or in different communities. Additionally, in this study, a step was taken to bring informal learning to a familiar venue, such as the classroom or the laboratory. Therefore, for further research, different locations or venues could be explored for free play, rather than remaining limited by them.

Due to the research questions, this study was mainly focused on audio data and some video data. However, if funds and manpower were not a problem, future research could include both audio and video data capture in order to gain better insights into how children learn science through play. From the observations in this study, the findings showed that there were silent moments when the children were in the flow of play and were deeply immersed, playing with their peers using gestures. Therefore, if further research can take such considerations into account and include video data, it could add a different dimension to the study.

With more funding and support for future research, more schools can participate, and even schools such as a single-sex boys' school could be included to compare with the data in this study (two co-educational schools and one all-girls school) to explore the differences in utterances by different genders. Besides what was investigated in this study, future research could be carried out on children's socio-economic status (SES), parental perceptions, and children's fluency in play. A similar study could also be carried out for different topics, even in the biological sciences.

In addition to these, the new framework created in this study can be used to research the nature of children's utterances on different topics and with different types of teachers, such as trainee teachers, beginning teachers, and experienced teachers. In addition, factors such as teachers' professional development, their characters, gender and background could also be considered in future research.

9.6 Concluding comments

This study has investigated children's and teachers' experiences and perspectives on play in primary science in Singapore. Through free-choice play, the nature and dominant types of talk in the utterances spoken in all talk and science talk were studied and analysed when children were given the opportunity to play freely with materials during a science lesson. Through the whole process of designing the new observational schedule, PSTPF, from scratch, fusing two pre-existing frameworks [Simon et al.'s (2008) DAF and Falk and Dierking's (2000) CML] into one, many hours of hard work analysing the data in an iterative cycle were undertaken to make sense of the data and come up with this framework to study the nature of children's talk in science. The ultimate findings in this study showed that, through play, the children were given an opportunity to talk in a science classroom, something that was often absent in normal lessons, and that they did most of the talking. Although the children did not engage in much science talk, the fact that most children found play fun and motivating helped them to explore science and become engaged in science talk, which was good for developing science skills. Through the children's perspectives on play, one can learn what motivates them or turns them off from play, using different lenses as a player, co-player, teacher and researcher. Play reduces the behavioural threshold (Howard & Miles, 2008) and allows children to enter play more easily. Children do not come to the class like a blank slate, and their prior knowledge, interests and experiences (KIE) did influence and inform what they would do when instructions were absent in the free play. They did fall back on class routines, choosing to play in a group.

From the findings, play works well for most children despite its complexity and multifaceted nature. Play motivates and has a unique appeal to children in particular. Valuable insights into the children's and teachers' perspectives were revealed in this study. Combining the perspectives from both sides, this study points out that sometimes letting go of part of the control in a science class during free play can equate to more gains in the children's cognitive, emotional and social development. It is time for adults to return the ownership of learning to the children because they know what they are doing. It is time for us to trust them and empower them to learn. With children's voices surfacing and their agency exerted during free play, verbalising and carrying out play, more opportunities can be given to them to exercise self and control in the context of a medium like play. Then we can tap the affordances it provides for the learning of primary science, which has elements of play (Laszlo, 2004). Play can help to develop the cognitive, emotional and social growth of older children in primary science.

Appendices

List of Appendices

Appendix 1.1

The Play Protocol (Session 1)

A Teacher's Guide

Topic: Magnets and their characteristics (Part 1)

Duration of play session: 15 minutes

Essential Learning Points from the Lesson (as a guide to ask guiding questions):

- Magnets come in different shapes and sizes.
- Magnets can be made of iron or steel.
- A magnet attracts objects made of magnetic materials.
- Materials that cannot be attracted to a magnet are called non-magnetic materials.
- Not all metals are magnetic.
- All non-metals are non-magnetic.

Materials:

- The different types of magnets:

-u-shaped magnet (big and small but weak)
-horseshoe magnet (big and small but weak)
-rod magnet
-bar magnet
-button magnet (weak and strong versions)
-ring magnet -novelty magnet

- Magnetic and non-magnetic items:

-Strings
-Coins from different countries-Singapore and UK (magnetic and non-magnetic ones)
Magnetic: the new 1 pence, the old 2 pence and the new 5 pence
Non-Magnetic- the 10 pence, 20 pence, 50 pence, 1 pound (new and old) and 2pounds

-twist tie
-marbles
-metal ring (which is non-magnetic)
-pipe cleaner
-metal rulers (aluminium and stainless steel)
-paper clips
-rubber band
-aluminium foil
-plastic spoon
-metal spoon
-can drink ring tab
-magnet's keeper
-wooden block -erasers -

*Acknowledgement: Images of the coins are downloaded from
http://f.tqn.com/y/coins/1/S/i/1/-/-/great-britain-coins-money.jpg

Procedures:

1. Group the children into groups of four.

2. Distribute the pre-packed materials to the groups.

3. Instruct the children not to touch the items before the activity.

4. Take turns and introduce yourself to the recording device by pressing the record button and saying your name.

5. After that, leave the device at the middle of the table and do not touch or play with the recording device.

6. Inform the children on the time allocated (15 minutes) and the teacher's availability to support them by raising their hands to seek help from the teacher.

7. Signal the start of the play session by announcing, "You have 15 minutes for the play session. With the limited resources in front of you, imagine that you are a scientist, play with the materials in the way you wish to investigate. You have the choice and you do not need to play with all the items provided."

8. Time the session by flashing the online stopwatch on the screen **http://www.online-stopwatch.com/eggtimer-countdown/full-screen/**

9. Walk around and just observe from a comfortable distance so as to not 'disrupt' their play.

10. Approach a group only when you can see that there is no activity going on and there is an awkward silence in the group.

11. Ask these suggested guiding questions:
    -Do you need help? How do you want me to help you? What is the problem here?

    If the group says 'no', respect their decision and move away.
    If they need help, proceed to the questions below.
    -How would you like to play with these materials?
    -Next, you wait for response from any child. Build on his/her/their responses by asking questions like:
    - Why did you do that? What did you think had happened? What were you trying to find out? Why did you play in that manner?

    Offer some period of wait time for the group to think and respond. If they are able to respond and can have a sense of what to do, allow them to start on their own and tell them that they can approach you again if they are stuck and do not know what to do next.

12. Give the children a reminder when time approaches the last 5 minutes before the end of the play session and invite them to wrap up with what they have been doing.

13. Stop the play session when time is up and instruct the children to return all materials to the bags on the tray. Collect all the materials back.

Appendix 1.2

The Play Protocol (Session 2)
A Teacher's Guide

Topic:
Magnets and their characteristics (Part 3)

Duration of play session: 15 minutes

Essential Learning Points from the Lesson (as a guide to ask guiding questions):
- A magnet will always come to rest in the North-South direction when it is allowed to turn freely.
- The pole that points to the North is called the North pole and the pole that points to the South is called the South pole.
- Magnets are used in some everyday objects.

Materials:
- Strings
- Scissors
- Compass
- Retort stand
- Masking tape
- Rubber bands
- Basin of water
- Magnetic strips
- Styrofoam plate
- Magnetic buttons
- 2 strong bar magnets

Procedures:

1. Group the children into groups of four.

2. Distribute the pre-packed materials to the groups.

3. Instruct the children not to touch the items before the activity.

4. Take turns and introduce yourself to the recording device by pressing the record button and saying your name.

5. After that, leave the device at the middle of the table and do not touch or play with the recording device.

6. Inform the children on the time allocated (15 minutes) and the teacher's availability to support them by raising their hands to seek help from the teacher.

7. Signal the start of the play session by announcing, "You have 15 minutes for the play session. With the limited resources in front of you, imagine that you are a scientist, play with the materials in the way you wish to investigate. You have the choice and you do not need to play with all the items provided."

8. Time the session by flashing the online stopwatch on the screen **http://www.online-stopwatch.com/eggtimer-countdown/full-screen/**

9. Walk around and just observe from a comfortable distance so as to not 'disrupt' their play.

10. Approach a group only when you can see that there is no activity going on and there is an awkward silence in the group.

11. Ask these suggested guiding questions:
    -Do you need help? How do you want me to help you? What is the problem here?

    If the group says 'no', respect their decision and move away.
    If they need help, proceed to the questions below.
    -How would you like to play with these materials?
    -Next, you wait for response from any child. Build on his/her/their responses by asking questions like:
    - Why did you do that? What did you think had happened? What were you trying to find out? Why did you play in that manner?

    Offer some period of wait time for the group to think and respond. If they are able to respond and can have a sense of what to do, allow them to start on their own and tell them that they can approach you again if they are stuck and do not know what to do next.

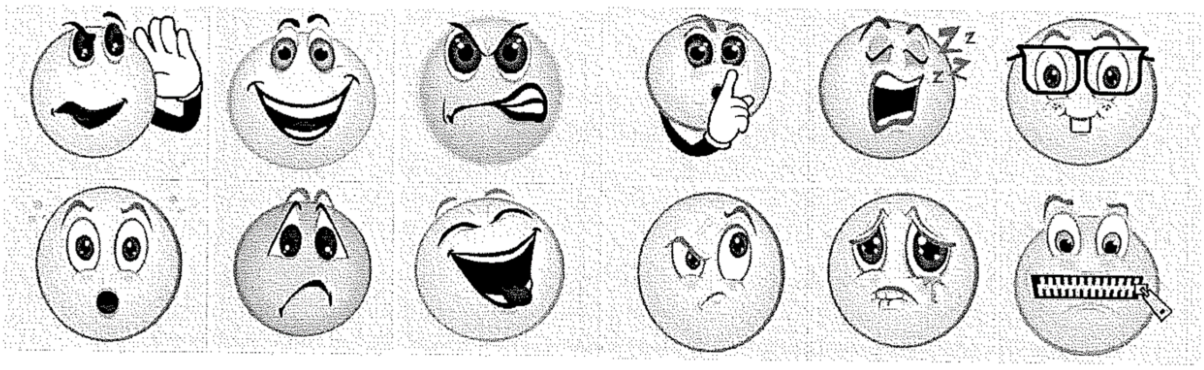
12. Give the children a reminder when time approaches the last 5 minutes before the end of the play session and invite them to wrap up with what they have been doing.

13. Stop the play session when time is up and instruct the children to return all materials to the bags on the tray.

14. Collect all the materials back.

Appendix 3.1

The Emojis used for the children's group interviews



Appendix 3.2

Screen shot of the email in which the ethics audit forms were cleared.

