Factors influencing the provision of science learning experiences in early childhood education in Ireland: a case study of educators' perceptions and practices

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Abstract

This thesis investigates early childhood educators' perceptions and practices in science within the context of Aistear, the curriculum framework in Ireland. The focus is on analysing the various factors that influence educators' provision of science learning experiences. Using a multi-site case study approach data were collected from eight educators using both classroom-based video observations and semi-structured interview methods. Analysis of the data revealed that science learning experiences were limited. There was no evidence of educators mediating children's science learning beyond the provision of activities. The children were not challenged to explore their world in scientific ways beyond the hands-on exploration of materials or the passive observation of the educator demonstrating an activity that is underpinned by complex scientific concepts. Such activities present little scope for the development and refinement of children's working theories in science. This thesis contends that a number of factors influence the current provision. Educators are tasked within *Aistear* (NCCA, 2009) to support children's science learning by a non-prescriptive and multi-theoretical national curriculum framework policy, which relies on educators' theoretical, content and pedagogical knowledge to implement appropriate science learning experiences. However, these educators have received little or no training in early childhood science education and therefore lack the relevant science-based pedagogical content knowledge to provide such experiences. Furthermore, educators' existential beliefs about how children learn reflect a Piagetian orientation where the educator facilitates learning by providing resources for children to discover knowledge for themselves. This thesis further contends that an unintended consequence of the combination of these factors results in the frequent use of the didactic approaches to teaching that those in the anti-schoolification lobby, who oppose including subject content in early childhood education, warned against. Therefore, it is incumbent on policymakers, training institutions, and educators collectively, to work towards the common goal of providing effective science learning experiences in early childhood education.

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Chapter 1: Introduction

1.1: Science in early childhood education

From the moment they are born, children strive to understand their world and are naturally drawn to explore their environment. Young children are frequently described as curious and persistent explorers, who, as they develop and grow, are inspired to question, imagine and be creative during their pursuit of knowledge. In recent years empirical research has shown that young children learn and think in similar ways to scientists, as they observe, hypothesise, experiment and evaluate during their everyday experiences (Gopnik, 2012). Indeed, their frequent asking of 'why' questions mirrors the type of questions that lead to scientific investigation. Furthermore, as children interact with their environment, they are motivated to investigate scientific concepts (Brenneman, Stevenson-Boyd, & Frede, 2009). During their explorations children are creative as they are inspired to generate ideas and strategies, reason critically and produce explanations that are consistent with the available information (Rossi et al., 2014). The increasing body of research evidence about the capability of children to learn science has served to emphasise its importance in early childhood education (Metz, 2009).

Research informs us that incorporating science learning experiences into an early childhood education programme benefits other areas of learning. For instance, educators and children may conduct research on the types of birds that visit their birdfeeder. Their investigations may involve ‘reading’ scientific books about native and migratory birds, and describing and counting the birds that they observe. All of these science-based activities also help to develop and reinforce basic skills in language, literacy, and mathematics (Clements & Sarama, 2016; Gelman, Brennerman, MacDonlad, & Román, 2010; Gerde, Schachter, & Wasik, 2013). Also, working together to find solutions helps to strengthen social and emotional development (Cremin, Glauert, Craft, Compton, & Stylianidou, 2015). Further, as children explore, ask questions and investigate, they are laying the foundations for the development of scientific literacy (Eshach & Fried, 2005; French, 2004).

The development of scientific literacy is important at both a macro and micro level. At a macro level, scientific literacy is linked to a nation's economic well-being, and so can be thought of as a form of human capital (Laugksch, 2000). In the current information-driven knowledge economy, the quest for skilled scientists and creative thinkers places an economic imperative upon education to provide learning opportunities that will challenge children to develop their reasoning skills, and innovative thinking (Rossi et al., 2014). At a micro level, scientific literacy has life long benefits for the individual, who by having a basic understanding of science and its role in society, will be better positioned to make decisions that enrich their lives (Hartmann, 2013).

In an early childhood education setting the provision of appropriate science learning opportunities is the responsibility of the educator. There is a significant body of research which shows that an appropriate and effective way for children to learn about science is through engaging in scientific inquiry. However, interpretations of that 'inquiry' are often limited to 'doing' through hands-on sensory experiences that present little cognitive challenge (Inan & Inan, 2015). Several studies have shown that inquiry-based learning (IBL) provides a catalyst to challenge children to move beyond the sensory exploration of materials and to explore phenomenon using the scientific skills of investigation such as observation, experimentation and evaluation (Worth, 2010). However, young children need support during their investigations, and a knowledgeable educator provides that support.

A knowledgeable educator has an understanding of scientific concepts and the pedagogical skills associated with IBL (Harlen, 2013). In other words, they have science-based pedagogical content knowledge (PCK) (Shulman, 1986, 1987). However, research indicates that in many early years settings the provision of science learning opportunities is inadequate (Neylon, 2014) and that many educators avoid science (Early et al., 2010; Tu, 2006). Several studies have found that many early childhood educators lack confidence in their ability to effectively support young children's science learning (Garbett, 2003; Lippard, Tank, Walter, Krogh, & Colbert, 2018). This lack of confidence is often attributed to a lack of scientific knowledge which can also lead educators to avoid science (Roehrig, Dubosarsky, Mason, Carlson, & Murphy, 2011).

1.2: Identifying a space for research

Despite the claims that children can learn science and that these experiences in early childhood education also lay the foundation for future learning, research suggests that children spend less time on science-related activities than other areas of learning (Early et al., 2010; Greenfield et al., 2009). In Ireland, where this research study took place, a report on school readiness (Ring et al., 2015) suggests that early childhood educators prioritise the learning of letter names and sounds, number recognition and counting. Furthermore, research by Neylon (2014), which applied the Early Childhood Environmental Rating Scale Extension to assess among other things, how preschools "provide for and encourage children to engage in scientific inquiry with natural materials" (p. 110), found that the provision of science in Irish preschools was inadequate. While this study generated valuable data, it provided little insight into educators' perspectives on science. Indeed, with the exception of Neylon's study, there appears to be a lacuna in Irish-based research on science in early childhood education.

Furthermore, from an Irish policy perspective, the knowledge and skills developed through science education are recognised in *Aistear: The Early Childhood Curriculum Framework* (National Council for Curriculum and Assessment (NCCA), 2009). Science is not a discrete subject in *Aistear*, rather it is placed within the 'Exploring and Thinking' theme which aims that children will "make sense of the world around them" and "use skills and strategies for observing, questioning, investigating, understanding, negotiating, and problem solving" (p.44). In addition, the child is recognised as an active learner, and value is placed on developing the "dispositions, skills, knowledge and understanding, attitudes and values that will help them grow as competent and confident learners" (p. 10). Also, *Síolta: The National Quality Framework for Early Childhood Education* (Centre for Early Childhood Development and Education (CECDE), 2006) recognises that early childhood is an optimal time for learning and laying the foundation for future learning. The critical role played by the early childhood educator in supporting children's learning is also emphasised within both frameworks.

As educators are responsible for the provision of resources and activities, it is logical to consider science education from their perspective. Much of the existing literature seems to fall into two categories. The first category relates to educators' beliefs about science in early childhood education. These studies reveal several factors including a lack of knowledge and competence, low self-efficacy, insufficient training, and a belief that language and literacy should be privileged (for example see Greenfield et al., 2009; Park, Dimitrov, Patterson, & Park, 2016). The second category of research focuses on the efficacy of educators' practices on children's science learning. However, many of the study designs tend to include various supports for participating educators including training before commencement of the study and the provision of ongoing support for educators on science concepts (for example see Dejonckheere, De Wit, Van de Keere, & Vervaet, 2016).

Moreover, there is limited research that explores science in early childhood education from the perspective of both the educators' beliefs and practices. One exception is Fleer's (2009a) Australian-based study which explores the impact of a teacher and teaching assistant's philosophical beliefs about how children learn within the context of children's scientific concept formation during play. The findings in this study indicate that an educator's philosophical beliefs about how children learn have a considerable impact on their pedagogical practices. However, Fleer acknowledges that more needs to be understood about educators' beliefs and pedagogical practices.

In considering all of the above, I wanted to find out what science learning experiences were being provided in Irish preschools and the factors that influence that provision. While Fleer (2009a) has provided some inspiration for my research project, the scope of my study differs from that of Fleer's work. My research study involved exploring educators' perceptions about science education, including their beliefs about how children learn, their understandings about science in early childhood education, and their attitude towards 'doing science'. Furthermore, it explored the factors that influence how these educators support children’s science learning in the context of the early childhood education policy framework in Ireland.

Early childhood education in Ireland spans from birth to six years. However, not all children attend an early years setting prior to three years of age. The Irish government provide full funding for children aged from 3 to 5 years to attend preschool (15 hours/week) for the two years prior to starting primary school. With a 95% uptake (Department of Children and Youth Affairs, 2019), the vast majority of settings have at least one 'preschool' room which caters for this age group. Therefore, I decided to focus on educators working with this age group of children.

Study Aims and Research Questions

This research study aimed to investigate early childhood educators' perceptions and practices in science within the context of *Aistear*, the early childhood curriculum framework in Ireland. The focus is on analysing the various factors that influence educators' provision of science learning experiences. To achieve this aim the following two research questions were developed:

- What perceptions do a group of educators who work with children aged from 3 to 5 years have about science in early childhood education?

- What factors influence how these educators practice science education?

Research scope

This research project is exploratory in the sense that it investigates the views, beliefs understandings and practices of a small number of early childhood educators in a south-western region in Ireland. These educators may have many similarities with others in the field and "extrapolation" of the findings may apply (Silverman, 2017, p. 278). However, this research study does not claim to produce definitive findings that are representative of the perceptions and practices in science education of all early childhood educators.

Although this research study focuses on the role of educators as actors in early childhood science education, it is important to highlight the active role that children play in that experience. Children are capable of constructing knowledge within a social context and can be viewed as agents of their own development (Santi & Di Masi, 2014; Vygotsky, 1986). Therefore, within this research study children are constructed as active, agentic partners in the learning process, with their own preferences and interests, which may be influenced, but not necessarily defined by the educators (Gmitrova, Podhajecká, & Gmitrov, 2009).

Clarification of terms

The terms, ‘early childhood education’, ‘early childhood education and care’ and ‘preschool’ are used interchangeably throughout this thesis. In addition, the titles used to describe the adults who work in an education capacity within those settings, including educator and teacher are similarly transposable.

1.3: Thesis Structure

This thesis is divided into six chapters.

Chapter one introduces the research area of science in early childhood education and then presents a rationale for investigating educators' perceptions and practices in science within the context of Irish early childhood education settings. The specific research questions and scope for the study are also outlined.

Chapter two presents a review of the literature. The aim of this chapter is to provide the reader with an understanding of the various factors that impact educators' perceptions and practices in early childhood science education. A critical examination of these issues may provide some insight into the complexity involved in how educators can effectively support children's science learning.

Chapter three presents the research methodology. This chapter explains the rationale for the interpretative research design and explains how decisions were made regarding data collection, analysis and reporting. The chapter concludes with a review of the particular ethical considerations inherent within this research study.

Chapters four and five present and discuss the findings and analysis for each research question. These two chapters are intended to build a picture of the factors that influence the provision of science learning experiences in Irish preschools.

Chapter six presents the conclusion. This chapter highlights the main points raised by this research study, its contribution to knowledge and suggestions for further research. The chapter concludes with a final reflection on the research project.

Chapter 2: Literature Review

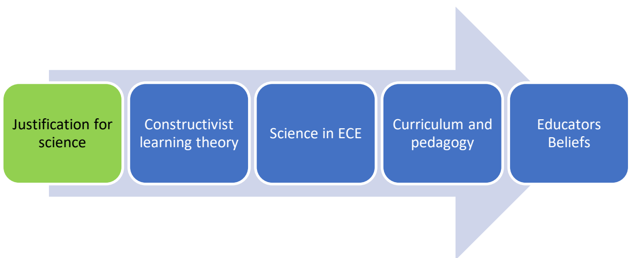
2.0: Introduction

Science in early childhood education is a multifaceted construct, and since the latter part of the 20th century, a growing body of international research has been published on this topic. Within this research, a consensus is emerging as to the importance of science learning in early childhood education, not only because children will learn about science but also because it provides an opportunity to lay the foundation for scientific literacy and to promote the holistic development of the child. Considering these opportunities, one would expect to find science occupying a central role, however, in practice, it is likely to take second place to language/literacy and numeracy-based activities (Early et al., 2010; Ring et al., 2015). In considering the provision of science learning opportunities in early childhood education, the role of the educator is central. It is, after all, the educator who determines the availability of science-related resources and facilitates the further exploration of topics that arise as part of the children's everyday experiences. In the everyday life of early childhood education, several factors influence their provision of science learning experiences. Therefore, to understand this topic further this chapter presents a synthesis of the literature surrounding science in early childhood education.