Search mail

Fwd: ethics for WY Tan

Claudine Bowyer-Crane <claudine.bowyer-crane@york.ac.uk>

to Lynda, Elpis, me

Wed, 14 Dec 2016, 11:54

For your information. Thank you for making the suggested changes Woei Yng and good luck with the research.
Claudine
---------- Forwarded message ----------
From: **Claudine Bowyer-Crane** <claudine.bowyer-crane@york.ac.uk>
Date: 14 December 2016 at 11:53
Subject: ethics for WY Tan
To: Jayne McCullagh <educ510@york.ac.uk>

Dear Jayne
Please find the approved ethics application for Woei Yng Tan.
A condition of approval is that Woei Yng has a TA present when conducting focus groups in the UK unless she has a current DBS check.
Best wishes
Claudine

--
Claudine Bowyer-Crane
Senior Lecturer
Psychology in Education Research Centre
Department of Education
The University of York
York, UK
YO10 5DD
01904 324398
http://www.york.ac.uk/education/research/perc/
https://twitter.com/yorkperc

Appendix 3.3: A sample of the actual approved ethical issues audit forms approved by the university.

UNIVERSITY of York

Education Ethics Committee

Ethical Issues Audit Form

This questionnaire should be completed for each research study that you carry out as part of your degree. Once completed, please email this form to your supervisor. You should then discuss the form fully with your supervisor, who should approve the completed form. **You must not collect your data until you have had this form approved by your supervisor (and possibly others - your supervisor will guide you).**

Surname / Family Name:	Tan
First Name / Given Name:	Woei Yng
Programme:	PhD in Education
Supervisor (of this research study):	Dr Lynda Dunlop
Topic (or area) of the proposed research study:	
Play and the learning of Primary Science: A comparative case study of middle primary children in Singapore Primary Schools and UK's Primary Schools.	
Where the research will be conducted:	
4 primary schools in Singapore and 4 primary schools in UK	
Methods that will be used to collect data:	
Video and audio recordings of classroom observations, semi-structured interviews for the teachers and the focus group interviews for the pupils on their perspectives of play before and after the implementation of play sessions during their science lessons.	
If you will be using human participants, how will you recruit them?	
For the pilot study, I would be approaching teachers from my previous school that I had taught in for help. With their help, I would recruit some pupils from the school to try the pilot study. Then for the actual study, I would be recruiting schools through personal contacts first, followed by seeking permissions from the Ministry of Education (MOE) in Singapore and local school authority in the United Kingdom to get schools to participate. I would also try to liaise with the Master teachers from the Academy of Singapore Teachers and ask them to help me to establish the contact with the potential schools.	

All supervisors, please read *Ethical Approval Procedures: Students*.

Taught programme supervisors. Note: If the study involves children, vulnerable participants, sensitive topics, or an intervention into normal educational practice, this form must also be approved by the programme leader (or Programme Director if the supervisor is also the Programme Leader)

Research student supervisors. The application is a joint one by the research student and supervisor(s). It should be submitted to the TAP member for initial approval and then to the Higher Degrees Administrator who will seek a second opinion from a designated member of Education Ethics Committee.

All students: forms may also require review by the full Ethics Committee (see below).

First approval: by the supervisor of the research study **(taught students);** or TAP member **(research students)** (after reviewing the form):

Please select one of the following options.

I believe that this study, as planned, meets normal ethical standards. I have checked that any informed consent form a) addresses the points as listed in this document, and b) uses appropriate language for the intended audience(s).	☒
I am unsure if this study, as planned, meets normal ethical standards	☐
I believe that this study, as planned, does not meet normal ethical standards and requires some modification	☐

TAP member's Name (please type):	Elpis Pavlidou
Date:	08 December 2016

Taught student supervisors - If the study involves children, vulnerable participants, sensitive topics, or an intervention into normal educational practice (see *Ethical Approval Procedures: Students*), please email this form for second approval to the Programme Leader (or Programme Director if the supervisor is also the Programme Leader). For this second approval, other documents may need to be sent in the same email e.g. the proposal (or a summary of it) and any informed consent and participant information sheets. If the study has none of the above characteristics, the supervisor should email this completed form to the Programme Administrator. This signals the end of the approval process and data collection can begin. If the study has none of the above characteristics, the supervisor should email this completed form to the Programme Administrator. This signals the end of the approval process and data collection can begin. The member of the EEC will notify the Programme Administrator only when the final outcome has been decided.

<u>Second approval:</u> by the Programme Leader; or Programme Director; or designated Ethics Committee member for research students:

Please select one of the following options:

I believe that this study, as planned, meets normal ethical standards. I have checked that any informed consent form a) addresses the points as listed in this document, and b) uses appropriate language for the intended audience(s).	x
I am unsure if this study, as planned, meets normal ethical standards	☐
I believe that this study, as planned, does not meet normal ethical standards and requires some modification	☐

Name of Programme Leader; or Programme Director; or Ethics Committee member (please type):	Claudine Bowyer-Crane
Date:	14.12.16

The supervisor should now email this completed form to the Programme Administrator, unless approval is required by the full Ethics Committee (see below).

<u>Approval required by the full Education Ethics Committee</u>

If the application requires review by the full Education Ethics Committee, please select one of the following options then forward the application to the Research Administrator (education-research-administrator@york.ac.uk).

The study involves deception	☐
The study involves an intervention and procedures could cause concerns	☐
The topic is sensitive or potentially distressing	☐
The study involves vulnerable subjects	☐
Other reason:	

Name of Programme Leader; or Programme Director; or TAP member (please type):	
Date:	Click here to enter a date.

FOR COMPLETION BY THE STUDENT

Data sources

1 If your research involves collecting secondary data only **go to SECTION 2**.

2 If your research involves collecting data from people (e.g. by observing, testing, or teaching them, or from interviews or questionnaires) **go to SECTION 1.**

SECTION 1: For studies involving people

3 Is the amount of time you are asking research participants to give reasonable? **YES**

4 Is any disruption to their normal routines at an acceptable level? **YES**

5 Are any of the questions to be asked, or areas to be probed, likely to cause anxiety or distress to research participants? **NO**

6 Are all the data collection methods used necessary? **YES**

7 Are the data collection methods appropriate to the context and participants? **YES**

8 Will the research involve deception? **NO**

9 Will the research involve sensitive or potentially distressing topics? (The latter might include abuse, bereavement, bullying, drugs, ethnicity, gender, personal relationships,

political views, religion, sex, violence. If there is lack of certainty about whether a topic is sensitive, advice should be sought from the Ethics Committee.) **NO**

If YES, what steps will you take to ensure that the methods and procedures are appropriate, not burdensome, and are sensitive to ethical considerations?

10 Does your research involve collecting data from vulnerable or high risk groups? (The latter might include participants who are asylum seekers, unemployed, homeless, looked after children, victims or perpetrators of abuse, or those who have special educational needs. If there is a lack of certainty about whether participants are vulnerable or high risk, advice should be sought from the Ethics Committee. Please note, children with none of the above characteristics are not necessarily vulnerable, though approval for your project must be given by at least two members of staff; see above). **NO**

If YES, what steps will you take to ensure that the methods and procedures are appropriate, not burdensome, and are sensitive to ethical considerations?

11 Are the research participants under 16 years of age? **YES**

If NO, go to question 12.

If YES, and you intend to interact with the children, do you intend to ensure that another adult is present during all such interactions? **NO**

If NO, please explain, for example:

i) This would seriously compromise the validity of the research because [***provide reason***]

I would like them to speak honestly about their experiences during the play sessions, which will be led by the teacher.

ii) I have/will have a full Disclosure and Barring Service check (formerly Criminal Records Bureau check). Choose an item.

iii) Other reasons:

I am currently still under the employment by the Ministry of Education in Singapore and has been a qualified and experienced primary school teacher for 16 years. I will carry out the focus groups in a room with open doors/window.

In the UK, I will carry out the focus groups with an adult such as a teaching assistant present.

Payment to participants

12 If research participants are to receive reimbursement of expenses or any other incentives, including financial, before or after the study, please give details. You should indicate what they will receive and, briefly, the basis on which this was decided.

Small tokens of thanks (such as stationery) as gifts to thank them for their time. This is a common gesture for researchers working in schools in Singapore.

It is often considered good practice to consider what the researcher might offer the participants, in the spirit of reciprocity. Some ideas of what this might be include: materials at the end of the study, a workshop summarising the results of the study, a delayed treatment/intervention at the end of the study, an indication about where the findings might be accessed at a later date, a letter or token of thanks. Please ensure that you have considered the potential for reciprocity in your research.

If your study involves an INTERVENTION i.e. a change to normal practice made for the purposes of the research, go to question 13 (this does not include 'laboratory style' studies i.e. where ALL participation is voluntary):

If your study does not involve an intervention, go to question 20.

13 Is the extent of the change within the range of changes that teachers (or equivalent) would normally be able to make within their own discretion? Choose an item.

14 Will the change be fully discussed with those directly involved (teachers, senior school managers, pupils, parents – as appropriate)? Choose an item.

15 Are you confident that *all* treatments (including comparison groups in multiple intervention studies) will potentially provide some educational benefit that is compatible with current educational aims in that particular context? (Note: This is *not* asking you to justify a non-active control i.e. continued normal practice) Choose an item.

Please **briefly** describe this / these benefit(s):

16 If you intend to have two or more groups, are you offering the control / comparison group an opportunity to have the experimental / innovative treatment at some later point (this can include making the materials available to the school or learners)? Choose an item.

If NO, please explain:

17 If you intend to have two or more groups of participants receiving different treatment, do the informed consent forms give this information? Choose an item.

18 If you are randomly assigning participants to different treatments, have you considered the ethical implications of this? Choose an item.

19 If you are randomly assigning participants to different treatments (including non-active controls), will the institution and participants (or parents where participants are under 16) be informed of this in advance of agreeing to participate? Choose an item.

If NO, please explain:

<u>General protocol for working in institutions</u>

20 Do you intend to conduct yourself, and advise your team to conduct themselves, in a professional manner as a representative of the University of York, respectful of the rules, demands and systems within the institution you are visiting? **YES**

21 If you intend to carry out research with children under 16, have you read and understood the Education Ethics Committee's *Guidance for Ethical Approval for Research in Schools*? **YES**

Informed consent

22 Have you prepared Informed Consent Form(s) which participants in the study will be asked to sign, and which are appropriate for different kinds of participants? **YES**

If YES, **please attach the informed consent form(s).**

If NO, please explain:

23 Please check the details on the informed consent form(s) match each one of your answers below. Does this informed consent form:

a) inform participants in advance about what their involvement in the research study will entail?

YES

b) if there is a risk that participants may disclose information to you which you may feel morally or legally bound to pass on to relevant external bodies, have you included this within a confidentiality clause in your informed consent form? **YES**

c) inform participants of the purpose of the research? **YES**

d) inform participants of what will happen to the data they provide (how this will be stored, who will have access to it, whether and how individuals' identities will be protected during this process)? **YES**

e) if there is a possibility that you may use some of the data publicly (e.g. in presentations or online), inform the participants how identifiable such data will be **and** give them the opportunity to decline such use of data? **YES**

f) give the names and contact details (e.g. email) of at least two people to whom queries, concerns or complaints should be directed? One of these people should be on the Education Ethics Committee (please use education-research-administrator@york.ac.uk) and not involved with the research. **YES**

g) in studies involving interviews or focus groups, inform participants that they will be given an opportunity to comment on your *written record* of the event? **NO**

If NO, have you made this clear this on your consent form? **NO**

If NO, please explain why not:

The written record for the interviews will be given to the teachers only for checking purposes as they will be interviewed alone and will be the point of contact.

h) inform participants how long the data is likely to be kept for? **YES**

i) inform participants if the data could be used for future analysis and/or other purposes?

YES

j) inform participants they may withdraw from the study during data collection?
YES

k) provide a date/timescale by which participants will be able to withdraw their data and tell the participants how to do this? (NB. If your data is going to be completely anonymised, any withdrawal of data needs to happen before this.)YES

**NA if your data will be anonymous at point of collection*

If your answer was NO to any of the above, please explain here, indicating which item(s) you are referring to (a-j):

24 Who will be asked to sign an Informed Consent Form? Please select all that apply:

CATEGORY	
Adult research participants	☐
Research participants under 16	☐
Teachers	☒
Parents	☒
Head/Senior leadership team member	☒
Other (please explain)	☐

25 In studies involving an **intervention** with under 16s, will you seek informed consent from parents?

If NO, please explain:

If YES, please delete to indicate whether this is 'opt-in' or 'opt-out'

If 'opt-out', please explain why 'opt-in' is not being offered:

SECTION 2

Data Storage, Analysis, Management and Protection

26 I am accessing data from a non-publicly available source (regardless of whether the data is identifiable) e.g. pupil data held by a school or local authority, learners' work. YES

If YES, I have obtained written permission, via an informed consent document, from a figure of authority who is responsible for holding the data. This informed consent a) acknowledges

responsibility for releasing the data and b) confirms that releasing the data does not violate any informed consents or implicit agreements at the point the data was initially gathered.

YES

27 I have read and understood the Education Ethics Committee's *Guidance on Data Storage and Protection* YES

28 I will keep any data appropriately secure (e.g. in a locked cabinet), maintaining confidentiality and anonymity (e.g. identifiers will be encoded and the code available to as few people as possible) where possible. YES

29 If your data can be traced to identifiable participants:

a) who will be able to access your data?

Woei Yng Tan and Dr Lynda Dunlop

b) approximately how long will you need to keep it in this identifiable format?

Within the 3 years of my PhD study

30 If working in collaboration with other colleagues, students, or if under someone's supervision, please discuss and complete the following:

We have agreed:

a) [Woei Yng Tan] will be responsible for keeping and storing the data

b) [Woei Yng Tan and Dr. Lynda Dunlop] will have access to the data

c) [Woei Yng Tan and Dr. Lynda Dunlop] will have the rights to publish using the data

Reporting your research

31 In any reports that you write about your research, will you do everything possible to ensure that the identity of any individual research participant, or the institution which they attend or work for, cannot be deduced by a reader? YES

If NO please explain:

Conflict of interests

32 If the Principal Investigator or any other key investigators or collaborators have any direct personal involvement in the organisation sponsoring or funding the research that may give rise to a possible conflict of interest, please give details:

No, there is no conflict of interest.

Potential ethical problems as your research progresses

33 If you see any potential problems arising during the course of the research, please give details here and describe how you plan to deal with them:

Buffer period for make-up sessions in the case if the teacher is sick or away for courses.

Student's Name (please type):	WOEI YNG TAN
Date:	09 November 2016

Please email this form to your supervisor. They must approve it, and send it to the Programme Administrator by email.

NOTE ON IMPLEMENTING THE PROCEDURES APPROVED HERE:

If your plans change as you carry out the research study, you should discuss any changes you make with your supervisor. If the changes are significant, your supervisor may advise you to complete a new 'Ethical issues audit' form.

For Taught Masters students, on submitting your MA dissertation to the programme administrator, you will be asked to sign to indicate that your research did not deviate significantly from the procedures you have outlined above.

For Research Students (MA by Research, MPhil, PhD), once your data collection is over, you must write an email to your supervisor to confirm that your research did not deviate significantly from the procedures you have outlined above.

Appendix 3.4: A sample of the actual approval letter from the Ministry of Education in Singapore for this study.

1 North Buona Vista Drive
Singapore 138675
Robinson Road P.O. Box 746
Telephone : (65) 68722220
Facsimile : (65) 67755826
Website : www.moe.gov.sg
Email : contact@moe.gov.sg

Ministry of Education
SINGAPORE

EDUN N32-07-005

Request No.: **RQ60-17(05)**

2 May 2017

Ms Tan Woei Yng

Dear Ms Tan,

PLAY AND THE LEARNING OF PRIMARY SCIENCE: A COMPARATIVE CASE STUDY OF MIDDLE PRIMARY CHILDREN IN SINGAPORE PRIMARY SCHOOLS AND UNITED KINGDOM (UK'S) PRIMARY SCHOOLS.

I refer to your application for approval to collect data from schools.

2. I am pleased to inform you that the Ministry has no objections to your request to conduct the research in **5 primary schools**, subjected to the following conditions:

a) the approved research proposal is adhered to during the actual study in the school;
b) the data collected is kept strictly confidential and used for the stated purpose only; and
c) the findings are not published without written approval from the Ministry and a copy of the findings is shared with the Ministry upon request.

3. When conducting the data collection in the school, please ensure that the following are carried out:

a) consent is obtained from the Principal for the study to be conducted in the school;
b) written parental consent is obtained before conducting the study with the students;
c) students and teachers are informed that participation in the study is voluntary and they do not need to provide any sensitive information (e.g. name and NRIC No.);
d) participation by the school is duly recorded in Annex A; and
e) the data collection in the school is completed within 1 year from the date of this letter.

4. Please show this letter and all the documents included in this mail package (i.e. the application form, research proposal and research instrument(s) marked as seen by MOE) to seek approval from the Principal and during the actual study.

Yours sincerely

Ang Lee Cheng Stephanie (Ms)
Senior Research Analyst, Corporate Research Office
Research & Management Information Division
for Permanent Secretary (Education)

Note to Principal: Please refer to MOE notification PA/02/17 for the Guidelines on Data Collection from Schools.

Appendix 3.5: Samples of the actual consent forms for the heads, teachers and children's parents or guardians.

THE UNIVERSITY of York

DEPARTMENT OF EDUCATION Heslington,
York, YO10 5DD
Direct Line: (01904) 323455 *Fax*: (01904) 323459
Email: *educ525@york.ac.uk*
Web: *www.york.ac.uk/educ*

Information Page- Principals/ Heads

PhD Project: The Impact of Play On the Learning of Primary Science

Dear Principal/ Head,

I am Miss Tan Woei Yng, a Ministry of Education (MOE) teacher from Singapore who is currently on Professional Development Leave to pursue my Doctorate of Philosophy (PhD) in Science Education at the University of York, in the United Kingdom (UK). I will be carrying out a research study to find out if play has an impact on the learning of primary science in Singapore and UK. I am writing to ask if you would be able to take part in the study.

What would this mean for you as the principal/ head in this study?

If you give consent to take part in this study, you would be asked to:

- Consent to a class from Year 3 (UK) or Primary 3 (Singapore) and their science teacher participating in the study
- Allow the researcher to video and audio-record 5 science lessons (including those involving scientific play), interview the selected science teacher and hold focus groups with children.
- Provide some background information about the school.

Anonymity and confidentiality

For this study, the information of the school will be stored separately from any information provided by the pupils and teacher during the interviews and/or focus groups. This means that your school's identity will only be known to me and not shared anywhere. However, the data we collect may be used in *anonymous* format in different ways: reports, presentations, journal articles and in public engagement activities. In the unlikely event that I gather information that raises concerns about the safety of children, teachers or others, I will pass this information onto an appropriate person in your school.

Storing and using your data

Data will be stored in secure cabinets and/or on a password protected computer. The data will be kept until June 2020, after which time any identifiable data will be destroyed. Anonymised data may be kept and used for future analysis and shared for research or training purposes but participants will not be identified individually.

Risks and Benefits

I do not expect my research to cause any stress or harm from taking part. I do not expect my research to cause any teacher and pupils distress or harm. As for benefits, the aim of the research is to help to provide more insights into how best to manage teaching and learning in primary science.

Right to withdraw

You have the right to withdraw your school at any time during the data collection as well as any set of data up to one week after data collection has taken place.

If you are happy and agree to participate, please sign the attached form and send it back to me.

If you have any questions about the study that you would like to ask before giving consent or after the data collection, please feel free to contact Miss Tan Woei Yng by email (wyt510@york.ac.uk). If you have any concerns about the research, please contact the supervisor (Dr Lynda Dunlop at lynda.dunlop@ork.ac.uk) or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk .

Please keep this information sheet for your own records.

Thank you for taking the time to read this information.

Yours sincerely,

Miss Tan Woei Yng

Researcher

To be submitted

UNIVERSITY of York

Consent Form

PhD Project: The Impact of Play On the Learning of Primary Science

1. I understand that my school will be participating in a research study conducted by the PhD researcher, Miss Tan Woei Yng from the University of York.
2. I understand that the purpose of this research study is to study the impact of play on the learning of primary science in Singapore and United Kingdom.
3. I understand that my identity as well as my school's identity would only be known to the researcher visiting the school and would not be shared anywhere else.
4. I agree to allow the researcher to collect data in the form of video and audio recordings of the science lessons, interviews and focus groups with the teachers and children.
5. I understand that teachers and parents will be asked to consent to take part, and children will be asked to verbally assent to take part in the study.
6. I understand that my school may withdraw at any time during the study and up to a week after data collection.