This literature review contains six further sections and begins by exploring the justification for science in early childhood education with primary emphasis placed on the development of scientific literacy and the role science learning plays in children's holistic learning and development. As educators' views about how children learn influences their pedagogical practices, the second section presents a broad investigation of the two theories that have strongly influence early childhood education practices since the 1980s, namely constructivism and socioculturalism. The third section explores the research surrounding science in early childhood education with particular emphasis on what science is, the use of scientific inquiry and its links to play, and the role played by the educator in supporting children's science learning. As a significant aspect of this support involves both the curriculum and the educator's pedagogical approach, the fourth section of this review examines both constructs. The Irish national curriculum framework is examined along with research surrounding educators' pedagogical knowledge and the strategies used to support science learning. Furthermore, as personal beliefs provide insight into how educators conceptualise their work and make decisions which influence their practice, the final section explores educators' beliefs about science in early childhood education. A chapter summary brings together the key points from this critical review and presents a justification for the current study.

As there is very little research available relating to science in early childhood education in Ireland, international research from Australia, Europe, New Zealand, and the USA is used within this review. Consequently, it is important to note that what is meant by 'early childhood education' in terms of age-range differs between countries. For instance, in the UK it is birth to five years, while in Ireland and New Zealand the age range is, birth to six years; in Sweden, early childhood education covers birth to seven years while in Australia and the USA it is birth to eight years. Also, as the current study is based in Ireland, the literature cited in this review reflects a western cultural perspective on the conceptions of science and early childhood education (Fleer, 1997).

A chart similar to the one shown below will be displayed at the end of each section to help signpost the reader's progress through this literature review. The area highlighted in green indicates the next section in the review.



2.1: Justification for science in early childhood education

2.1.1: Scientific literacy

Young children are frequently described as curious and persistent explorers of their world. Over the last few decades an increasing level of empirical research has shown that young children learn and think in similar ways to scientists through their everyday experiences as they observe, hypothesise, experiment and evaluate (Gopnik, 2012). This increasing evidence about the capability of children to learn science has served to emphasise its importance in early childhood education (Metz, 2009).

Exposing young children to science education when their cognitive function, interests and inquiries are being established is not just for those children with an aptitude for science, it is for all children to help them become what is known as scientifically literate citizens. Scientific literacy is described as "the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen" (Organisation for Economic Co-operation and Development (OECD), 2013, p. 7). It is based on the premise that by having a basic understanding of science and its role in society, people will be better positioned to make decisions that enrich their lives. Key components of scientific literacy not only include what science is and what scientists do but also, and very importantly, the nature of science (NOS) (Bybee, 1997). At a fundamental level, NOS refers to the epistemology of science, which as Abd-El-Khalick, Bell, and Lederman (1998) explain is, "science as a way of knowing, or the values and the beliefs existing in the nature of the development of scientific knowledge" (p. 418). Acknowledging the abstract level of this explanation, especially in relation to teaching younger children (5+ years) Abd-El-Khalick and colleagues suggest that for this age group NOS should be considered as:

> …tentative (subject to change); empirically based (based on and/or derived from observations of the natural world); subjective (theory-laden); partly the product of human inference, imagination, and creativity (involves the invention of explanation); and socially and culturally embedded (p. 418).

Research by Akerson, Buck, Donnelly, Nargund-Joshi, and Weiland (2011) indicates that young children can develop basic conceptualisations of NOS if they are introduced using appropriate methods such as educator guided inquiries. Specifically, their research found that children as young as five were better able to conceptualise aspects of science such as creativity, tentativeness and observation versus inference (Akerson et al., 2011). Proposing that young children should be introduced to NOS is naturally predicated on educators having adequate knowledge and understanding of this construct. However, in a review of relevant literature on NOS in early childhood, Bell and St.Clair (2015) found that early childhood educators had underdeveloped and often inadequate views relating to NOS. It seems that since Lederman (1992) published his review of the literature surrounding NOS, in which he concluded "educators cannot teach what they do not understand" (p. 351), not much has changed. Disappointingly, this lack of focus on NOS is reflected in the Irish context as it is not mentioned in *Aistear: The Early Childhood Curriculum Framework* (NCCA, 2009). Furthermore, as *Aistear* does not include discrete subject areas, it is left to the educators' discretion how they enact science in the early childhood classroom.

2.1.2: Holistic benefits of engaging in scientific inquiry

Engaging in scientific inquiry has the potential to lay the foundation for children's science knowledge, skills and interest, as well as providing a purposeful context for integrating their learning and development across the domains of language, literacy and mathematics. For instance, Gelman et al., (2010) point out that during science inquiry children engage in recording their observations and making simple charts, which directly supports their literacy skills. Similarly, science provides a rich context for language development. The educator encourages children to learn the correct scientific terminology as they look at non-fiction science books, use scientific tools, make predictions, and describe phenomena (Gelman et al., 2010; Gerde et al., 2013; Patrick, Mantzicopoulos, & Samarapungavan, 2009).

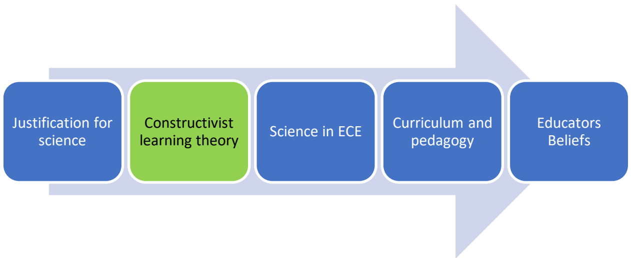
According to the US-based National Science Teachers Association (NSTA, 2014), scientific investigations also have the potential to reinforce and integrate numeracy skills. For instance, Clements and Sarama (2016) suggest that as children explore the properties of objects they frequently count, measure, compare, sort and classify. In other research, Howitt, Lewis, and Upson (2011) discuss children measuring the size of paw prints found in their classroom as they sought to solve a mystery.

The literature shows that scientific inquiry learning also encourages collaboration amongst children and adults. Through collaborating with others, children strengthen their social and emotional development. Indeed, Cremin et al. (2015) suggest that the communication about scientific ideas and processes, by a knowledgeable adult provides opportunities for young children to share their thoughts, listen to others and reflect on their understanding. This outcome for children is, however, predicated on the adult's knowledge and understanding of scientific concepts and skills.

The period of early childhood provides unique opportunities to develop life skills and competencies and research in early childhood education suggests that science can play a significant role in children's holistic development. Children have an innate fascination with how the world works, and early science learning experiences can afford the opportunity to build on this curiosity through social interactions and collaborations in "experience-rich and language-rich environments" (French, 2004 p. 147). Considering these opportunities, one would expect to find science playing a leading role in early childhood settings, but research indicates that in practice this does not seem to be the case. Indeed, in a recent report from Ireland on school readiness Ring et al. (2015) suggest that early childhood educators prioritise the learning of letter names and sounds, number recognition and counting. This finding is not altogether surprising considering Irish early childhood education policy places significant emphasis on literacy and numeracy. This emphasis can be traced back to 2011 when, following a decline in both literacy and numeracy rankings for Ireland in *Pisa 2009: Results for Ireland and Changes Since 2000* (Perkins, Cosgrove, Moran, & Sheil, 2012), the Department of Education and Skills (DES) introduced the *National strategy: Literacy and Numeracy for Learning and Life 2011-2020* (DES, 2011) with a subsequent review and update in 2017 (DES, 2017a). The strategy acknowledges that experiences in early childhood education, which support the development of literacy and numeracy knowledge and skills, significantly impact on later learning experiences.

As there is no mention of science in Ring et al.'s (2015) report, this raises questions about the emphasis placed on preschool children's science learning. Reflecting on this research also draws attention to the educator, as they play a critical role in deciding the focus of activities in early childhood education. In the current study, the role of the educator is a central point of focus. Specifically, the study explores the perceptions and practices of educators in an attempt to understand the factors influencing their provision of science learning experiences, including the extent to which early childhood educators can engage with children's interests and inquiries.

As the provision of science, and indeed all, learning opportunities in early childhood education are framed by the educator's understanding of how children learn, the following section will consider the constructivist theory of learning, which has influenced Western early childhood education practice since the 1990s (Fleer, 1995).



2.2: Constructivist learning theory

Learning combines multidimensional cognitive, social, embodied and affective processes, and over the years, several theories have been developed in an attempt to explain how young children learn. Two theories of learning have significantly influenced early childhood education practice since the 1980s, namely behaviourism and constructivism (Fleer, 1995). However, as behaviourism has been well-rehearsed in the literature, and as constructivism is the dominant theory underpinning current early childhood education practices, this review will focus on constructivism. Furthermore, Agarkar and Brock (2016) posit that constructivism is currently regarded as the most dominant way of thinking about science education. Constructivist learning theory is concerned with how children make meaning of events and learning is viewed as a process of active discovery (Hoy, Davis, & Anderman, 2013). There are different approaches to constructivism; some emphasise a personal construction of knowledge while others view it as a social activity.

The origins of personal (or cognitive) constructivism can be found in the work of developmental theorist Jean Piaget (1896 – 1980). Piaget's theory of cognitive development is based on the premise that children are active agents who construct knowledge through physically manipulating their environment as they explore their world. Piaget focuses on the individual learner as a meaning maker, and learning is considered as a process of interpreting new information based on previous knowledge, understanding and experience (Pritchard, 2010). In the classroom, the personal constructivist theory of learning underpins the discovery learning approach, where learning is considered an individual act.

According to Piaget (1950), the child's cognitive development proceeds through a fixed series of four qualitatively distinct stages, where each stage represents increasingly complex ways of thinking, see Table 2.1. By the time the child reaches the end of each stage, they have achieved the central objective of cognitive development, and are ready to progress to the next level. However, Woodhead (2006) points out that Piaget's stage theory has been criticised in the literature for representing the stages of cognitive development as universal and stable.

Table 2.1: Piaget's stages of cognitive development

Approximate age range (years)	Stage	The central objective of cognitive development	Examples of cognitive development
Birth - 2	Sensorimotor	Acquire the capacity for internalised thinking.	Searching for a hidden object
2 - 7	Preoperational	Make intelligence less egocentric and more socialised.	Use of communicative as opposed to self-stimulating language, acquisition of gender concepts and basic concepts of causality
7 - 11	Concrete operational	Bring intelligence into conformity with the fundamental laws of logic and mathematics.	Development of reasoning skills
11 - adult	Formal operational	Extend logical and mathematical reasoning to an abstract, symbolic level, with the aid of language.	Reasoning becomes reflective and analytical

(Adapted from Brainerd, 2003, p.259)

At the centre of Piaget's theory of cognitive development is the concept of schemas, which are an integrated network of mental structures that store categories of information, perception and knowledge that are used to interpret our surroundings (Gonzalez-DeHass & Willems, 2013) Schemas are organised around themes and represent all of the knowledge an individual has on that theme. When new information relating to a theme is encountered, it is considered in terms of how well it fits into the existing schema.

Piaget uses the term equilibration to describe the process of cognitive development. Equilibration involves three processes, namely, assimilation, accommodation, and equilibrium (Schunk, 2014). New information is assimilated when it strengthens a child's existing knowledge. In such instances, a new schema is not created; rather, an existing schema is enriched or extended. However, when new information challenges the child's existing knowledge, it is accommodated. The process of accommodation involves adjusting an existing schema or creating a new schema to make sense of this new information. When either assimilation or accommodation occurs, the child is in a state of equilibrium where they can explain their world. However, in situations where cognitive conflict exists between the child's existing knowledge and new information, they experience disequilibrium, which initiates either assimilation or accommodation.

According to Piaget (1964), this state of disequilibrium is essential for cognitive development to occur. However, the cognitive conflict cannot be too great as it will not trigger equilibration. The child's mental capacity must be sufficiently developed such that the new information is partially understood in order to promote change within the mental structures. Therefore, learning is limited by developmental constraints (Brainerd, 2003).

One of the basic tenets of Piaget's theory is that development precedes learning, "learning is subordinated to development and not vice versa" (Piaget, 1964, p. 17). The educator who ascribes to Piaget's view of learning is likely to provide science resources that they deem suitable for the child's developmental level and will only introduce more complex activities when the child is developmentally ready. According to Grieshaber (2008), educators adopting such a view are unlikely to engage in instruction and indeed may be unwilling to intercede in children's activities in case their actions are viewed as developmentally inappropriate. When considering early childhood education, the implications of adopting a personal constructivist view of learning are far-reaching. Indeed, Hatch (2020) suggests that the privileging of development over learning, as described by Piaget, consigns the adult to a self-described role of facilitator rather than an educator. A position, it could be argued, that may result in the educator believing that merely providing objects for physical manipulation and exploration, will result in children learning about science concepts. Concepts such as buoyancy using a floating and sinking activity, or magnetism by providing magnets may constitute such examples.