Please kindly put a tick (✓) in the box provided if you give consent to participate in the study. ☐

School's name:____

Name of Principal/ Head: ____________________________________

Contact number(s): ______________________________________

Contact's email: ____

Signature: ______________________ Date: ______________________

THE UNIVERSITY of York

DEPARTMENT OF EDUCATION Heslington, York, YO10 5DD
Direct Line: (01904) 323455 *Fax*: (01904) 323459
Email: educ525@york.ac.uk
Web: www.york.ac.uk/educ

Information Page-Teachers

PhD Project: The Impact of Play on the Learning of Primary Science

Dear Teacher,

I am Miss Tan Woei Yng, a Ministry of Education (MOE) teacher from Singapore who is currently on Professional Development Leave to pursue my Doctorate of Philosophy (PhD) in Science Education at the University of York, in the United Kingdom (UK). I will be carrying out a research study to find out if play has an impact on the learning of primary science in Singapore and the United Kingdom (UK). I am writing to ask if you would be able to take part in the study.

What would this mean for you as the teacher in this study?

If you give consent to take part in this study, you would:

- Participate in an interview on your perspectives on what is play to you as a teacher or an adult. This would last for 30 minutes and would take place at a time that is at your convenience.
- Be videoed and audio-recorded in your interactions with the pupils during 5 science lessons (1 normal science lesson and 4 science lessons with the last 15 minutes incorporated with scientific play). You would also allow the researcher to carry out focus groups with children about their experiences of scientific play. Verbal assent will be sought from the children, and written consent from their parents.
- Take part in an interview lasting 60 minutes about your experience of scientific play. This would take place at a time that is at your convenience.

The written records for both interviews will be given to you to check that your ideas have been captured accurately.

Anonymity and confidentiality

For this study, your personal information about your teaching experience will be stored separately from the information you provide in your interviews. This means that your identity will only be known to me and will not be shared anywhere. The data we collect in interviews may be used in *anonymous* format in different ways: reports, presentations, journal articles, and in public engagement activities. In the unlikely event that I gather information that raises concerns about their safety or the safety of others, I will pass this information onto an appropriate person in your school.

Storing and using your data

Data such as the storage cards and transcripts will be stored in secure cabinets and/or on a password protected computer. The data will be kept until June 2020, after which any personally identifiable data will be destroyed. Anonymised data may be kept and used for future analysis and shared for research or training purposes but participants will not be identified individually.

We hope you will agree for your data to be included, in anonymous form, in any information shared as a result of this research.

Risks and Benefits

I do not expect my research to cause any teacher stress or harm from taking part. As for benefits, the research aims to find out about the impact of play on teaching and learning in primary science.

Right to withdraw

You have the right to withdraw your school or your own data at any time during the data collection as well as any set of data up to one week after data collection has taken place.

Your school has consented to take part in the study. You would be the point of contact for your school in the study. If you are happy to participate, please sign the attached form and send it back to me.

If you have any questions about the project that you would like to ask before giving consent or after the data collection, please feel free to contact Miss Tan Woei Yng by email (wyt510@york.ac.uk). If you have any concerns about the research, please contact the supervisor (Dr Lynda Dunlop at lynda.dunlop@ork.ac.uk) or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk .

Please keep this information sheet for your own records.

Thank you for taking the time to read this information.

Yours sincerely,

Miss Tan Woei Yng

Researcher

UNIVERSITY of York

To be submitted

Consent Form

PhD Project: The Impact of Play on the Learning of Primary Science

1. I understand that my school is participating in a research study conducted by the PhD researcher, Miss Tan Woei Yng from the University of York.
2. I understand that the purpose of this research study is to study the impact of play and the learning of primary science in Singapore and the United Kingdom.
3. I understand that my identity would only be known to the researcher visiting the school and would not be shared anywhere else.
4. I agree to be recorded during usual teaching sessions and scientific play sessions. I agree to be interviewed about my experiences during scientific play.
5. I understand that I may withdraw at any time during the study and up to a week after data collection.

Please kindly put a tick (✓) in the box provided if you give consent to participate in the study. ☐

School's name: ____

Name of teacher: ____

Contact number(s): ____

Contact's email: ____

Signature: ___________________________ Date: _________________

THE UNIVERSITY of York

DEPARTMENT OF
EDUCATION Heslington,
York, YO10 5DD
Direct Line: (01904)
323455 *Fax*: (01904)
323459
Email:
educ525@york.ac.uk
Web:
www.york.ac.uk/educ

Information Page-Parents/ Caregivers/ Guardians

PhD Project: The Impact of Play on the Learning of Primary Science

Dear Parent/Caregiver/Guardian,

I am Miss Tan Woei Yng, a Ministry of Education (MOE) teacher from Singapore who is currently on Professional Development Leave to pursue a Doctorate of Philosophy (PhD) in Science Education at the University of York, in the United Kingdom (UK). I will be carrying out a research study to find out if play has an impact on the learning of primary science in Singapore and the United Kingdom. I am writing to ask if your child/ward is able to take part in the study.

Your child's class teacher has consented to take part in this study.

What would this mean for your child/ward?
If you consent to your child/ward taking part in this study, he/she would:

- Be asked questions about their experiences of play and how they learn. This would last for 30 minutes.
- Be videoed and audio-recorded for 15 minutes, 4 times in their usual science lessons.
- Be put into focus group and take part in a focus group interview lasting 30 minutes about their experiences of scientific play and what they have learnt.

Your child/ward will be asked to assent to take part in the study, and will be free to withdraw at any time.

Risks and benefits
Please note that all research activities will take place at a time that minimises disruption to their usual classes. Importantly, the research activities will not cause any stress or harm to participants. However, in the unlikely event that I gather information that raises concerns about their safety or the safety of others, I will pass this information onto an appropriate person in your school. As for benefits, these collected data would help to provide more insights in supporting and mediating the learning needs of your child/ward (especially in the subject of Science) in the class as he/she passes through this transition in his/her primary school

education. These would in turn help your child/ward to manage and ease any possible stress that would arise from the transition and learning of a new subject, Science.

Anonymity and confidentiality

For this study, your child's/ward's personal information will be stored separately from the information they provide in their interviews/ focus groups. This means that your child's/ ward's identity will only be known to me and not shared anywhere. The data I collect in interviews may be used in *anonymous* format in different ways: reports, presentations, journal articles, and in public engagement activities. In the unlikely event that I gather information that raises concerns about the safety of your child/ward or the safety of others, I will pass this information onto an appropriate person in their school.

Storing and using your child's data

Data will be stored in secure cabinets and/or on a password protected computer. The data will be kept until June 2020, after which time any personally identifiable data will be destroyed. Anonymised data may be kept and used for future analysis and shared for research or training purposes but participants will not be identified individually.

We hope you will agree for your child's/ward's data to be included, in anonymous form, in any information shared as a result of this research.

Right to withdraw

Research activities will not cause any stress or harm to participants. It will be possible for you and/or your child/ward to withdraw his/her participation individually at any time during the data collection without providing a reason, simply by informing the researcher.

Your child's/ward's teacher has consented to take part in the study. If you are happy for your child/ward to participate, please sign the attached form and send it back to school via your child's/ward's form teachers.

If you have any questions about the project that you would like to ask before giving consent or after the data collection, please feel free to contact Miss Tan Woei Yng by email (wyt510@york.ac.uk). If you have any concerns about the research, please contact the supervisor (Dr Lynda Dunlop at lynda.dunlop@ork.ac.uk) or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk .

Please keep this information sheet for your own records. Thank you for taking the time to read this information.

Yours sincerely,

Miss Tan Woei Yng
Researcher

To be submitted

UNIVERSITY of York

Consent Form

PhD Project: The Impact of Play on the Learning of Primary Science

Please complete this form and return to your child's science teacher.

- I understand that my child's/ward's school is participating in a research study conducted by the PhD researcher, Miss Tan Woei Yng from the University of York.
- I understand that the purpose of this research study is to study the impact of play and the learning of primary science in Singapore and the United Kingdom.
- I understand that my child's/ward's identity would only be known to the researcher visiting the school, and would not be shared anywhere else.
- I agree for my child/ward to take part in a focus group, to be recorded during scientific play sessions and to be interviewed about his/her experiences.
- I understand that my child/ward will be asked for their verbal assent to take part.
- I understand that I may withdraw my child/ward at any time during the study and up to a week after data collection.

I **consent/do not consent*** to my child taking part in the study

School's name: ____

Name of your child/ward: ______________________________ (   )

Class of your child/ward: Primary 3 ____________________

Name of parent/ caregiver/ guardian: ______________________________

Signature: __________________________ Date: __________________________

***Please delete as applicable.**

List of Tables for Appendix 5.3

Appendix 5.3: List of tables and statistical tests for Section 5.3 – Children's Group Talk and Teachers' Talk during the Scientific Play Sessions.

Appendix 5.3 is a collection of tables and statistical tests that were done on the frequency counts on the type of talk that the children [Section 5.31] and teachers [Section 5.32] engaged in during the two scientific play sessions (PS 1 and PS 2) for all talk and science talk. This appendix expands on the data in Chapter 5.

5.31 (a). All Talk: Children

Aim: To find out if there are any statistically significant differences between the grouping of the children for all talk for the 17 types of talk they engaged in during the scientific play session (s).

(i). Scientific Play Session 1 (All Talk- Children)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of CQ is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.230	Retain the null hypothesis.
2	The distribution of CN is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.613	Retain the null hypothesis.
3	The distribution of CE is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.310	Retain the null hypothesis.
4	The distribution of CO is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.756	Retain the null hypothesis.
5	The distribution of CR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.454	Retain the null hypothesis.
6	The distribution of CS is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.763	Retain the null hypothesis.
7	The distribution of CA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.932	Retain the null hypothesis.
8	The distribution of CF(R) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.179	Retain the null hypothesis.
9	The distribution of CF(NR) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.884	Retain the null hypothesis.
10	The distribution of CIP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.221	Retain the null hypothesis.
11	The distribution of COC is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.887	Retain the null hypothesis.
12	The distribution of CTP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.698	Retain the null hypothesis.
13	The distribution of CNM is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.445	Retain the null hypothesis.

14	The distribution of CGH is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.429	Retain the null hypothesis.
15	The distribution of CSR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.395	Retain the null hypothesis.
16	The distribution of CAR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.932	Retain the null hypothesis.
17	The distribution of CIA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.090	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.13: A Hypothesis Test Summary Table for 17 Types of Talk for All Talk Which Took Place During Scientific Play Session 1 for Children.

A Kruskal-Wallis test was carried out here using the percentage of the utterances from Scientific Play Session 1 (PS1). The test shows that the distributions of the percentage of utterances for all types of talks were not similar for all groups, as assessed by visual inspection of a boxplot.

Conclusion:

All 17 types of talk for all talk were not statistically significantly different between different groups of children (Table 5.13) at $p < .05$ level.

There were 17 types of science talk and thus the list of rank means were displayed as below (Table 5.14).

Ranks

	Grp	N	Mean Rank
CF(NR)	1.00	5	8.70
	2.00	5	8.00
	3.00	5	7.30
	Total	15	
CIP	1.00	5	9.00
	2.00	5	5.20
	3.00	5	9.80
	Total	15	
COC	1.00	5	7.60
	2.00	5	8.80
	3.00	5	7.60
	Total	15	
CTP	1.00	5	8.00
	2.00	5	9.20
	3.00	5	6.80

	Total	15	
CNM	1.00	5	9.80
	2.00	5	6.20
	3.00	5	8.00
	Total	15	
CGH	1.00	5	10.00
	2.00	5	6.40
	3.00	5	7.60
	Total	15	
CSR	1.00	5	10.20
	2.00	5	7.20
	3.00	5	6.60
	Total	15	
CAR	1.00	5	8.40
	2.00	5	8.20
	3.00	5	7.40
	Total	15	
CIA	1.00	5	11.30
	2.00	5	6.20
	3.00	5	6.50
	Total	15	
CQ	1.00	5	6.60
	2.00	5	6.60
	3.00	5	10.80
	Total	15	
CN	1.00	5	6.60
	2.00	5	9.40
	3.00	5	8.00
	Total	15	
CE	1.00	5	9.80
	2.00	5	5.60
	3.00	5	8.60
	Total	15	
CO	1.00	5	7.60
	2.00	5	9.20
	3.00	5	7.20
	Total	15	
CR	1.00	5	10.00
	2.00	5	6.60
	3.00	5	7.40
	Total	15	
CS	1.00	5	7.40

	2.00	5	7.40
	3.00	5	9.20
	Total	15	
CA	1.00	5	7.60
	2.00	5	8.60
	3.00	5	7.80
	Total	15	
CF(R)	1.00	5	5.20
	2.00	5	10.40
	3.00	5	8.40
	Total	15	

Table 5.14: A Rank Table for Scientific Play Session 1 (All Talk- Children).

(ii) Scientific Play Session 2 (All Talk- Children)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of CQ is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.179	Retain the null hypothesis.
2	The distribution of CN is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.331	Retain the null hypothesis.
3	The distribution of CE is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.025	Reject the null hypothesis.
4	The distribution of CO is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.613	Retain the null hypothesis.
5	The distribution of CR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.827	Retain the null hypothesis.
6	The distribution of CS is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.756	Retain the null hypothesis.
7	The distribution of CA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.113	Retain the null hypothesis.
8	The distribution of CF(R) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.080	Retain the null hypothesis.
9	The distribution of CF(NR) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.932	Retain the null hypothesis.
10	The distribution of CIP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.482	Retain the null hypothesis.
11	The distribution of COC is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.101	Retain the null hypothesis.
12	The distribution of CTP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.852	Retain the null hypothesis.
13	The distribution of CNM is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.619	Retain the null hypothesis.
14	The distribution of CGH is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.969	Retain the null hypothesis.

15	The distribution of CSR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.395	Retain the null hypothesis.
16	The distribution of CAR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.298	Retain the null hypothesis.
17	The distribution of CIA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.634	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.15: A Hypothesis Test Summary Table for 17 Types of Talk for All Talk Which Took Place During Scientific Play Session 2 for Children.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for all talk between groups. Distributions of the percentage of utterances for all types of talks were not similar for all groups, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 17 dependent variables for all talks, 16 of them were not statistically significantly different between different groups of children (Table 5.15). The percentages of utterances for all talk were only statistically significantly different for Child's Encouragement: $\chi 2(2) = 7.000$, $p = .025$.

Next, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .017$ level. This post hoc analysis revealed statistically significant differences in the percentages of the utterances for Child's Encouragement (CE) between Group B (mean rank=5.40) and Group A (mean rank=12.40) ($p = .040$) but not between Group B and Group C (mean rank-5.20) or Group C and Group A.

Figure 5.3: Statistical relationship between A, B and C during Scientific Play Session 2 (All talk- Children)

(iii) Scientific Play Sessions 1 and 2 (All Talk- Children)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of CQ is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.057	Retain the null hypothesis.
2	The distribution of CN is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.254	Retain the null hypothesis.
3	The distribution of CE is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.016	Reject the null hypothesis.
4	The distribution of CO is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
5	The distribution of CR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.503	Retain the null hypothesis.
6	The distribution of CS is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.939	Retain the null hypothesis.
7	The distribution of CA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.619	Retain the null hypothesis.
8	The distribution of CF(R) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.034	Reject the null hypothesis.
9	The distribution of CF(NR) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.759	Retain the null hypothesis.
10	The distribution of CIP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.181	Retain the null hypothesis.
11	The distribution of COC is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.348	Retain the null hypothesis.
12	The distribution of CTP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.922	Retain the null hypothesis.
13	The distribution of CNM is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.303	Retain the null hypothesis.
14	The distribution of CGH is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.472	Retain the null hypothesis.
15	The distribution of CSR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.125	Retain the null hypothesis.
16	The distribution of CAR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.719	Retain the null hypothesis.
17	The distribution of CIA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.138	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.16: A Hypothesis Test Summary Table for 17 Types of Talk for All Talk Which Took Place During Scientific Play Session 1 and 2 for Children.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for all talk between groups that were assigned by their teachers: the "Group A" (n = 10), "Group B" (n = 10) and "Group C" (n = 10).

Distributions of the percentage of utterances for all types of talks were not similar for all groups, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 17 dependent variables for all talks, 15 of them were not statistically significantly different between different groups of children (Table 5.16). The percentages of utterances for all talk were only statistically significantly different between different groups of children for two types of talks; Child's Encouragement, $\chi 2(2) = 8.276$, $p = .016$ and Child's Feedback [CF (R)], $\chi 2(2) = 6.760$, $p = .034$.

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .017$ level. This post hoc analysis revealed statistically significant differences in the percentages of the utterances for Child's Encouragement (CE) between Group B (mean rank=10.60) and Group A (mean rank=21.70) (p = .005) but not between Group B and Group C (mean rank-14.20) or Group C and Group A and Child's Feedback [CF (R)] between Group A (mean rank= 11.30) and Group B (mean rank= 21.20) (p = .012) but not between Group A and Group C (mean rank=14.00) or Group C and Group B.

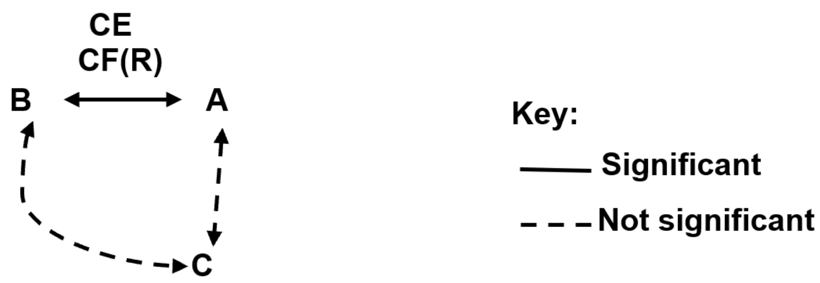


Figure 5.4: Statistical relationship between A, B and C during Scientific Play Sessions 1 and 2 (All talk- Children)

5.31 (b) Science Talk: Children

Aim: To find out if there are any statistically significant differences between the grouping of the children for science talk for the 17 types of talk the children engaged in during the scientific play session (s).

(i) Scientific Play Session 1 (Science Talk- Children)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of CQ is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.369	Retain the null hypothesis.
2	The distribution of CN is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.065	Retain the null hypothesis.
3	The distribution of CE is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.137	Retain the null hypothesis.
4	The distribution of CO is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.230	Retain the null hypothesis.
5	The distribution of CR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.777	Retain the null hypothesis.
6	The distribution of CS is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.541	Retain the null hypothesis.
7	The distribution of CA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.772	Retain the null hypothesis.
8	The distribution of CF_(R) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.196	Retain the null hypothesis.
9	The distribution of CF_(NR) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
10	The distribution of CIP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.357	Retain the null hypothesis.
11	The distribution of COC is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.925	Retain the null hypothesis.
12	The distribution of CTP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.961	Retain the null hypothesis.
13	The distribution of CNM is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.602	Retain the null hypothesis.
14	The distribution of CGH is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.362	Retain the null hypothesis.
15	The distribution of CSR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.613	Retain the null hypothesis.
16	The distribution of CAR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.460	Retain the null hypothesis.
17	The distribution of CIA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.275	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.17: A Hypothesis Test Summary Table for 17 Types of Talk for Science Talk Which Took Place During Scientific Play Session 1 for Children.

A Kruskal-Wallis H test was conducted using the percentage of the science utterances of children for Scientific Play Session 1 (PS1).

Conclusion:

The test shows that the distributions of the percentage of utterances for all types of talks were not similar for all groups, as assessed by visual inspection of a boxplot. All 17 types of talk for all talk were not statistically significantly different between different groups of children (Table 5.17) at $p < .05$ level. There were 17 types of science talks and thus the mean ranks were displayed as below (Table 5.18).