The roots of criticism of personal constructivism lie in Piaget's assumption that learning is a solitary activity, with less attention paid to the social context. As O'Loughlin (1992) argues after reviewing critics of Piaget's theory,

> …knowledge is socially constructed…we cannot talk of knowing without considering the historically and socially constituted self that engages in the process of knowing. Furthermore… knowing is a dialectical process that takes place in specific economic, social, cultural, and historical contexts (p. 799).

While Piaget's work was dominant in approaches to early childhood education in the 1980s, its relevance was questioned in the 1990s as understandings of the social and cultural context of children's learning began to emerge (Fleer, 1995) . This questioning ultimately led to the embracing of sociocultural approaches to early childhood education.

Sociocultural theory, also known as social constructivism, emphasises the critical importance of the social and cultural context of learning (Hoy et al., 2013). The roots of sociocultural theory lie in the work of Lev Vygotsky (1978, 1986). Although Vygotsky was also a developmental theorist, he held the view that learning leads development and is fundamentally a social activity whereby the child learns from interacting with a more knowledgeable other and this drives development. In *Mind and Society,* Vygotsky (1978) articulates, "learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment" (p.90). Sociocultural theories have been further developed by scholars including, Lave (1988), Lave and Wenger (1991) Lemke (2001), Rogoff (1990, 2003) and Wertsch (1991, 2007).

In contrast to Piaget's theory of development, which views the individual, social or cultural context as separate entities, Rogoff (2003) stresses that a sociocultural approach assumes "individual development must be understood in, and cannot be separated from, its social and cultural-historical context" (p. 50). The learning and development of a child in early childhood education are, therefore, shaped by the cultural values and practices within the setting.

A central theme in Vygotsky's theory of cognitive development is mediation. He suggested that humans do not act directly or in an unmediated way in their social or physical world, but instead, their actions are mediated by "cultural tools" (Wertsch, 2007, p. 190). These cultural tools exist within the learning environment and can be physical such as objects, signs and symbol systems, or psychological such as language. According to Vygotsky (1978), "The tool's function is to serve as the conductor of human influence on the object of the activity" (p.55), The child uses the tools in collaboration with others to achieve their goal. In essence, the tools are mediators between the child and their actions in their physical or social world.

Particular attention is paid to the cultural tool of language in mediating how people experience, communicate and understand reality.

> A special feature of human perception … is the perception of real objects … I do not see the world simply in colour and shape but also as a world with sense and meaning. I do not merely see something round and black with two hands; I see a clock…
>
> (Vygotsky, 1978, p.33).

Children benefit from this mediation through social interactions with adults, peers, family and community. Within an early childhood education setting, social interactions occur between adults and children and amongst peers. According to Vygotsky, interactions in the form of mediation from a more knowledgeable other provide a platform for the child to achieve their learning potential. Vygotsky (1978) explains the process through his theory of the zone of proximal development (ZPD) which he describes as,

> [T]he distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers.
>
> (Vygotsky, 1978, p. 86).

Educators who ascribe to Vygotsky's sociocultural theory do not wait for development to occur. Instead, they are proactive and provide learning experiences to drive development.

The role of the educator in supporting learning also links to Vygotsky's theory of concept development. According to Vygotsky (1978), conceptual development occurs at two dialectically related levels: spontaneous or everyday concepts which emerge from the child's reflections on everyday experiences, and scientific concepts which are culturally formed and explicitly taught. Vygotsky (1978) proposed that as each concept develops, they move in opposite directions influencing and transforming each other dialectically. Everyday concepts move upwards through scientific concepts towards a more abstract level, and scientific concepts move downwards through everyday concepts towards a more concrete level. Chaiklin (2003) suggests that this interactive space represents Vygotsky's ZPD. It is here that the child's current level of knowledge, their everyday conceptual understanding, interacts with scientific concepts which is the knowledge supplied by the educator.

The work of (Hedges, 2011, 2012, 2014) on the sociocultural theorisation of children's working theories offers further clarity around how these two types of conceptual knowledge combine and progress children's thinking and learning. With clear links to Vygotsky's social constructivist learning theory in which learning leads development Hedges and Jones (2012) offer the following definition of working theories.

> Working theories are present from childhood to adulthood. They represent the tentative, evolving ideas and understandings formulated by children (and adults) as they participate in the life of their families, communities and cultures and engage with others to think, ponder, wonder and make sense of the world in order to participate more effectively within it.
>
> Working theories are the result of cognitive inquiry, developed as children theorise about the world and their experiences. They are also the means of further cognitive development, because children are able to use their existing (albeit limited) understandings to create a framework of new experiences and ideas. (p.36)

While the concept of working theories provides a way to think about how children's everyday understandings interact with conceptual knowledge, it also acknowledges the important role that social context and participation play in learning. Accordingly, in the context of an early childhood setting the role of the educator is critical. As children engage in cognitive inquiry, educators need to be able to recognise the working theories that result from simple everyday events. However, as working theories are complex, this is not a straightforward task. As Hedges (2011) shows, educators need comprehensive training on the theoretical ideas underpinning working theories to build sufficient professional knowledge and influence practice.

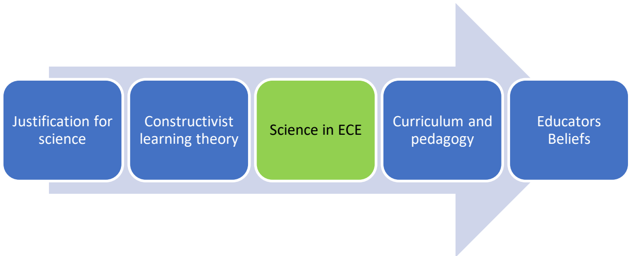
Research by Fleer (2009b) provides relevant data on the pedagogical implications of the influence of many aspects of Vygotsky's sociocultural theory. Her study investigated the dialectical relationship between the development of everyday concepts and scientific concepts within two play-based Australian preschools. Fleer

(2009b) found that in a materially rich environment “without focused educator-child interactions at the scientific level, only everyday concepts could develop for the children” (p. 294). This finding is significant for the educator who relies on adding more resources for exploration to the environment without planning for the introduction of scientific concepts during or after children’s play. Moreover, Fleer (2009b) found that children will develop scientific concepts when science learning is systematically integrated into children’s everyday play experiences. The mediation of learning in this instance took the form of focused educator-child interactions. In addition, Fleer (2009b) notes the importance of adult language in mediating children’s science learning as it “provides vocabulary to describe the concepts emerging from the investigations and provides models for discourse functions such as describing and explaining” (p. 294). Indeed, Hedges and Cooper (2016) offer interesting ways to think about how adult mediation can be used to develop children’s working theories by drawing on their funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992). The concept of funds of knowledge is informed by post-Vygotskian sociocultural theory which is important in this study as it acknowledges that children’s interests can originate from the social context of learning and the influence of family and community (Hedges, Cullen, & Jordan, 2011).

Based on this discussion of Vygotsky’s sociocultural theory, determining appropriate practice in early childhood science education centres on the educator mediating the child’s science learning. While this mediation involves the provision of physical resources the critical element is the focused educator-child interaction. During these interactions the educator introduces a scientific concept that can be linked to the child’s everyday conceptual knowledge. Importantly, learning about this scientific concept must be within the child’s ZPD.

In summary, this section has described the constructivist theory of learning and its relationship to science learning in early childhood education. Constructivism, particularly sociocultural theory, was highlighted as highly influential in contemporary approaches to early childhood education. The importance of the social and cultural context of science learning and the critical role of the educator in mediating children’s science learning were examined.

So far, this literature review has discussed the justification for science learning in early childhood education, which led on to an examination of learning theories and how they influence both the curriculum and educators' approaches to the provision of science learning opportunities. These two elements lay the foundation for the next section which examines the construct of science in early childhood education.



2.3. Science in early childhood education

Earlier in this review, one of the justifications cited for introducing science in early childhood education was its role in developing scientifically literate citizens. The teaching and learning of science in early childhood education directly impact that development. However, before exploring these processes, it is important to establish a definition of science. While many different characterisations of science exist, they share common features which are nicely captured in the description offered by Duschl, Schweingruber, and Shouse (2007):

> Science is both a body of knowledge that represents current understanding of natural systems and the process whereby that body of knowledge has been established and is being continually extended, refined, and revised. Both elements are essential: one cannot make progress in science without an understanding of both. Likewise, in learning science one must come to understand both the body of knowledge and the process by which this knowledge is established, extended, refined, and revised (p. 26).

This definition presents science as both a body of knowledge and the process that gives rise to that knowledge. Zimmerman (2000) describes these two interrelated types of knowledge as domain-specific knowledge and domain-general knowledge. Domain-specific knowledge refers to the conceptual knowledge held by children and adults about phenomena in the different domains of science. According to Bradley (1996), scientific concepts are “those ideas or general notions of the common attributes of objects or events that help us to understand the natural world around us” (p. 46).

In contrast, domain-general knowledge refers to the scientific process that involves the reasoning and problem-solving skills and strategies used to coordinate theory and evidence (Zimmerman, 2000). These skills and strategies, which are the foundation of scientific inquiry, include but are not limited to observing, questioning, comparing, measuring, predicting, checking, recording, and evaluating, reporting (Gelman et al., 2010). Indeed, many of these skills and strategies are often associated with young children as they are innately curious and enjoy exploring the world around them. According to Eshach and Fried (2005), these natural inclinations indicate that young children are ready to engage in science learning.

The construction of science as incorporating domain-specific knowledge and domain-general knowledge is well established. However, what is significant for the present study is to explore how the educator develops these two types of knowledge within early childhood education. In their definition of science, Duschl et al. (2007) make the critical point that science learning involves an interplay between both domain-specific knowledge and domain-general knowledge. This approach to science teaching and learning has been used within early childhood education. For example, the EU-funded *Creative Little Scientists* (CLS) project highlights a Scottish preschool where the children explored changes in weather and life cycles during their weekly visits to a local wildlife area (Rossi et al., 2014).

Implementing science learning in early childhood education requires careful consideration by the educator. According to Gelman et al. (2010), a “big science idea” or “central concepts” (p. 18), such as transformation and change or form and function, should underpin preschool children’s science learning experiences. The knowledge children gain during their exploration of broad scientific concepts will lay the foundation for future science learning in school (Harlen, 2010). However, the development of conceptual knowledge is not a single step operation, it is a process. According to Vygotsky (1986), merely introducing scientific concepts to children does not mean they are assimilated in ready-made form. Therefore, scientific concepts are not taught in isolation; instead, Harlen (2013) claims they form the basis for scientific inquiry which utilises the various skills and strategies incorporated in domain-general knowledge. There are several examples in the literature of this approach being used. For instance, Samarapungavan, Mantzicopoulos, and Patrick (2008) used scientific inquiry to teach young children about the science concept of change by investigating the life-cycle of Monarch butterflies. While recommending that educators base learning activities on a central scientific concept is very appealing, research suggests this could be problematic as concern has been raised about early childhood educators' lack of science content knowledge (Appleton, 2006; Gropen, Kook, Hoisington, & Clark-Chiarelli, 2017; Nilsson & Elm, 2017).

Furthermore, merely engaging in scientific inquiry does not mean children will fully understand the scientific concept under investigation. As Hedges (2011) suggests, children develop working theories which evolve with experience or instruction. While providing an environment in which young children can experience a variety of scientific phenomena may appear to be an ideal situation, such exposure without guidance or instruction can be problematic. As Driver, Guesne, and Tiberghien (1985) point out, children develop concepts based on their experience yet they may equally form misconceptions if they do not receive appropriate guidance. While misconceptions may seem somewhat harmless, Black and Harlen (1993) argue that if they remain into the early primary school years they may become a barrier to understanding and learning science.

However, not all researchers agree with changing children's misconceptions. In a study exploring eight young children's understandings of natural science phenomena, in this case, a rainbow, Siry and Kremer (2011) reflect on children's "magical thinking" (p. 654). While accepting that some of the children's ideas were not correct Siry and Kremer (2011) do not advocate seeking to change them; instead, they suggest using these misconceptions as a starting point from which to plan further instruction.

Similarly, Hedges (2012) suggests that children's misconceptions may reflect their developing working theories, which provide the basis for future science learning. While developing children's working scientific theories is an attractive proposition, this approach is predicated on the educator having sufficient knowledge to support the children's developing knowledge. In reality this may also be challenging because many educators lack science knowledge and consequently lack confidence in their ability to teach science (Garbett, 2003; Gerde, Pierce, Lee, & Van Egeren, 2018; Lippard et al., 2018; Pendergast, Lieberman-Betz, & Vail, 2017).