Ranks

	GRP	N	Mean Rank
CQ	1.00	5	9.20
	2.00	5	5.70
	3.00	5	9.10
	Total	15	
CN	1.00	5	11.20
	2.00	5	8.20
	3.00	5	4.60
	Total	15	
CE	1.00	5	11.20
	2.00	5	5.90
	3.00	5	6.90
	Total	15	
CO	1.00	5	9.40
	2.00	5	9.40
	3.00	5	5.20
	Total	15	
CR	1.00	5	7.00
	2.00	5	9.00
	3.00	5	8.00
	Total	15	
CS	1.00	5	6.20
	2.00	5	9.00
	3.00	5	8.80
	Total	15	
CA	1.00	5	9.00
	2.00	5	7.00
	3.00	5	8.00
	Total	15	

CF_(R)	1.00	5	7.40
	2.00	5	10.80
	3.00	5	5.80
	Total	15	
CF_(NR)	1.00	5	8.00
	2.00	5	8.00
	3.00	5	8.00
	Total	15	
CIP	1.00	5	8.40
	2.00	5	9.80
	3.00	5	5.80
	Total	15	
COC	1.00	5	7.90
	2.00	5	7.50
	3.00	5	8.60
	Total	15	
CTP	1.00	5	8.00
	2.00	5	7.60
	3.00	5	8.40
	Total	15	
CNM	1.00	5	6.60
	2.00	5	8.00
	3.00	5	9.40
	Total	15	
CGH	1.00	5	9.30
	2.00	5	8.20
	3.00	5	6.50
	Total	15	
CSR	1.00	5	8.00
	2.00	5	9.40
	3.00	5	6.60
	Total	15	
CAR	1.00	5	8.80
	2.00	5	9.00
	3.00	5	6.20
	Total	15	
CIA	1.00	5	6.80
	2.00	5	7.00
	3.00	5	10.20
	Total	15	

Table 5.18: A Rank Table for Scientific Play Session 1 (Science Talk- Children).

(ii) Scientific Play Session 2 (Science Talk- Children)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of CQ is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.289	Retain the null hypothesis.
2	The distribution of CN is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.049	Reject the null hypothesis.
3	The distribution of CE is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.067	Retain the null hypothesis.
4	The distribution of CO is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.811	Retain the null hypothesis.
5	The distribution of CR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.470	Retain the null hypothesis.
6	The distribution of CS is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.811	Retain the null hypothesis.
7	The distribution of CA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.811	Retain the null hypothesis.
8	The distribution of CF_(R) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.445	Retain the null hypothesis.
9	The distribution of CF_(NR) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
10	The distribution of CIP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.264	Retain the null hypothesis.
11	The distribution of COC is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.125	Retain the null hypothesis.
12	The distribution of CTP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.454	Retain the null hypothesis.
13	The distribution of CNM is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.533	Retain the null hypothesis.
14	The distribution of CGH is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.620	Retain the null hypothesis.
15	The distribution of CSR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.887	Retain the null hypothesis.
16	The distribution of CAR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.990	Retain the null hypothesis.
17	The distribution of CIA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.317	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.19: A Hypothesis Test Summary Table for 17 Types of Talk for Science Talk Which Took Place During Scientific Play Session 2 for Children.

A Kruskal-Wallis H test was conducted using the percentage of the science utterances of children for Scientific Play Session 2 (PS 2).

Conclusion:

The test shows that the distributions of the percentage of utterances for all types of talks were not similar for all groups, as assessed by visual inspection of a boxplot. 16 out of 17 types of science talk were not statistically significantly different between different groups of children (Table 28) at $p < .05$ level. The percentages of utterances for science talk were only statistically significantly different for Child's Non-Reasoned Question (CN), $\chi2(2) = 6.020$, $p = .049$.

Next, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .017$ level. This post hoc analysis revealed statistically significant differences in the percentages of the utterances for CN between Group A (mean rank=4.20) and Group B (mean rank=11.00) ($p = .049$) but not between Group A and Group C (mean rank=8.80) or Group C and Group B.

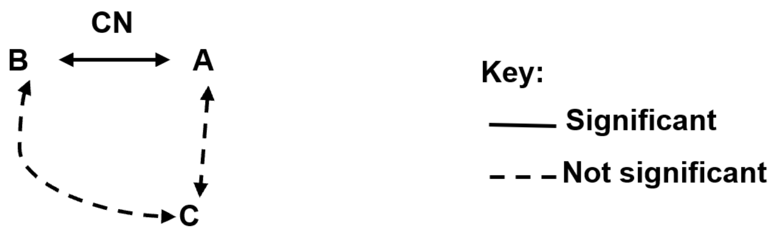


Figure 5.5: Statistical relationship between A, B and C in Scientific Play Session 2 (Science Talk- Children)

(iii) Play Sessions 1 and 2 (Science Talk- Children)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of CQ is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.119	Retain the null hypothesis.
2	The distribution of CN is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.436	Retain the null hypothesis.
3	The distribution of CE is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.925	Retain the null hypothesis.
4	The distribution of CO is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.285	Retain the null hypothesis.
5	The distribution of CR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.654	Retain the null hypothesis.
6	The distribution of CS is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.426	Retain the null hypothesis.
7	The distribution of CA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.906	Retain the null hypothesis.
8	The distribution of CF_(R) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.612	Retain the null hypothesis.
9	The distribution of CF_(NR) is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
10	The distribution of CIP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.401	Retain the null hypothesis.
11	The distribution of COC is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.495	Retain the null hypothesis.
12	The distribution of CTP is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.865	Retain the null hypothesis.
13	The distribution of CNM is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.563	Retain the null hypothesis.
14	The distribution of CGH is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.817	Retain the null hypothesis.
15	The distribution of CSR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.572	Retain the null hypothesis.
16	The distribution of CAR is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.622	Retain the null hypothesis.
17	The distribution of CIA is the same across categories of Grp.	Independent-Samples Kruskal-Wallis Test	.823	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.20: A Hypothesis Test Summary Table for 17 Types of Talk for Science Talk Which Took Place During Scientific Play Sessions 1 and 2 for Children.

A Kruskal-Wallis H test was run to determine if there were differences in the percentages of scores in utterances for the 17 types of science talk between three groups of children with different grouping: A, B and C. Distributions of percentages of utterances for the 17 types of science talk were not similar for all groups, as assessed by visual inspection of a boxplot.

Conclusion:

All 17 types of talk for science talk were not statistically significantly different between different groups of children (Table 5.20) at $p < .05$ level. There were 17 types of science talk and thus the list of rank means was displayed as below.

Ranks

	GRP	N	Mean Rank
CQ	1.00	10	19.00
	2.00	10	11.05
	3.00	10	16.45
	Total	30	
CN	1.00	10	13.70
	2.00	10	18.40
	3.00	10	14.40
	Total	30	
CE	1.00	10	14.70
	2.00	10	15.55
	3.00	10	16.25
	Total	30	
CO	1.00	10	17.20
	2.00	10	17.40
	3.00	10	11.90
	Total	30	
CR	1.00	10	15.70
	2.00	10	17.20
	3.00	10	13.60
	Total	30	
CS	1.00	10	12.70
	2.00	10	17.75
	3.00	10	16.05
	Total	30	
CA	1.00	10	15.90
	2.00	10	14.50
	3.00	10	16.10
	Total	30	
CF_(R)	1.00	10	13.60
	2.00	10	17.50

	3.00	10	15.40
	Total	30	
CF_(NR)	1.00	10	15.50
	2.00	10	15.50
	3.00	10	15.50
	Total	30	
CIP	1.00	10	12.70
	2.00	10	18.00
	3.00	10	15.80
	Total	30	
COC	1.00	10	12.85
	2.00	10	17.25
	3.00	10	16.40
	Total	30	
CTP	1.00	10	15.10
	2.00	10	16.70
	3.00	10	14.70
	Total	30	
CNM	1.00	10	14.85
	2.00	10	13.80
	3.00	10	17.85
	Total	30	
CGH	1.00	10	16.70
	2.00	10	14.60
	3.00	10	15.20
	Total	30	
CSR	1.00	10	14.20
	2.00	10	17.90
	3.00	10	14.40
	Total	30	
CAR	1.00	10	16.55
	2.00	10	16.55
	3.00	10	13.40
	Total	30	
CIA	1.00	10	15.95
	2.00	10	14.40
	3.00	10	16.15
	Total	30	

Table 5.21: A Rank Table for Scientific Play Sessions 1 and 2 (Science Talk- Children).

5.32 (a). All Talk: Teachers

Aim: To find out if there are any statistically significant differences between the type of teacher for all talk for the 13 types of talk she or he engaged in during the scientific play session (s).

(i). Scientific Play Session 1 (All Talk- Teachers)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of TN is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.055	Retain the null hypothesis.
2	The distribution of TQ is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.063	Retain the null hypothesis.
3	The distribution of TE is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.034	Reject the null hypothesis.
4	The distribution of TO is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.519	Retain the null hypothesis.
5	The distribution of TR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.073	Retain the null hypothesis.
6	The distribution of TS is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.406	Retain the null hypothesis.
7	The distribution of TA is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.174	Retain the null hypothesis.
8	The distribution of TF (R) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.201	Retain the null hypothesis.
9	The distribution of TF (NR) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.214	Retain the null hypothesis.
10	The distribution of TIC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.026	Reject the null hypothesis.
11	The distribution of TTC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.076	Retain the null hypothesis.
12	The distribution of TOH is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.519	Retain the null hypothesis.
13	The distribution of TGR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.037	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.22: A Hypothesis Test Summary Table for 13 Types of Talk for All Talk Which Took Place During Scientific Play Session 1 for Teachers.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for all talk between the five teachers for Play Session 1: Teacher 1 (n = 1), Teacher 2 (n = 1), Teacher 3 (n = 1), Teacher 4 (n = 1) and Teacher 5 (n = 1), during the play session. Distributions of the percentage of utterances for all types of talks were not similar for all teachers, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 13 dependent variables for all talks, 10 of them were not statistically significantly different between different teachers (Table 5.22). The percentages of utterances for all talk were statistically significantly different for three types of talks for all talk:

(i) Teacher's Encouragement (TE)- $\chi2(4) = 10.436$, $p = .034$,
(ii) Teacher Instructing Child (TIC)- $\chi2(4) = 11.086$, $p = .026$,
(iii) Teacher Giving Reassurance (TGR)- $\chi2(4) = 10.207$, $p = .037$,

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .005$ level for each of three talks.

(i) Teacher's Encouragement (TE)
The post hoc analysis showed no statistically significant pairwise comparisons in all five teachers.

(ii) Teacher Instructing Child (TIC)
A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 4 (mean rank = 2.67) and Teacher 5 (mean rank = 13.33) (p=.035), but not between any other teacher's combinations.

(iii) Teacher Giving Reassurance (TGR)
A post hoc analysis revealed statistically significant differences in the percentages of utterances between Teacher 5 (mean rank = 2.50) and Teacher 1 (mean rank = 12.67) (p=.050), but not between any other teacher's combinations.

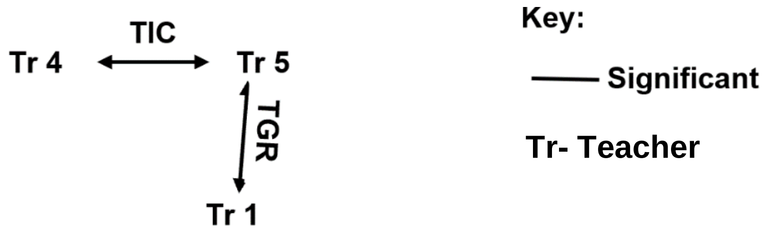


Figure 5.6: Statistical relationship between Tr 4 and Tr 5 and Tr 1 and Tr 5 in Scientific Play Session 1 (All Talk- Teachers)

(ii) Scientific Play Session 2 (All Talk- Teachers)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of TN is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.041	Reject the null hypothesis.
2	The distribution of TQ is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.015	Reject the null hypothesis.
3	The distribution of TE is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.073	Retain the null hypothesis.
4	The distribution of TO is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.077	Retain the null hypothesis.
5	The distribution of TR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.451	Retain the null hypothesis.
6	The distribution of TS is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.406	Retain the null hypothesis.
7	The distribution of TA is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.054	Retain the null hypothesis.
8	The distribution of TF_(R) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.067	Retain the null hypothesis.
9	The distribution of TF_(NR) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.113	Retain the null hypothesis.
10	The distribution of TIC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.016	Reject the null hypothesis.
11	The distribution of TTC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.298	Retain the null hypothesis.
12	The distribution of TOH is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.256	Retain the null hypothesis.
13	The distribution of TGR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.103	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.23: A Hypothesis Test Summary Table for 13 Types of Talk for All Talk Which Took Place During Scientific Play Session 2 for Teachers.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for all talk between the five teachers for Play Session 2: Teacher 1 (n = 1), Teacher 2 (n = 1), Teacher 3 (n = 1), Teacher 4 (n = 1) and Teacher

5 (n = 1), during the play session. Distributions of the percentage of utterances for all types of talks were not similar for all teachers, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 13 dependent variables for all talks, 10 of them were not statistically significantly different between different teachers (Table 5.23). The percentages of utterances for all talk were statistically significantly different for three types of talks for all talk:

(i) Teacher's Non-Reasoned Questions (TN)- $\chi2(4) = 9.990$, $p = .041$,
(ii) Teacher's Reasoned Questions (TQ)- $\chi2(4) = 12.368$, $p = .015$,
(iii) Teacher Instructing Child (TIC)- $\chi2(4) = 12.142$, $p = .016$,

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .005$ level for each of three talks.

(i) Teacher's Non-Reasoned Questions (TN)

The post hoc analysis showed no statistically significant pairwise comparisons in all five teachers.

(ii) Teacher's Reasoned Questions (TQ)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 2.50) and Teacher 4 (mean rank = 13.67) (p=.020), but not between any other teacher's combinations.

(iii) Teacher Instructing Child (TIC)

A post hoc analysis revealed statistically significant differences in the percentages of utterances between Teacher 4 (mean rank = 2.33) and Teacher 5 (mean rank = 13.50) (p=.020), but not between any other teacher's combinations.

Figure 5.7: Statistical relationship between Tr 4 and Tr 5 in Scientific Play Session 2 (All Talk- Teachers)

(iii) Scientific Play Sessions 1 and 2 (All Talk- Teachers)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of TN is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.003	Reject the null hypothesis.
2	The distribution of TQ is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
3	The distribution of TE is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.004	Reject the null hypothesis.
4	The distribution of TO is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.302	Retain the null hypothesis.
5	The distribution of TR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.048	Reject the null hypothesis.
6	The distribution of TS is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.540	Retain the null hypothesis.
7	The distribution of TA is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.362	Retain the null hypothesis.
8	The distribution of TF_(R) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.026	Reject the null hypothesis.
9	The distribution of TF_(NR) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.085	Retain the null hypothesis.
10	The distribution of TIC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
11	The distribution of TTC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.022	Reject the null hypothesis.
12	The distribution of TOH is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.217	Retain the null hypothesis.
13	The distribution of TGR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.002	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.24: A Hypothesis Test Summary Table for 13 Types of Talk for All Talk Which Took Place During Scientific Play Sessions 1 and 2 for Teachers.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for all talk between the five teachers for Session 1 and 2:

Teacher 1 (n = 2), Teacher 2 (n = 2), Teacher 3 (n = 2), Teacher 4 (n = 2) and Teacher 5 (n = 2), during the play session. Distributions of the percentage of utterances for all types of talks were not similar for all teachers, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 13 dependent variables for all talks, 5 of them were not statistically significantly different between different teachers (Table 5.24). The percentages of utterances for all talk were statistically significantly different for eight types of talks for all talk:

(i) Teacher's Non-Reasoned Questions (TN)- $\chi2(4) = 16.100$, $p = .003$,
(ii) Teacher's Reasoned Questions (TQ)- $\chi2(4) = 21.465$, $p = .000$,
(iii) Teacher's Encouragement (TE)- $\chi2(4) = 15.577$, $p = .004$,
(iv) Teacher's Recall (TR)- $\chi2(4) = 9.581$, $p = .048$,
(v) Teacher's Reasoned Feedback [TF (R)]- - $\chi2(4) = 11.061$, $p = .026$,
(vi) Teacher Instructing Child (TIC)- $\chi2(4) = 23.283$, $p = .000$,
(vii) Teacher Teaching Child (TTC)- $\chi2(4) = 11.416$, $p = .022$, and
(viii) Teacher Giving Reassurance (TGR)- $\chi2(4) = 16.542$, $p = .002$,

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .005$ level for each of three talks.

(i) Teacher's Non-Reasoned Questions (TN)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 2.50) and Teacher 4 (mean rank = 13.67) (p=.020), but not between any other teacher's combinations.

(ii) Teacher's Reasoned Questions (TQ)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 6.25) and Teacher 1 (mean rank = 22.17) (p= .017), Teacher 5 and Teacher 4 (mean rank = 25.67) (p= .001) and

Teacher 3 (mean rank = 9.17) and Teacher 4 (mean rank = 25.67) (p= .011), but not between Teacher 2 (mean rank= 14.25) or any other teacher's combinations.

(iii) Teacher's Encouragement (TE)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 9.50) and Teacher 4 (mean rank = 26.17) (p=.002) and Teacher 2 (mean rank = 13.50) and Teacher 4 (mean rank = 26.17) (p=.049), but not between Teacher 1 (mean rank= 14.67), Teacher 3 (mean rank = 13.67) or any other teacher's combinations.

(iv) Teacher's Recall (TR)

The post hoc analysis showed no statistically significant pairwise comparisons in all five teachers.

(v) Teacher's Reasoned Feedback [TF (R)]

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 5.50) and Teacher 1 (mean rank = 20.92) (p=.020) but not between Teacher 2 (mean rank = 17.83), Teacher 3 (mean rank = 16.25) and Teacher 4 (mean rank = 17.00) or any other teacher's combinations.

(vi) Teacher Instructing Child (TIC)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 4 (mean rank = 4.67) and Teacher 3 (mean rank = 21.00) (p=.013), Teacher 4 and Teacher 5 (mean rank = 26.00) (p=.000) and Teacher 1 (mean rank = 9.17) and Teacher 5 (p=.009), but not between Teacher 2 (mean rank= 16.67) or any other teacher's combinations.

(vii) Teacher Teaching Child (TTC)

The post hoc analysis showed no statistically significant pairwise comparisons in all five teachers.

(viii) Teacher Giving Reassurance (TGR)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 6.50) and Teacher 1 (mean rank = 25.33) (p=.001) and Teacher 2 (mean rank = 11.42) and Teacher 1 (p=.047), but not between Teacher 3 (mean rank= 16.67), Teacher 4 (mean rank= 17.58) or any other teacher's combinations.

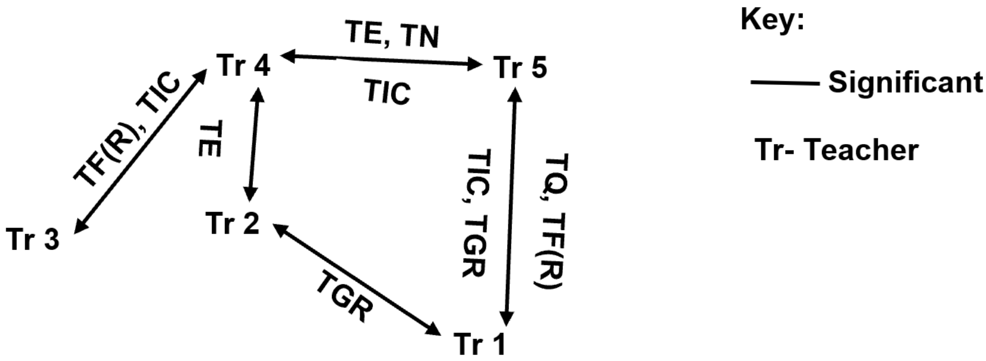


Figure 5.8: Statistical relationship between 5 teachers in Scientific Play Sessions 1 and 2 (All Talk- Teachers)

5.32 (b) Science Talk: Teachers

To find out if there are any statistically significant differences between the type of teacher for science talk for the 13 types of talk she or he engaged in during the scientific play session (s).

(i) Scientific Play Session 1 (Science Talk- Teachers)

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of TN is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.030	Reject the null hypothesis.
2	The distribution of TQ is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.031	Reject the null hypothesis.
3	The distribution of TE is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.066	Retain the null hypothesis.
4	The distribution of TO is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.406	Retain the null hypothesis.
5	The distribution of TR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.406	Retain the null hypothesis.
6	The distribution of TS is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.406	Retain the null hypothesis.
7	The distribution of TA is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.362	Retain the null hypothesis.
8	The distribution of TF_(R) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.190	Retain the null hypothesis.
9	The distribution of TF_(NR) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
10	The distribution of TIC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.202	Retain the null hypothesis.
11	The distribution of TTC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.152	Retain the null hypothesis.
12	The distribution of TOH is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.519	Retain the null hypothesis.
13	The distribution of TGR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.078	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.25: A Hypothesis Test Summary Table for 13 Types of Talk for Science Talk Which Took Place During Scientific Play Session 1 for Teachers.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for science talk between the five teachers for Play Session 1: Teacher 1 (n = 1), Teacher 2 (n = 1), Teacher 3 (n = 1), Teacher 4 (n = 1) and Teacher 5 (n = 1), during the play session. Distributions of the percentage of utterances for science talk were not similar for all teachers, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 13 dependent variables for science talks, 11 of them were not statistically significantly different between different teachers (Table 40). The percentages of utterances for science talk were statistically significantly different for two types of science talk:

(i) Teacher's Non-Reasoned Questions (TN)- $\chi2(4) = 10.729$, $p = .030$ and
(ii) Teacher's Reasoned Questions (TQ)- $\chi2(4) = 10.633$, $p = .031$,

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .005$ level for each of two science talk.