Considering the above research literature, it is likely that educators may have different views about how best to use children's misconceptions or working theories, as they strive to support children's science learning. However, there are concerns that educators may only be able to use children's misconceptions or working theories as the starting point for developing science knowledge if they themselves have the scientific knowledge to be able to recognise these misconceptions or working theories in the first place.

Science learning opportunities in early childhood education need to be relevant. As Vygotsky (1978) clearly articulates, there is a strong link between children's conceptual development and their everyday experiences. Therefore, scientific concepts can be explored with preschool children in a developmentally appropriate way, by basing the activities on their current knowledge and understanding. Indeed, Roychoudhury (2014) cautions against science activities which include complexities that are likely to overwhelm young children. One such activity is floating and sinking which involves complex concepts such as buoyancy, density and liquid displacements; concepts with which Roychoudhury (2014) suggests secondary and even tertiary level students often struggle. Somewhat in contrast, Watts, Salehjee, and Essex (2017) contend that while a topic core is important, no essential science concepts have to be covered and so "[n]othing, but nothing is off the science table" (p.281).

Considering that science involves both conceptual knowledge and the skills and strategies of domain-general knowledge, the question facing the early childhood educator is how to implement science learning opportunities that develop both of these types of knowledge for the preschool child. According to Worth (2010), young children need to practice science, and they do this by engaging in scientific inquiry. Indeed, Harlen (2013) points out that as children engage in the process of scientific inquiry they directly interact with the natural and human-made world and this helps to build their knowledge and understanding about the world.

2.3.1: Scientific inquiry

The use of inquiry in education is not a new phenomenon; its origins can be found in the philosophies of some of the early educators such as Pestalozzi (1746-1827), Montessori (1870-1952) and Dewey (1870-1952). These pioneers of early education acknowledge the child as an active, curious thinker who learns through experiences in their environment. From these foundations, inquiry-based learning has evolved, and according to Harlen (2013), it is now described as embodying a constructivist model of learning where children construct new knowledge based on their previous experiences. It is, however, only in the past two decades that inquiry-based learning in early childhood education has increased in popularity, particularly in early childhood science education (Cremin et al., 2015). The increased popularity of this constructivist model of learning can be understood when we consider the emerging dominance of sociocultural theory in early childhood education.

There is some variation in the literature as to what constitutes scientific inquiry in early childhood education. According to Inan and Inan (2015) science activities tend to focus on children ’doing’ through a ‘hands-on’ approach and rarely involves further scientific investigation. A similar point is made by Worth (2010) who notes that while many classrooms have a science table filled with interesting objects and observation tools such as magnifying glasses and scales, this is often the extent of the science inquiry as children’s observations and questions frequently remain unanswered. Indeed, Metz (1995) attributes this privileging of concrete exploration above abstract conceptual development to Piagetian assumptions surrounding educational stages and notions of readiness. Nevertheless, while hands-on activity is essential, Gelman et al. (2010) propose that what children are thinking about is almost more important than what they are physically doing.

According to Smith and Trundle (2014), meaningful scientific inquiry starts with the educator carefully observing the children to identify their interests. Children learn about the world around them by engaging in sensory explorations that are motivated by their innate curiosity. According to Spektor-Levy, Baruch, and Mevarech (2013), sensory exploration assists scientific thinking as children engage, explore, manipulate and interact with their environment. The challenge for the preschool educator is to develop this sensory exploration by guiding children's interests and everyday experiences into further scientific inquiry. In the daily life of children in an early years setting these scientific inquiry-based learning experiences often take place during play.

Play is acknowledged as the dominant pedagogy used in western preschool contexts (Organisation for Co-operation and Economic Development, 2012). In Ireland, the curriculum framework *Aistear* (NCCA, 2009) and the quality framework *Síolta* (Centre for Early Childhood Development and Education, 2006) both emphasise the importance of play in children's learning and development.

> *Aistear:*
>
> Much of children's early learning and development takes place through play and hands-on experiences. Through these, children explore social, physical and imaginary worlds. These experiences help them to manage their feelings, develop as thinkers and language users, develop socially, be creative and imaginative and lay the foundations for becoming effective communicators and learners.
>
> (NCCA, 2009 p. 11)

> *Síolta:*
>
> Play is an important medium through which the child interacts with, explores and makes sense of the world around her/him. These interactions with, for example, other children, adults, materials, events and ideas are key to the child's well-being, development and learning…As such, play will be a primary focus in quality early childhood settings.
>
> (CECDE, 2006 p. 9)

Many aspects of inquiry learning exist in children's play. According to Dewey (1910), the natural curiosity of young children encourages them to explore their world through play. These playful explorations help children to learn about the world by asking questions and making connections that build on their everyday experiences (Cremin et al., 2015; Siraj-Blatchford, 2009). Additionally, while play enables children to draw on their everyday experiences, according to Fleer (2017), play also provides opportunities for children to develop their conceptual understanding that goes beyond their ordinary knowledge, such as science concepts. However, (Fleer, 2009a, 2009b) also makes the point that children's understanding will not progress from an everyday conceptual level to a scientific level unless their learning is appropriately mediated through the provision of resources to initiate inquiry and focused educator-child interactions.

Pistorova and Slutsky (2018) suggest that from the child's perspective their play naturally incorporates inquiry and learning. In explanation, they argue that while play is inextricably linked to a child's development, "inquiry for a child is a natural 'habit of mind' that permeates what they do, think and learn" (p. 504). Children will avail of any opportunity to play, and to them, it is a serious business (Vygotsky, 1978). According to Watts et al. (2017), there is a mischievous element in play which is important for children's science learning as they are encouraged to take risks and to think as they test out ideas and solve problems creatively. Different types of play have been shown to align with inquiry learning. For instance, van Oers (2003) found that imaginative play encourages abstract and divergent thinking, which are integral aspects of scientific inquiry (Cremin et al., 2015).

Play also provides the context for children to naturally engage in inquiry as it enables them to challenge and extend the boundaries of their knowledge (Pistrova & Slutsky, 2018). As noted by Eshach and Fried (2005) the pleasure children derive from engaging with nature through playing, observing and collecting, makes them "temperamentally ready not only for the things of science but also for first steps towards the ideas of science" (p. 320). However, from the educator's perspective what is perhaps equally important is whether they can harness the children's natural curiosity and investigative skills to support the everyday opportunities for science learning that may occur during play.

There are several examples in the literature which explore how educators can develop children's everyday experiences into scientific investigations. One approach which is available to educators is the 5E instructional model (Bybee et al., 2006). The 5E model is based on a constructivist approach to learning where learners have ideas of the world around them and construct new knowledge by testing new ideas against existing knowledge. Learners easily assimilate familiar ideas about how the world works, however, unfamiliar ideas require a process of accommodation (Colburn, 2003). A summary of the model's five stages is briefly outlined in Table 2.2.

Table 2.2: Summary of the 5E Instructional Model (Adapted from Bybee et al., 2006).

Phase	Summary
Engage	Children are engaged in a new concept through a short activity which links past and present learning experiences.
Explore	Children explore the concept through hands-on activities
Explain	Children develop an explanation for the concepts they have been exploring with guidance from the educator.
Elaborate	The educator challenges the children to extend their understanding
Evaluate	The educator and the children have an opportunity to evaluate the children's understanding of the concepts.

The 5E model provides a framework for educators to design science activities that build on children's interests and prior experiences and facilitates their active engagement in science learning. While the 5E model has been used in the compulsory education sector for some years (Yoon & Onchwari, 2006), its use with preschool children is more recent. For example, Dominguez, McDonald, Kalajian, and Stafford (2013) used the model to investigate 'wiggly worms'; Hoisington, Chalufour, Winokur, and Clark-Chiarelli (2014) describe the use of a variant of the 5E model, called the Engage-Explore-Reflect cycle, to investigate water; Roseno, Geist, Carraway-Stage, and Duffrin (2015) used the 5E model to further children's science learning as they examine sunflower seeds.

So far, this section has explored literature on the use of an inquiry-based approach to science learning in early childhood education. However, the efficacy of an inquiry-based approach to science learning is strongly influenced by the role played by the educator. According to Harlen (2013), there is a 'mistaken view' that inquiry means children must 'discover' knowledge for themselves without input from the educator or other sources. Such an assertion essentially consigns the role of the educator to that of passive observer. Left to their own devices, it is questionable as to how much science young children will learn (Hatch, 2010). Indeed, Samarapungavan et al. (2008) acknowledge the challenges involved in science learning for young children and posit that these "universal novices" (p. 903) require the educator to mediate their learning in all stages of the process.

Empirical evidence from research by Hong and Diamond (2012) which involved the science learning of 104 children aged between four and five years, shows that those children whose learning was mediated by their educator were more successful in learning scientific concepts, vocabulary and problem-solving skills. Similarly, in their meta-analysis of 164 studies, Alfieri, Brooks, Aldrich, and Tenenbaum (2011) found that unassisted discovery is less effective for learners than assisted inquiry. While this evidence is compelling, the investigation of several studies exploring the efficacy of an inquiry-based approach on children's science learning raises important issues for this research project. Of primary interest is that study designs tend to include various supports for participating educators including training before commencement of the study and the provision of ongoing support for educators on scientific concepts (for example see Dejonckheere et al., 2016; Eckhoff, 2017; Hollingsworth & Vandermaas-Peeler, 2017; Samarapungavan et al., 2008).

Moreover, the crucial point to be gleaned here is that the literature is indicating that inquiry-based science learning is most effective when mediated by a knowledgeable educator. The knowledgeable educator will know that the purpose of such mediation is to meet curriculum goals through drawing on children's interests and funds of knowledge. However, while educator mediation is crucial, its success is predicated on the educator having the confidence, knowledge and competence to provide appropriate science learning opportunities that are within the child's ZPD and involve the introduction of scientific concepts that can be linked to the child's everyday conceptual knowledge. As research suggests that many educators lack science knowledge and consequently lack confidence in their ability to teach science (Bell & St. Clair, 2015; Garbett, 2003; Gerde et al, 2018; Lippard et al., 2018; McNerney & Hall, 2017), the efficacy of their mediation is questionable.

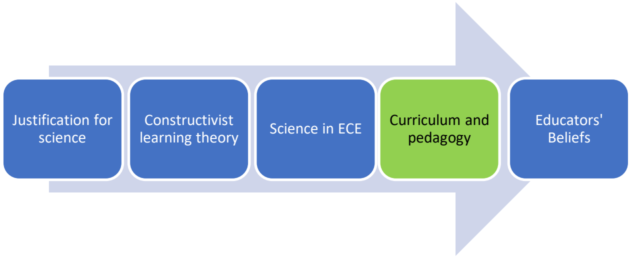
The same assumptions about confidence and competence underpin Fleer et al.'s (2014) suggestion that educators' with a "sciencing attitude" (p. 46) will purposefully design an environment that stimulates the children's interests and promotes science learning. Therefore, if educators lack science knowledge, their ability to successfully engage children in science learning is likely to be compromised. The concept of 'sciencing' was introduced by Tu (2006) and is used to describe science learning opportunities in terms of the materials and educators' engagement with them. Tu examined sciencing in 20 preschools in the United States. She categorised preschool sciencing under three headings, formal, informal and incidental. Formal sciencing refers to pre-planned science related activities such as cooking. Informal sciencing is where an educator organises a space in the classroom to promote scientific interactions, for instance a nature table, sand and water areas. Incidental sciencing refers to unplanned interactions between the educator and children, such as may occur when a child brings in items such as horse chestnuts or sea shells. In her study Tu (2006) found that even though plenty of opportunities were available in early childhood classrooms many of them were missed by the educator who only spent 13.2% of their time engaging in science activities with the children.

From an Irish perspective, *Aistear* (NCCA, 2009, p. 12) states, "The learning environment (inside and outside) influences what and how children learn". Responsibility for the environment lies with the educator and, from a science learning perspective, it is their role to provide resources that capture the children's interests and curiosity and motivates them to engage in scientific inquiry and exploration. A study by Neylon (2014) evaluated the opportunities for children to engage in scientific inquiry with natural materials across 26 preschools in Ireland using the Early Childhood Environmental Rating Scale Extension (ECERS/E). Neylon's findings indicate that from an environment perspective, the opportunities for children to engage in scientific inquiry was scored as inadequate, which is the lowest possible category. While Neylon's findings provide data from an environment perspective, the educator's perspectives were not considered. Only one incident of an educator led activity was observed, but was not scored because it was presented in a confusing manner (Neylon, 2014).

In summary, this section has explored the construct of science. The two types of knowledge that form the basis of scientific reasoning, namely domain-specific knowledge and domain-general knowledge, were discussed in relation to their influence on science in early childhood education. Vygotsky's (1978) work on conceptual development was used to emphasise the importance of basing science learning on children's everyday experiences and interests. The fundamental requirement for the educators to have enough science content knowledge to identify relevant science learning activities, effectively scaffold learning and support children's working theories was also highlighted.

The predominant approach to science learning is inquiry-based learning and in recent years Bybee et al.'s (2006) 5E instructional model has gained prominence in early childhood science education. More recently, research has investigated the synergy between science inquiry learning and play (Fleer, 2017). There is little debate in the literature regarding the vital role played by the educator in guiding children's science learning. However, much of the research focuses on exploring the efficacy of an inquiry-based approach to children's science learning. Study designs tend to involve various supports, including training and the provision of ongoing expertise for educators on science concepts. There appears to be little research available that explores how early childhood educators, in the absence of such supports, assist children's science learning during their everyday practice.

As it has been suggested that the educator plays an essential role in guiding science learning, the next section will explore the factors that influence their teaching of science in early childhood education.



2.4: Curriculum and pedagogy

Curriculum and pedagogy both play an integral role in the provision of learning experiences in early childhood education. Broadly speaking a curriculum provides a structure for planning learning experiences and pedagogy refers to the educator's practices in supporting those experiences. However, the specific definition of curriculum is widely contested in the literature. According to Mueller and Whyte (2020), the curriculum is often considered in terms of the formal products and documents that guide classroom practices, in other words, the "'stuff' of what happens in school" (p. 65). In comparison, Hatch (2020) describes curriculum as "the intellectual substance of what should be taught in educational settings" (p. 51). Interestingly, Hatch does not include any reference to the how of teaching; in other words, pedagogy. Purposefully separating curriculum and pedagogy, Hatch argues that it helps educators to avoid confusion between the what and the how of teaching.

In contrast, Scott (2008) offers a four dimensional organisational structure for curriculum that includes both content and pedagogy. The four dimensions are, aims or objectives, content or subject-matter, methods or procedures, and assessment or evaluation.

> The first dimension refers to reasons for including specific items in the curriculum and excluding others. The second dimension is content or subject matter and this refers to knowledge, skills or dispositions which are implicit in the choice of items, and the way that they are arranged. Objectives may be understood as broad general justifications for including particular items and particular pedagogical processes in the curriculum; or as clearly defined and

> closely delineated outcomes or behaviours; or as a set of appropriate procedures or experiences. The third dimension is methods or procedures and this refers to pedagogy and is determined by choices made about the first two dimensions. The fourth dimension is assessment or evaluation and this refers to the means for determining whether the curriculum has been successfully implemented. (pp. 19-20)

Scott's (2008) broad conception of curriculum, while void of details around the organisation of learning, directly relates pedagogy to the objectives and content of the curriculum, which may prove useful in my data analysis.

Definitions of pedagogy are also disputed in the literature, with some describing it as the contextually driven art or craft of teaching. In contrast, others align it to a more prescriptive rule-driven action. While pedagogy is about actions or work, there are also many nuances and influencing factors as captured by Alexander (2008, p. 47):

> *Pedagogy is the act of teaching together with its attendant discourse of educational theories, values, evidence and justifications. It is what one needs to know, and the skills one needs to command, in order to make and justify the many different kinds of decision of which teaching is constituted.* (original emphasis)

2.4.1: Curriculum and pedagogy in the Irish context

In Ireland, *Aistear: The Early Childhood Curriculum Framework* (NCCA, 2009) offers a broad definition of curriculum describing it as, "all the experiences, formal and informal, planned and unplanned in the indoor and outdoor environment, which contribute to children's learning and development" (p. 54). In relation to Scott's first dimension of a curriculum, the aims or objectives, *Aistear* presents children's learning and development in terms of four themes, namely, Identity and Belonging, Exploring and Thinking, Communicating, and Well-being. Each theme consists of four aims and 24 learning goals. However *Aistear* does not provide specific information on Scott's second dimension, 'content or subject matter', instead it describes the 'what' of children's learning in terms of "dispositions, attitudes and values, skills, knowledge and understanding" (NCCA, 2009, p. 11). In relation to Scott's third dimension, *Aistear* describes pedagogy in terms of "all the practitioner's actions or work in supporting children's learning and development" (p. 56). This broad definition provides little guidance for educators, particularly as they reflect on their practice. This lack of guidance is further evidenced by the fact that the term 'pedagogy' only appears in the glossary. The fourth dimension is captured by a comprehensive set of guidelines on assessment.

An early childhood curriculum is not developed in a vacuum; it reflects the social, political, economic and cultural contexts in which it exists. However, what is equally important to consider is that a curriculum is underpinned by philosophical beliefs about how children learn. As previously mentioned, Piaget's developmental theory has strongly influenced early childhood education; however, in more recent times, questions are being raised about the relevance of this approach (Wood & Hedges, 2016). Indeed, Hatch (2010, 2020) strongly rejects the value of developmental theory for understanding curriculum, claiming that when development is perceived to precede learning the focus rests on how children learn with little or no attention paid to the content. Instead, Hatch (2020) suggests a Vygotskian approach where learning is understood to lead development, and therefore curriculum content would play a more prominent role.

The influence of both Piaget's developmental theory and Vygotsky's (1978, 1986) sociocultural theory are apparent in *Aistear.* For instance, Vygotsky's emphasis on social interactions and the use of cultural tools such as language and play resources exists alongside a Piagetian division of early childhood into three age-related stages. Furthermore, Vygotsky's sociocultural perspective on children's learning is evidenced through the promotion of a relational pedagogy which is based on interactions and relationships between the educator and child (Papatheodorou, 2009) and through emphasising and advocating a balance between child-initiated and adult-initiated activities. However, this Vygotskian approach is countered in *Aistear's* (NCCA, 2009, p. 53) definition of 'active learning' where Piaget's influence is striking.

> Active learning involves children learning by doing, using their senses to explore and work with the objects around them. Through these experiences, children develop the dispositions, attitudes, skills, knowledge, and understanding that will help them to grow as confident and competent learners.

The non-prescriptive and multi-theoretical nature of *Aistear* presents a dilemma. On the one hand, this approach accommodates the various philosophical approaches to early childhood education that are used in Irish preschools, including Montessori, play-based, HighScope, and Steiner-Waldorf. On the other hand, its lack of specific guidance around subject content and pedagogy clearly reflect assumptions that educators will have the requisite theoretical, content and pedagogical knowledge to effectively support children's learning.

2.4.2: Pedagogical content knowledge

The skills and knowledge needed to make a 'good educator' have captured the interest of researchers and scholars for many years. One of the most noted among these is Lee Shulman and his work on educator knowledge. Although Shulman (1986, 1987) identified a number of categories of knowledge, his work on Pedagogical Content Knowledge (PCK) is of particular relevance to this review. Shulman (1986) recognised that educators have two types of knowledge, pedagogical knowledge and content knowledge; the former being the 'how' of teaching and the latter the 'what' of teaching. He also claims that to teach a subject effectively, educators must interpret the subject content and find ways to teach it so that it is understandable, and accessible to others. In other words, pedagogical knowledge and content knowledge should be amalgamated. Shulman (1987) defined PCK as,

> [T]he blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and adapted to the diverse interests and abilities of learners, and presented for instruction. (p. 8)

Shulman's (1987) conceptualisation of PCK in which pedagogy and content knowledge are linked resonates with Scott's (2008) previously discussed dimensions of curriculum. Based on the above definition, it follows, therefore, that PCK is subject dependent and an educator may adopt a different PCK when teaching, for example, science versus literacy. In addition, the educator's perception of how children learn is likely to influence their pedagogical knowledge. Educators' favouring a sociocultural view are likely to embrace a collaborative inquiry-based approach, whereas those advocating a Piagetian constructivist approach where the assumption is that development leads learning, are likely to limit children's science learning to hands-on exploration of materials.

Both subject knowledge and pedagogical knowledge exist within the educator, PCK is personal. However, Smith and Banilower (2015) make the point that along with personal PCK there is "canonical PCK" (p. 90) which means "PCK that is widely accepted and formed through research and/or collective expert wisdom of practice" (p. 90). They further suggest that canonical PCK and personal PCK are inextricably linked as canonical PCK becomes personal through the experience of teaching. PCK is therefore not a static entity, different strategies may be employed within different contexts, and these strategies may also change over time with experience. Indeed, Loughran, Mulhall, and Berry (2004) suggest, PCK is formed through preparing to teach, teaching and reflecting on teaching a specific subject to a particular group of students. While the particularities of the situation highlight the context, the three elements of 'preparing to teach', 'teaching' and 'reflecting on teaching' indicate activities which provide sources of pedagogical knowledge used to inform PCK.

Sources of pedagogical knowledge

In their extensive synthesis of the literature surrounding the relationship between educators' knowledge and practice, Cochran-Smith and Lytle (1999) identified three conceptions of educator learning, each of which has a very different purpose. The first, "knowledge-*for*-practice" (p. 253, emphasis in original), assumes that the knowledge educators need to teach well is provided by 'experts', primarily university-based researchers and scholars. This knowledge is provided during pre-service training or professional development training and is subsequently applied in practice (Cochran-Smith and Lytle, 1999). Fundamentally, knowledge-*for*-practice is based on the premise that educators have a formal knowledge base from which they can draw relevant information. Regarding science teaching, the implication here is that educators should receive specific knowledge-for-*science*-practice. However, as a nationally representative U.S. based study conducted by Early and Winton (2001) found, most preschool educator training institutions including higher education institutions, focus on general play-based pedagogy rather than subject-specific pedagogy. Indeed, this focus is not surprising due to the widespread inclusion of play-based pedagogy in early childhood policy. This focus is certainly true in Ireland where play is a central concept in *Aistear* (NCCA, 2009).

In more recent research Piasta, Logan, Pelatti, Capps, and Petrill (2015) provide evidence that preschool educators who receive science professional development give the children more science learning opportunities. It is, however, also worth noting that in reality, child development theory is the underpinning body of knowledge that influences early childhood educator training and policy frameworks, more so than any other age phase (Hatch 2010, 2020). In practice, this is associated with a ‘hands-off’ approach by educators as children are left to discover knowledge for themselves through exploration and play, with little emphasis on subject-specific content.

Cochran-Smith and Lytle’s (1999) second conception of educator learning, “knowledge-*in*-practice” (p. 262), is acquired through educators reflecting upon their experiences in the classroom and learning from other more experienced or expert educators. In other words, ‘what’ educators need to learn is practical knowledge generated by a competent educator as they deal with situations in the classroom and the ‘how’ is by reflecting on the experience. This type of learning can occur in a dyadic situation between a novice and expert educator, and among groups of experienced educators who can learn from each other by jointly reflecting on experiences (Cochran-Smith and Lytle, 1999). While this notion of an ‘expert’ educator is appealing, such educators may be somewhat scarce when it comes to preschool science. As contemporary literature suggests, many early childhood educators avoid science (Roehrig et al., 2011; Tu, 2006) due to a lack of confidence and competence in science teaching (Gerde et al., 2018).

Cochran-Smith and Lytle’s (1999) third educator learning conception, “knowledge-*of*-practice”, is acquired through “systematic inquiries into teaching, learning and learners, subject matter and curriculum, schools and schooling” (p. 274). By engaging in inquiry (research), the educator’s role becomes one of knowledge creator rather than a receiver of formal and practical knowledge as outlined above. Knowledge-*of*-practice also differs from the two previous conceptions in that it is constructed collectively by educators, academics, children, parents and the wider community, and produces a “locally developed curriculum and more equitable social relations” (p. 274). Cochran-Smith and Lytle (1999) contend that knowledge-of-practice changes educators’ views of what ‘practice’ means as it emphasises the relationship between the educator and the children, parents and other stakeholders. In essence, the collaborative approach highlighted in this conception of learning creates a new lens through which educators interpret their practice. Indeed, experienced educators who engage in research within their classrooms are challenged to examine their views of practice as they think about “what is regarded as expert knowledge, examining underlying assumptions, and making the lives of families and communities part of the curriculum” (p.277). This third conception of educator learning aligns with sociocultural theory as it describes learning as emerging in and from social contexts, and where the educator is viewed as both a user and co-creator of knowledge. The promotion of a sociocultural perspective in *Aistear* (NCCA, 2009), therefore, presents the preschool educator with opportunities to provide science learning that is socially, culturally and historically relevant. In relation to the current study, Cochran-Smith and Lytle’s tripartite approach may provide a useful framework for investigating the sources of early childhood educators’ scientific pedagogical knowledge.