(i) Teacher's Non-Reasoned Questions (TN)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of science talk between Teacher 5 (mean rank = 3.50) and Teacher 4 (mean rank = 14.00) (p=.030) but not between Teacher 1 (mean rank = 8.17), Teacher 2 (mean rank = 5.00) and Teacher 3 (mean rank = 9.33) or any other teacher's combinations.

(ii) Teacher's Reasoned Questions (TQ)

The post hoc analysis showed no statistically significant pairwise comparisons in all five teachers.

Figure 5.9: Statistical relationship between Tr 4 and Tr 5 in Scientific Play Session 1 (Science Talk- Teachers)

(ii) Scientific Play Session 2 (Science Talk- Teachers)

	Hypothesis Test Summary			
	Null Hypothesis	**Test**	**Sig.**	**Decision**
1	The distribution of TN is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.041	Reject the null hypothesis.
2	The distribution of TQ is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.014	Reject the null hypothesis.
3	The distribution of TE is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.027	Reject the null hypothesis.
4	The distribution of TO is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.048	Reject the null hypothesis.
5	The distribution of TR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.224	Retain the null hypothesis.
6	The distribution of TS is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.406	Retain the null hypothesis.
7	The distribution of TA is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.252	Retain the null hypothesis.
8	The distribution of TF_(R) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.034	Reject the null hypothesis.
9	The distribution of TF_(NR) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
10	The distribution of TIC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.016	Reject the null hypothesis.
11	The distribution of TTC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.259	Retain the null hypothesis.
12	The distribution of TOH is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.256	Retain the null hypothesis.
13	The distribution of TGR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.294	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 5.26: A Hypothesis Test Summary Table for 13 Types of Talk for Science Talk Which Took Place During Scientific Play Session 2 for Teachers.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for science talk between the five teachers for Play Session 2: Teacher 1 (n = 1), Teacher 2 (n = 1), Teacher 3 (n = 1), Teacher 4 (n = 1) and Teacher 5 (n = 1), during the play session. Distributions of the percentage of utterances for science talk were not similar for all teachers, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 13 dependent variables for science talk, 7 of them were not statistically significantly different between different teachers (Table 5.26). The percentages of utterances for science talk were statistically significantly different for six types of science talk:

(i) Teacher's Non-Reasoned Questions (TN)- $\chi2(4) = 9.982$, $p = .041$,
(ii) Teacher's Reasoned Questions (TQ)- $\chi2(4) = 12.481$, $p = .014$,
(iii) Teacher's Encouragement (TE)- $\chi2(4) = 10.925$, $p = .027$,
(iv) Teacher's Observations (TO)- $\chi2(4) = 9.581$, $p = .048$,
(v) Teacher's Reasoned Feedback [TF (R)]- - $\chi2(4) = 10.432$, $p = .034$ and
(vi) Teacher Instructing Child (TIC)- $\chi2(4) = 12.122$, $p = .016$,

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .005$ level for each of two science talk. The post hoc analysis was carried out for all six types of science talk and they showed that there were no statistically significant pairwise comparisons in all five teachers for all the cases.

(ii) Scientific Play Sessions 1 and 2 (Science Talk- Teachers)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of TN is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.001	Reject the null hypothesis.
2	The distribution of TQ is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
3	The distribution of TE is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.001	Reject the null hypothesis.
4	The distribution of TO is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.114	Retain the null hypothesis.
5	The distribution of TR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.064	Retain the null hypothesis.
6	The distribution of TS is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.540	Retain the null hypothesis.
7	The distribution of TA is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.336	Retain the null hypothesis.
8	The distribution of TF_(R) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.003	Reject the null hypothesis.
9	The distribution of TF_(NR) is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
10	The distribution of TIC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.029	Reject the null hypothesis.
11	The distribution of TTC is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.033	Reject the null hypothesis.

12	The distribution of TOH is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.217	Retain the null hypothesis.
13	The distribution of TGR is the same across categories of TR.	Independent-Samples Kruskal-Wallis Test	.021	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Table 5.27: A Hypothesis Test Summary Table for 13 Types of Talk for Science Talk Which Took Place During Scientific Play Sessions 1 and 2 for Teachers.

A Kruskal-Wallis test was conducted to determine if there were differences in the percentages of utterances for science talk between the five teachers for Play Session 2: Teacher 1 (n = 2), Teacher 2 (n = 2), Teacher 3 (n = 2), Teacher 4 (n = 2) and Teacher 5 (n = 2), during the play session. Distributions of the percentage of utterances for science talk were not similar for all teachers, as assessed by visual inspection of a boxplot.

Conclusion:

Out of the 13 dependent variables for science talk, 6 of them were not statistically significantly different between different teachers (Table 5.27). The percentages of utterances for science talk were statistically significantly different for seven types of science talk:

(i) Teacher's Non-Reasoned Questions (TN)- $\chi2(4) = 18.532$, $p = .001$,
(ii) Teacher's Reasoned Questions (TQ)- $\chi2(4) = 22.187$, $p = .000$,
(iii) Teacher's Encouragement (TE)- $\chi2(4) = 17.848$, $p = .001$,
(iv) Teacher's Reasoned Feedback [TF (R)]- - $\chi2(4) = 15.822$, $p = .003$,
(v) Teacher Instructing Child (TIC)- $\chi2(4) = 10.789$, $p = .029$,
(vi) Teacher Teaching Child (TTC)- $\chi2(4) = 10.488$, $p = .033$, and
(vii) Teacher Giving Reassurance (TGR)- $\chi2(4) = 11.508$, $p = .021$,

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was made with statistical significance accepted at the $p < .005$ level for each of the seven science talk.

(i) Teacher's Non-Reasoned Questions (TN)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of science talk between Teacher 5 (mean rank = 6.50) and Teacher 4 (mean rank = 25.42) (p=.001), and Teacher 2 (mean rank = 10.92) and Teacher 4 (p= .032), but not between Teacher 1 (mean rank= 20.25), Teacher 3 (mean rank= 14.42) or any other teacher's combinations.

(ii) Teacher's Reasoned Questions (TQ)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of science talk between Teacher 3 (mean rank = 9.00) and Teacher 1 (mean rank = 22.00) (p= .047), Teacher 3 and Teacher 4 (mean rank = 25.33) (p= .004), Teacher 5 (mean rank = 9.00) and Teacher 1 (p= .047), Teacher 5 and Teacher 4 (p= .004) and Teacher 2 (mean rank = 12.17) and Teacher 4 (mean rank = 25.33) (p= .042) but not any other teacher's combinations.

(iii) Teacher's Encouragement (TE)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of science talk between Teacher 5 (mean rank = 11.00) and Teacher 4 (mean rank = 26.33) (p=.002), Teacher 3 (mean rank = 13.00) and Teacher 4 (p=.012), Teacher 2 (mean rank = 13.17) and Teacher 4 (p=.014) and Teacher 1 (mean rank = 14.00) and Teacher 4 (p=.028) but not any other teacher's combinations.

(iv) Teacher's Reasoned Feedback [TF (R)]

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 3 (mean rank = 11.50) and Teacher 1 (mean rank = 24.92) (p=.007), Teacher 5 (mean rank = 11.50) and Teacher 1 (p=.007) and Teacher 2 (mean rank = 13.75) and Teacher 1 (p=.048) but not between Teacher 4 (mean rank = 17.00) or any other teacher's combinations.

(v) Teacher Instructing Child (TIC)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of science talk between Teacher 3 (mean rank = 10.83) and Teacher 1 (mean rank = 24.00) (p=.042) but not between Teacher 2 (mean rank= 17.00), Teacher

4 (mean rank= 14.17), and Teacher 5 (mean rank = 11.50) or any other teacher's combinations.

(vi) Teacher Teaching Child (TTC)

The post hoc analysis showed no statistically significant pairwise comparisons in all five teachers.

(vii) Teacher Giving Reassurance (TGR)

A post hoc analysis revealed statistically significant differences in the percentages of utterances of all talk between Teacher 5 (mean rank = 10.00) and Teacher 1 (mean rank = 23.67) (p=.019) but not between Teacher 2 (mean rank= 11.83), Teacher 3 (mean rank= 15.83), Teacher 4 (mean rank= 16.17) or any other teacher's combinations.

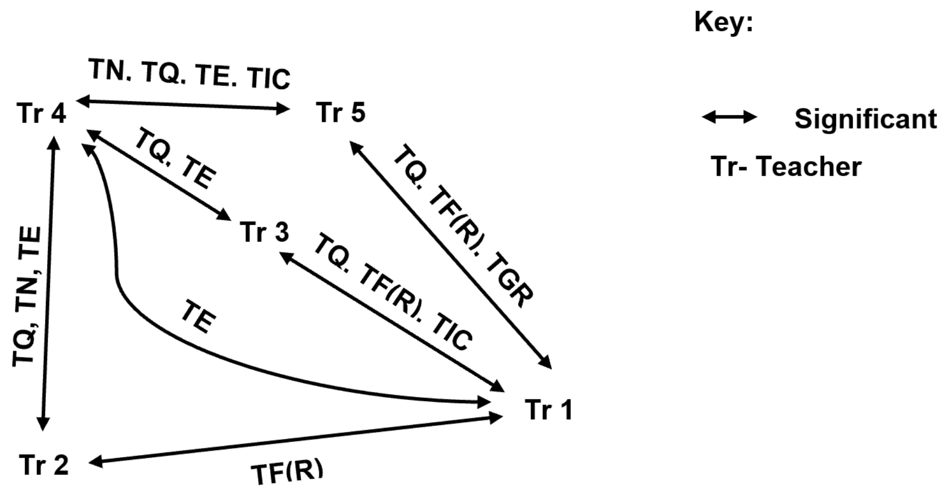


Figure 5.10: Statistical relationship between all five teachers for the total in Scientific Play Sessions 1 and 2 (Science Talk- Teachers).

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