Pedagogical science knowledge

Young children will develop their scientific knowledge and understanding when a knowledgeable adult intentionally supports their scientific inquiries (French, 2004; Nayfeld, Brenneman, & Gelman, 2011; Samarapungavan et al., 2008). The success of this support is directly dependent on the educators’ knowledge and understanding of the scientific concepts and the process of inquiry (Worth, 2010), in other words, their PCK. However, many preschool educators lack science understanding due to a lack of experience and training in science (Gropen et al., 2017). Appleton (2013) also makes the point that educators who think about science solely as a collection of facts may miss the opportunity to use “informal everyday science knowledge arising from hobbies, interests and experiences” (p. 41).

Nevertheless, with targeted training at either pre-service or in-service levels, educators can provide opportunities that support children’s science learning. For example, McNerney and Hall (2017) undertook an action research project with early childhood educators in a single setting in the UK. The researchers initially discovered all educators defined science as being about acquiring facts, which led to a lack of confidence in teaching unfamiliar science topics. However, they subsequently found the process of defining a shared understanding of NOS (nature of science) was beneficial in dealing with educators' lack of confidence. Also, the development of a specific scientific inquiry framework encouraged children's scientific thinking and reasoning skills, rather than the acquisition of facts. McNerney and Hall (2017) conclude that the educators were "freed from their own imposed expectation to be the 'science expert' with all the knowledge at their fingertips, and instead were promoting the children to look at and question the world around them" (p. 218).

An important point raised by McNerney and Hall's (2017) study is that the content aspect of PCK can be considered in terms of NOS rather than specific scientific content knowledge. Combining this type of PCK alongside a sociocultural approach to learning, where educators see themselves and the children as co-constructors of knowledge, presents endless possibilities for science learning experiences. As there is no expectation that the educator will have all the answers, this may well boost their confidence in dealing with unfamiliar topics. However, this is not to suggest that educators do not need to have some scientific conceptual knowledge. If the 'big ideas' of science are to form the basis for scientific inquiry the educator needs some basic conceptual understanding to effectively mediate learning (Gelman et al., 2010; Harlen, 2013). Effective educator mediation in children's science learning also involves the use of various pedagogical strategies.

2.4.3: Pedagogical strategies

According to Hadzigeorgiou (2001), in order to build a strong conceptual base for science learning children have to develop a relationship with the world of science, and a fundamental perquisite for this are children's attitudes towards science. Attitudes such as intellectual curiosity can, according to Hadzigeorgiou (2001), be facilitated through hands-on activities that incite "wonder" and "casts a magic spell" (p. 65) on the children. While acknowledging the necessary provision of opportunities for action and experimentation, Hadzigeorgiou nevertheless places great emphasis on the initial wonder of children as an important element in the design of science activities. The use of the term ‘magic spell’ in relation to young children’s science learning is perhaps an unfortunate one as it implies that children need to be entertained through some form of theatrical wizardry rather than real science learning. The idea that preschool science is presented as some form of trickery is strongly rejected by Gelman et al. (2010) who point out that science learning in early childhood is more than “magic show science” (p.26) where the educator creates an exciting visual display and the children sit back and merely observe. Rather, science learning involves children exploring and learning about central concepts through a series of related experiences. Watts et al. (2017) further support this point as they suggest that science involves “good thinking” where decisions are based on evidence and “for science to work there is a need to dispel any ’capricious magic’ involved” (p. 229). The rejection of science in early childhood education as a magical visual display is understandable; however, it is difficult to ignore the influence of educators’ lack of scientific knowledge as a potential reason for using such an approach. At a system level, this approach may also be attributed to the persistent influence of developmental theory on early childhood curriculum, which as Hatch (2020) posits inevitably results in a curriculum that privileges ‘activities’ and ‘experiences’ and fails to give critical thought to the intellectual content children should learn.

Observation and listening are two of the most commonly used pedagogical strategies in early childhood education (Hyson & Tomlinson, 2014). In preparing for science activities educators observe and listen to children to discover their interests and previous experience (Edson, 2013; Gelman et al., 2010; Smith & Trundle, 2014). These two strategies are not only employed during the planning phase they are continually used throughout science learning activities, including those which occur during everyday experiences. Research by Andersson and Gullberg (2014) involving five preschool and primary educators facilitating a floating and sinking activity, found that educators must be observant throughout children’s everyday activities to “capture unexpected things at the moment they occur” (p. 287). Also, they identify that educators “’*Remain*’ in the situation and listen to children and their explanations…Remaining in the situation means educators need to trust in her/his ability to actively listen to the children”(p. 287). Actively listening to children’s ideas provides the educator with an indirect way to sustain the children’s interest and guide their learning.

Through the process of actively listening to children's explanations and questions, educators learn about their conceptual understanding (Gelman et al., 2010). The educator's task is to guide the child towards developing scientific conceptual knowledge by starting from familiar everyday concepts and developing the dialectical relationship mentioned previously. According to Harlan and Rivkin (2014), educators can use modelling to guide children's thinking indirectly. They do this by verbalising their reasoning processes; in other words, 'thinking out loud' and encouraging children to do likewise. The processes of active listening and modelling their own thinking within science activities provides educators and children with a rich context to engage in "meaningful conversations" (Gerde et al., 2013, p. 317) as they co-construct knowledge. These type of adult-child verbal interactions provide a platform for 'sustained shared thinking'.

The concept of sustained shared thinking was first presented in the UK government funded five-year longitudinal research project, *Effective Preschool Education Provision* (EPPE) (Siraj-Blatchford et al., 2003) and the related study, *Researching Effective Pedagogy in the Early Years* (REPEY) (Siraj-Blatchford, Sylva, Muttock, Gilden, & Bell, 2002). In these two studies an association was made between sustained shared thinking and positive cognitive outcomes for young children in early years settings The EPPE study followed the progress of 3000 preschool children across 141 early years settings in England and showed that early childhood education significantly impacts child development (Siraj-Blatchford et al., 2003). The EPPE study was qualitatively extended by the REPEY project which identified the pedagogical strategies that are used to support the development of knowledge, skills and attitudes that enable young children to make a good start at school (Siraj-Blatchford & Sylva, 2004). Within the REPEY study, Siraj-Blatchford and colleagues (2002) identify a link between positive cognitive outcomes and sustained adult-child interactions, and consequently sustained shared thinking was deemed to be an effective pedagogical interaction. They define sustained shared thinking as,

> An episode in which two or more individuals "work together" in an intellectual way to solve a problem, clarify a concept, evaluate activities, extend a narrative etc. Both parties must contribute to the thinking and it must develop and extend. (p.8)

In line with Shulman's (1986) theory of subject-related PCK, Siraj-Blatchford and colleagues (2002) suggest that while sustained shared thinking was a prerequisite for pedagogy, educators also require knowledge and understanding of the relevant subject area. They found that instances where educators' subject content knowledge was inadequate, led to missed opportunities for pedagogical interactions (p.67).

Preliminary analysis of educator observation data in the REPEY study revealed that instances of sustained shared thinking were associated with the pedagogical strategy of questioning (Siraj-Blatchford et al., 2002). In the context of science education, Harlen and Qualter (2014) maintain that "[t]eachers' questioning is one of the most important factors in determining children's opportunities for developing their understanding and inquiry skills" (p. 148). However, not all question types promote sustained shared thinking. Questions can be either open-ended, allowing for several answers or closed, which prompt a single correct response. Subsequent analysis of the 5808 questions coded in the REPEY study found that only open-ended questions have the potential to lead to sustained shared thinking/talking (Siraj-Blatchford & Manni, 2008). In their analysis of the nature of adult-child interactions, McInnes, Howard, Crowley, and Miles (2013) found the sustained interactions that support-problem solving are complex and involve an extended dialogue between the educator and child that incorporates a number of open-ended questions.

In the context of science education, the skilful use of open-ended questions can promote high-level discussions with children (Ogu & Schmidt, 2009) and encourage inquiry by the children (Harlen and Qualter, 2014). Indeed, Harlan and Rivkin (2014) further point out that open-ended questions serve many purposes within the inquiry process including, "*instigating discovery…eliciting predictions…probing for understanding…promoting reasoning…serving as a catalyst…encouraging creative thinking and reflection…reflecting on feelings"* (p. 36-7) (emphasis in original). Furthermore, while emphasising the limited role of closed questions in stimulating creative thinking and synthesising, Harlan and Rivkin (2014) acknowledge that they can be beneficial for directing attention and recalling facts.

Although educators recognise the crucial role of questioning in education, research suggests that they rarely pay attention to the form or quality of questions asked (Crowe & Stanford, 2010). The analysis of questions in the REPEY database previously mentioned, Siraj-Blatchford and Manni (2008) found that 94.5% of all the questions asked by early childhood educators were closed, and only 5.5% were open-ended. Similarly, in a more recent study involving six preschool educators working with a group of six-year-old children, Günay Bilaloğlu, Aktaş Arnas, and Yaşar (2017) found that 90% of questions posed by educators during science activities involved closed questions. Furthermore, the educators reacted to the children's responses by either repeating their answers or with vapid statements. In cases where the response was incorrect, the educators tended to answer the question themselves. Günay Bilaloğlu et al.'s (2017) research suggests that these preschool educators privileged the learning of facts over developing the children's creative thinking or problem-solving skills. These findings highlighted above provide a useful benchmark for the inappropriate use of questioning with preschool children. Young children are innately curious and when faced with continuous closed questions, their interest to engage in any form of inquiry, learning is likely to be quite limited (Harlan & Rivkin, 2014).

Moreover, the insightful use of questioning is a helpful tool for mediating children's learning. According to Siraj-Blatchford et al. (2002), questioning plays an integral role in sustained shared thinking interactions such as scaffolding. Furthermore, Inan and Inan (2015), the educator can scaffold children's learning by asking the right question at the right time. Andersson and Gullberg (2014) identify this as productive questioning which occurs when the preschool educator poses questions that challenge young children's thinking and stimulates further inquiry. Also, the educator may redraft children's 'why' questions into an investigable form. Productive questioning is similarly acknowledged by Smith and Trundle (2014) as an important step in moving children from child instigated incidental learning to educator instigated intentional learning. However, this is not to suggest that incidental learning, which occurs when the child's curiosity is aroused, has no place in the classroom. Rather, the educator capitalises on this moment by asking questions to extend the inquiry. Indeed, Harlen and Qualter (2014) urge educators to make the most of these impromptu investigations as they "add freshness to the classroom and create a partnership in the knowledge business between the children and the educator" (p. 33).

Educator-initiated questions play a fundamental role in scientific inquiry learning and, according to Harlan and Rivkin (2014), directly impact the quality of that learning. The importance of developing the skill of questioning is captured by Postman and Weingartner (1971 p.37) (cited in Watts *et al*., 2017),

> Once you have learned how to ask – relevant and appropriate and substantial questions- you have learned how to learn, and no-one can keep you from learning whatever you want or need to know. (p. 276)

However, rather than simply accepting that the pedagogic skill lies in asking questions, how educators respond to children's answers also plays an important role in the overall effectiveness of this pedagogical strategy. As Alexander (2008, p. 137) posits,

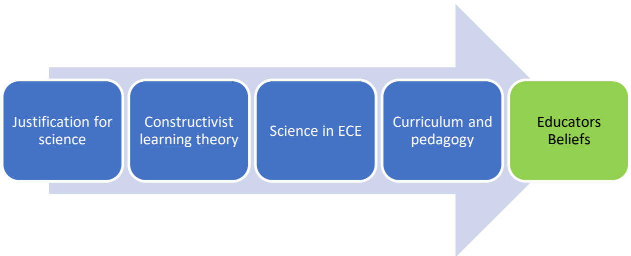
> The most refined and searching questioning technique is pointless if the educator does nothing with the answer that the student provides other than pronounce it correct or incorrect, or – equivocating to avoid even that elementary judgement – 'interesting'.

Providing opportunities for children to develop their investigative questioning skills is an essential task for the preschool educator. According to Ashbrook (2016), if the educator creates an environment in which the children feel safe and appreciated for asking questions, this will encourage them to ask more questions. An ethos of respect underpins such an environment. As the educator models respect for ideas expressed and questions asked this will also facilitate children learning from each other (Harlan and Rivkin, 2014). When the educator responds to children's questions, they show children that their thoughts and ideas are important. Such responses can take the form of an explanation or indeed a question.

The pedagogical strategies outlined above reflect what contemporary literature offers as optimum practice in inquiry-based science learning. It is, however, important to recognise that tacit assumptions regarding educators' science knowledge underpin much of this literature. For instance, recognising the potential for science learning within children's everyday experiences presupposes that the educator has the necessary scientific content and process knowledge to do this. Similarly, knowing which questions to ask or indeed modelling specific behaviours require the educator to have some basic knowledge and understanding of the relevant scientific concept. A noteworthy exception in the literature is the REPEY study which makes the point that educators' PCK is as important in early childhood education as it is in later education (Siraj-Blatchford et al., 2002).

In summary, the literature in this section has explored the factors influencing the teaching of science in early childhood education. Shulman (1986) provides a useful insight into the 'what' and 'how' of teaching through his work on PCK. This model presupposes that the educator will have some scientific content knowledge which serves to determine the pedagogical practices used. Additionally, it was suggested that educators' assumptions about how children learn are likely to influence their provision of science learning opportunities. Cochran-Smyth and Lytle's (1999) three sources of educators' PCK (knowledge-*for*-practice, knowledge-*in*-practice, and knowledge-*of*-practice) were examined. It was clear, however, that this approach is based on the premise that educators receive adequate training and have access to expert in-service educators, which research suggests, in the case of early childhood science education, may not be the case (Early and Winton, 2001; Roehrig et al., 2011). Educators' views of what science is, were also shown to impact on practice. Research shows that educators who lack confidence primarily view science as a collection of facts; whereas those who consider science in terms of NOS appreciate that they do not need to know everything and embrace science more confidently (McNerny and Hall, 2017). Much of the literature reviewed in this section contained implicit assumptions regarding educators' science knowledge. The literature on pedagogical strategies assumes educators have a basic level of scientific knowledge and understanding. In addition, there seems to be limited research available that takes a more global view of pedagogical practices in science education. Indeed, all of the research cited above investigates the use of a specific pedagogical strategy within science teaching.

So far, this literature review has discussed the justification for science learning in early childhood education which led on to an examination of learning theories and how they influence curriculum and educators' approaches to the provision of science learning opportunities. The construct of science and the use of inquiry-based learning were then examined, and this led on to a review of teaching science in early childhood education. Throughout these sections the critical role of the educator in supporting children's science learning was emphasised. However, it was also shown that the efficacy of this support is predicated on the educators' scientific process and content knowledge. This knowledge underpins the pedagogical approach used within the classroom and is a cornerstone of the educator's PCK. While educators' knowledge of science directly impacts on practices, it does not provide full insight into what drives educators' behaviour. As one of the main determinants of decisions and actions are an educator's beliefs (Pajares, 1992; Vartuli, 2005), the final section of this literature review will examine this construct.



2.5: Educators' beliefs

The study of educators' beliefs about science in early childhood education provides insight into how they conceptualise their work and make decisions that influence their practice. Described as "the most valuable psychological construct to educator education" (Mansour, 2009, p. 25), educators' beliefs are complex and formed over a long period time through experiences such as education (Gürsoy, 2013; Vartuli, 2005) professional training and development (Duran, Ballone-Duran, Haney, & Beltyukova, 2009; Saçkes, Flevares, Gonya, & Trundle, 2012), teaching experience (Kagan, 1992; Pajares, 1992; Saçkes et al., 2012) and culture (Mansour, 2009). For such an important construct, there is a remarkable inconsistency in definitions of educators' beliefs. In his seminal review of the literature on this topic Pajares (1992) refers to educators' beliefs as a 'messy construct' which:

> …travel in disguise and often under alias - attitudes, values, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, implicit theories, explicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principles, repertoires of understanding, and social strategy to name but a few that can be found in the literature.
> (p. 309)

Pajares further contends that this myriad of definitions exists due to the confusion surrounding the distinction between beliefs and knowledge. In an attempt to provide some clarity Nespor (1987) identified four characteristics that distinguish beliefs from knowledge, namely, existential presumption, alternativity, affective and evaluative loading, and episodic structure.

Existential presumptions are an individual's deeply held personal truths. According to Rokeach (1968), beliefs based on such assumptions are so ingrained within a person that they are beyond question. The formation of these highly stable beliefs is not time-dependent as they can occur after a single experience or series of events. As Pajares (1992) points out, "[e]xistential presumptions are perceived as immutable entities that exist beyond individual control or knowledge. People believe them because, like Mount Everest, they are there" (p. 309). While Nespor (1987) acknowledges that beliefs systems are often based on assumptions about the existence or nonexistence of entities, such as God, for example, he further suggests that existential presumptions also exist at more 'mundane' levels of thought. Referencing his own research Nespor (1987) cites an example of an educator's beliefs about entities embodied within students such as 'ability', 'maturity', and 'laziness'. In relation to science in early childhood education, existential presumptions may result in the educator limiting the provision of science learning opportunities to solely hands-on exploration of materials because they believe that the children are not developmentally ready to think more deeply about science (Metz, 1995).

Alternativity, according to Nespor (1987), refers to “conceptualisations of ideal situations differing significantly from present realities” (p. 319). An educator may look back favourably on their own school experiences and try to replicate those positive experiences within their classroom. Alternatively, Nespor (1987) suggests that educators who have negative memories associated with their schooling may decide to create their idealised environment for which they have no direct experience or knowledge. For instance, in relation to science, early childhood educators whose personal experience of science in school consisted of strictly controlled procedures may believe that science in early childhood education should solely consist of child-led playful, fun activities which are based on exploration and discovery.

According to Nespor (1987) beliefs are strongly influenced by affective and evaluative components, in other words, how one feels about a subject. One can have certain feelings about a subject, and these can operate independently of the knowledge they may have about that subject. Nespor (1987) elaborates using the example of chess, where he suggests that knowledge of the rules and strategies of the game are not dependent upon how one feels about playing chess. In relation to the current study on science in early childhood education, an educator may have some science content knowledge or indeed may have undertaken training in science, but if they harbour negative feelings about science, which in turn affect their beliefs, this may influence how, or indeed if, they provide science learning opportunities. Conversely, an educator who is fascinated and excited by science may be motivated to seek out more information and training to enhance their science teaching. The relationship between training and beliefs is not straightforward. Research by Breffni (2011) found that while an early childhood educator training programme increased educator knowledge, their beliefs were not significantly impacted. One reason for this may be found in the work of Talbot and Campbell (2014) who suggest that training programmes may not be successful due to tensions between beliefs that are implicit within a training programme and a educator’s own beliefs. They suggest these tensions can be reduced by making these implicit beliefs explicit and giving educators help to consider how the two sets of beliefs can work together.

Nespor (1987) further contends that beliefs exist in episodic memory and are composed of personal experiences or cultural knowledge such as customs and traditions. Nespor suggests that the relative strength of beliefs is based on the impact past experiences have on subsequent events. Indeed, other research on educators' beliefs suggests the impact of past experiences is particularly relevant (Gürsoy, 2013; Hsiao et al., 2010; Pajares, 1992; Vartuli, 2005). While educators learn a lot about teaching from their own experiences as a student, Nespor (1987) suggests it is unlikely that such learning results from reflection. Rather, he proposes that "some crucial experience or some particularly influential educator produces a richly-detailed episodic memory which later serves the student as an inspiration and a template for his or her own teaching practices" (p. 320). Such experiences may be of interest in the current study as the participant educators may have encountered another educator who inspires their teaching of science as they gained their "knowledge-*in*-practice" (Cochran-Smith and Lytle, 1999, p. 262). However, as early childhood educators tend to avoid science (Early et al., 2010), such encounters may be unlikely.

2.5.1: The relationship between beliefs and practice

The relationship between beliefs and practice, while "complex and context-dependent" (Mansour 2009, p.25), plays a significant role in determining student outcomes and consequently the success of education (Fives & Buehl, 2012; Mansour, 2009; Pajares, 1992). According to Kelchtermans (2009), educators' beliefs form the foundation for a personal interpretive framework which "operates as a lens through which educators look at their job, give meaning to it and act in it" (p. 260). Although beliefs are "hidden in people's hearts" (Hsiao & Yang, 2010, p. 299) they guide behaviour and thinking. Moreover, beliefs provide the support structure for practice, as Hsiao and Yang (2010) describe:

> Beliefs are like the part of an iceberg that is hidden under sea level; this larger proportion of the iceberg securely supports the smaller portion above sea level providing tremendous influence [on] one's behaviour. (p. 29)

There is some debate in the literature regarding the relationship between educators' beliefs and their classroom practices. Research by Rubie-Davies, Flint, and McDonald

(2012) found that educators' beliefs influenced instructional decisions which in turn shaped the type of learning opportunities provided for children. Research relating educators' beliefs to their science practices in early childhood education is sparse. However, in one such study, Fleer (2009a) found that early childhood educators' philosophical beliefs about how children learn significantly influence the types of science learning opportunities afforded to children. Indeed, Fleer (2009a) also suggests that educators' beliefs have more of an impact on children's science learning than educators' knowledge of science or confidence to teach science. In contrast, a study on early childhood educators' attitudes towards science teaching, found that despite having a positive attitude, the link between their attitude and the frequency of science activities provision was weak (Erden & Sönmez, 2011). The inconsistency in the literature is not new, and Pajares (1992) while acknowledging the debate, refers to several sources which firmly support the assumption that "beliefs are the best indicators of decisions people make throughout their lives" (p. 307). Giving little countenance to the opposing view, he concludes there is "a strong relationship between teachers' educational beliefs and their planning, instructional decisions, and classroom practices" (p. 326).

Although Fives and Buehl (2012) agree that "beliefs are precursors to action" (p.481) they also suggest that researchers should try to understand the reasons why beliefs and practice may not always be consistent. A lack of consistency may be due to factors which are outside the control of the educator. One such factor is the perceived culture within a school. In research by Barkatsas and Malone (2005), one educator described a school's lack of innovation and failure to acknowledge her attempts to improve practice as a reason for inconsistencies between her constructivist beliefs and instructivist classroom practice. Similarly, Mansour (2013) found that the sociocultural context of the classroom played a significant role in either supporting or inhibiting the enactment of educators' constructivist beliefs. Pedagogical beliefs do not solely underpin educators classroom practices; they can also be influenced by what educators believe their peers and school administrators think they should do (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012). The influence of school leadership can also profoundly influence practice, sometimes superseding the influence of the educator's own beliefs around appropriate practice. A change in school principal had a profound effect on the practice of the two educators in a study by Enyedy, Goldberg, and Welsh (2006). They found that one educator, a self-described risk-taker who liked to try out new ideas, felt inhibited from continuing to enact her beliefs due to a lack of support and encouragement from the new principal.

In his conclusion, Pajares (1992) identifies 16 fundamental assumptions that can be made when studying educators' beliefs. I have selected five which may prove useful during data analysis in my study.

1. Beliefs are formed early and tend to self-perpetuate, persevering even against contradictions caused by reason, time schooling or experience.
2. Knowledge and beliefs are inextricably intertwined, but the potent affective, evaluative, and episodic nature of beliefs makes them a filter through which new phenomena are interpreted.
3. Belief substructures, such as educational beliefs, must be understood in terms of their connections not only to each other but also to other, perhaps more central, beliefs in the system. Psychologists usually refer to these substructures as attitudes and values.
4. Individuals' beliefs strongly affect their behaviour.
5. Beliefs must be inferred, and this inference must take into account the congruence among individuals' belief statements, the intentionality to behave in a predisposed manner, and the behaviour related to the belief in question.

(Pajares, 1992 pp. 325-6)

While this section has provided insight into the construct of educator's beliefs and their impact on practice, a high percentage of the literature on beliefs sourced for this review focuses on educators' self-efficacy beliefs.

2.5.2: Educators' science teaching self-efficacy

While many external factors influence educators' beliefs and practice, two internal factors, knowledge and self-efficacy, also play a significant role (Fives & Buehl 2012). As the intertwined relationship between knowledge and beliefs has been described above, this section will focus on self-efficacy. Educator self-efficacy is described as “the educator’s belief in his or her ability to organise and execute the course of action required to accomplish a specific teaching task in a particular context” (Tschannen-Moran, Hoy, & Hoy, 1998, p. 233). Educators’ self-efficacy, therefore, influences practice as decisions about science teaching are based on their belief in their ability to complete the task. Bandura (1977) identifies four sources of self-efficacy, including performance accomplishment, vicarious experiences, verbal persuasion and physiological states.

Performance accomplishment is considered to be the most important source of self-efficacy (Bandura, 1977). It exists where the educator masters a particular skill, or successfully performs a task. Moreover, Dimopoulou (2012) suggests that while success strengthens self-efficacy, equally failure weakens it.
Vicarious experiences occur when the educator observes another educator successfully modelling a task. Modelling acts to persuade the observing educator that “if others can do it, they should at least be able to achieve some improvement in performance” (Bandura, 1977 p. 197). Additionally, observing success increases self-efficacy and seeing failure decreases it.

Verbal persuasion involves persuading the educator that they have the skills and capability to achieve success. Self-doubt is overcome by receiving positive feedback and encouragement. However, Bandura (1977) also notes that verbal persuasion on its own is not as effective as performance accomplishment as it lacks an experiential base. Furthermore, Bandura (1986) later suggested that the effectiveness of the persuasion depends upon credibility, trustworthiness and expertise of the persuader.
Physiological states refer to the emotional response associated with a teaching situation. According to Bandura (1977) perceptions of such reactions in oneself can influence self-efficacy. The preschool educator who feels anxious or stressed about providing science learning opportunities is likely to have a low sense of self-efficacy in such situations. However, Bandura (1997) notes that it is how one copes with and reduces such anxiety that helps to strengthen self-efficacy. The most important point here is that self-efficacy reflects personal perceptions of capability rather than actual ability.

Much of the research sourced for this review revealed that early childhood educators tend to have low science teaching self-efficacy beliefs. An important point to note regarding this research is that the data is primarily based on participant surveys and quantitative methods are used for data analysis. While such data provides valuable information, it does not provide a rich picture of the individual stories behind the numbers. Nevertheless, it is useful to explore what these studies found. A variety of reasons are offered, including uncertainty surrounding their role as an educator of science, a lack of science-based knowledge, inadequate preservice or in-service training, a lack of resources, time management, and uncertainty about what constitutes effective science teaching (for example see: Bautista, 2011; Garbett, 2003; Greenfield et al., 2009; Kallery, 2004; Maier, Greenfield, & Bulotsky-Shearer, 2013; Olgan, 2015; Park et al., 2016; Pendergast et al., 2017). However, educators with an average level of science teaching self-efficacy may not necessarily teach science effectively. Research by Hollingsworth and Vandermaas-Peeler (2017) involving 58 in-service preschool educators, revealed that while the educators with an average sense of self-efficacy had some appreciation of topic areas and activities typically considered as science, they were not engaging the children in complete cycles of scientific inquiry. Therefore, this study highlights that efficacy alone does not provide a true picture of the knowledge and practices surrounding early childhood science education. Rather, it indicates that a more fullsome representation requires data on educators' efficacy and PCK.

Furthermore, considering the general trend of low science teaching self-efficacy beliefs among educators and the strong link between beliefs and practice previously outlined, it is not surprising that science is often avoided in the early childhood classroom. In a study of 20 preschool classrooms, Tu (2006) observed that 86.8% of educators' activities were unrelated to science. Corroborating evidence is presented by Early et al. (2010) in their large-scale study involving 652 pre-kindergarten programmes across 11 states in the USA, where it was found that children spent the majority of their time engaged in language/literacy, social studies and art activities and less time on science and mathematics. In more recent years the trend is mixed. There is some evidence to suggest that more time (25%) is being spent on science (Piasta, Pelatti, & Miller, 2014). However, the situation in Ireland does not seem to be as positive. A recent report on school readiness identified language, literacy and numeracy as the perceived priorities among the stakeholders in early years education (Ring et al., 2015).

In summary, the study of educator's beliefs about science education in early childhood education provides insight into how they conceptualise their work and make decisions which influence their practice. While the distinction between beliefs and knowledge is often blurred, some implicit distinctions have been discussed. Belief systems often include assumptions about the existence of entities or alternate realities, affective feelings and evaluations, and personal memories. While such explanations help to explain the formation of beliefs, the significance of educators' beliefs lies in their strong relationship to classroom practice (Pajares, 1992). Much of the research surrounding beliefs focuses on educators' self-efficacy in their ability to teach science. It was noted that the primary methodology used in such studies is based on a quantitative approach and therefore does not provide insight into individual educator's beliefs and how they relate to their practice. Bandura's (1977) four sources of self-efficacy provide a useful framework for examining educators' science teaching self-efficacy. While research suggests that early childhood educators have low self-efficacy, this construct alone does not provide a complete representation of their science teaching knowledge and practices. Consideration must be given to educators' beliefs about how children learn, their personal understanding of science and their pedagogical practices in the classroom. This thesis makes a significant and original contribution to knowledge by examining these factors in the context of the contemporary early childhood education policy framework in Ireland.

2.6: Chapter Summary

This literature review has shown that several factors influence the enactment of science in early childhood education. Constructivist views of learning dominate in science education and indeed early childhood education literature. In Ireland, the early childhood curriculum framework policy, *Aistear* (NCCA, 2009), reflects a constructivist view. While both Piagetian and Vygotskian influences can be found, Piaget's approach to learning holds a dominant position, with active learning described in terms of discovery learning through sensory exploration.

Educators holding either Piagetian or Vygotskian views enact early childhood science education very differently. The educator following a Piagetian approach views the child as a solitary constructor of knowledge, who learns about science through sensory exploration and discovery. As development is privileged over learning, the educator adopts a 'hands-off' approach and merely facilitate the child's scientific learning through the provision of resources. However, questions have been raised as to how scientific conceptual development can be achieved without the support of a knowledgeable educator (Fleer, 2009a; Gelman et al., 2010; Harlan & Rivkin, 2010). Alternately, educators who hold the Vygotskian view where learning is believed to precede development, acknowledge the social nature of learning. The educator not only mediates but also co-constructs scientific learning with the child. Fleer (2009b) offers clarity concerning Vygotsky's (1986) theory of scientific conceptual development. Pointing out that to effectively support children's science learning, educators need to be aware of the dialectical relationship between children's everyday and scientific concepts. Furthermore, understanding children's working theories offers educators further clarity about the relationship between these two types of conceptual knowledge (Hedges, 2011, 2012). It is on these points that another significant factor that influences how educators enact science in the classroom emerges, namely, educator's science content knowledge.

To effectively support children's science learning, educators not only need to understand what science is, but they also require science content knowledge (Hedges & Cullen, 2005). Educators need this knowledge to recognise the potential for scientific conceptual development that exists within children's everyday concepts and working theories. Equally significant is the influence of content knowledge on the educators pedagogical content knowledge (PCK) (Shulman, 1986, 1987). To effectively support children's science learning educators must interpret science content and find ways to teach it so that it is understandable and accessible to young children. There is broad agreement in the literature that an inquiry-based approach, supported by a knowledgeable educator offers an effective way for young children to learn about science (Nayfield et al., 2011; Worth, 2010).

The effectiveness of pedagogical strategies employed by educators is also influenced by their subject content knowledge. Educators' gain their PCK during their pre-service training, from academics in colleges or if they come across 'expert' educators in the field (Cochran-Smyth & Lytle, 1999). However, gaining PCK is not guaranteed as many early childhood education pre-service training institutions do not include subject-specific training (Early et al., 2010), and many educators in the field lack the confidence and competence to teach science (Garbett, 2003; McNerney & Hall, 2017). Importantly, *Aistear* does not provide specific guidance on science-based content or pedagogical strategies for scientific inquiry.

A final key influencing factor on the practices of science in early childhood education are educators' beliefs. Educators' beliefs about science education provide insight into how they conceptualise their work and make decisions which influence their practice. In particular, educators' philosophical beliefs about how children learn play a significant role in how they support science learning (Fleer, 2009a). Much of the research on educator beliefs focus on self-efficacy, and findings indicate that educators have low science teaching self-efficacy. However, as this research predominantly generates quantitative data, it does not provide an insight into how educators perceptions and understandings influence their practice.

This literature review has critically examined the multiplicity of factors that influence how early childhood educators support children's science learning. As a consequence, it has both informed and provided a conceptual framework for my research project. Research on science in early childhood education in Ireland is limited, and indeed no study was located that explored how early childhood educators perceive and practice science. Furthermore, research on educators' beliefs also needs to take into account the education policy frameworks that influence their practice.

The following chapter will outline the methodological approach used to explore the perceptions and practices in science education of a group of early childhood educators in Ireland.

Chapter 3: Methodology

3.1: Introduction

According to Bassey (1999), educational research can be defined as "systematic, critical and self-critical enquiry which aims to contribute to the advancement of knowledge" (p.39). This definition aligns with the aim of my study, which is to contribute to the knowledge base in early childhood science education. This aim will be achieved by critically examining early childhood educators' perceptions and practices in science within the context of *Aistear*, *the Early Childhood Curriculum Framework* (NCCA, 2009) in Ireland. The analytical focus for this study are the various factors that influence educators' provision of science learning experiences. This research project aims to answer the following research questions:

- What perceptions do a group of educators who work with 3- to 5-year-old children have about science in early childhood education?

- What factors influence how these educators practice science education?

Several decisions have to be made concerning research design in order to provide answers to these research questions. These include methodological decisions such as what will constitute appropriate data, how that data will be collected and analysed, and how the research will be reported. For research findings, claims and conclusions to be credible, the researcher must "be able to justify and argue a methodological case for their reasons for choosing a particular approach and procedures" (Sikes, 2004, p. 17). However, the methodological and procedural choices faced by the researcher are not straightforward. There is no off-the-shelf research design box containing everything the researcher needs in terms of methodology and methods. Indeed, Sikes (2004) cautions that:

> To present a research design as being a straightforward, technical matter of 'horses for courses', with researchers 'objectively' choosing the most appropriate, if not the only possible, methodology and procedures for a specific research project, would be misleading and even dishonest and immoral. (p.17/18)

Furthermore, Sikes identifies researcher positionality as the most significant factor influencing their choice of methodology and methods. The researcher's positionality is based on their philosophical stance and fundamental assumptions concerning ontology, epistemology, and human nature and agency (Sikes, 2004). Ontology is described as "a theory of what exists and how it exists" (Clough & Nutbrown, 2012, p. 37). Therefore, ontological assumptions concern assumptions about the nature or essence of social reality. According to Crotty (1998), epistemology is "the theory of knowledge embedded in the theoretical perspective and thereby the methodology" (p.3). Therefore, epistemological assumptions refer to assumptions about the nature of knowledge and how we acquire it. From a philosophical perspective, there is a connection between ontological and epistemological assumptions (Crotty, 1998). According to Sikes (2004), if the researcher believes knowledge is objective and out there to be discovered then epistemologically, it can be observed, measured and quantified. On the other hand, if knowledge is assumed to be subjectively experienced, and socially constructed then epistemologically, it cannot be quantified or measured, but rather is open to interpretation and needs to be explained. According to Grix (2004, p. 68), the researcher's ontological position is the starting point for research:

> Setting out clearly the relationship between what a researcher thinks can be researched (her ontological position) linking it to what we can know about it (her epistemological position) and how to go about acquiring it (her methodological approach), you can begin to comprehend the impact your ontological position can have on what and how you decide to study.

Assumptions about human nature and agency are concerned with the relationship between human beings and their environment; whether they are products of their environment; or active contributors, utilising their free will to produce their environment (Cohen, Manion, & Morrison, 2011).

This chapter aims to explain my research project in a critical way that highlights my reflective and reflexive approach. As the three sets of assumptions outlined above have a direct impact on the methodological concerns in this research, it makes sense to begin this chapter by highlighting my positionality. At the start of this section, I will provide a brief account of my background as I believe this will give some context for the project choice and explain how my epistemological assumptions have developed over time. I will continue by explaining my philosophical and paradigmatic stance, which led to the decision to use an interpretivist theoretical perspective for this research project. The next section will examine the research approach and provide a rationale for the choice of a case study approach. The research participants will be introduced, and the recruitment procedure explained. A rationale for the choice of two data collection methods, namely semi-structured interview and video observation, will be followed by an explanation of the thematic analysis process used to make sense of the data. The chapter concludes with an examination of the ethical considerations and approach.

3.2: Positionality

My background in early childhood education

My involvement in early childhood education started over twenty years ago when I enrolled on a Montessori educator training course. Before that, I worked as an electronics engineer in the semiconductor industry. On completion of my undergraduate degree in Montessori Education, I worked for several years as a Montessori educator in a preschool which catered for children aged from 3 to 5 years. During my time as a preschool educator, I followed the Montessori curriculum, which is a structured and prescriptive curriculum that sets out specific activities for children aged 3 to 6 years. The Montessori educator's role is that of a facilitator, who provides materials and resources for the children. Influenced by Piaget's theory in which development leads learning, the Montessori approach views children as solitary constructors of knowledge. It wasn't until I undertook further education that I began to question this theory.

In 2011 I enrolled on an MA in Teaching and Learning. This course culminated with a small-scale research project, and as I had an interest in technology, I investigated the role technology plays in enhancing learning in Montessori preschools. Perhaps still harking back to my engineering days I stayed within my comfort zone and carried out a quantitative study. I collected data via an online survey and used some basic statistics to analyse the data. While the study achieved its aim, I remember that on many occasions during the analysis, I had the feeling that I was missing something. I felt that I had little insight into how the Montessori educators would have described their use of technology in early childhood education, their interpretations and beliefs, instead of selecting a predefined response. In essence, their individual perspectives were missing. Reflecting on this now, I believe that this was my first step, in what Wellington (2015) describes as epistemological development.

In 2015 I left my Montessori teaching position and took a lecturing role in a local higher education institution. I am currently the Programme Lead on the full-time, and part-time, BA in Early Childhood Education and Care. This role involves lecturing and visiting students when they are out on placement in early childhood settings. In October 2015, I started my EdD. Over the six assignments in part 1 of the EdD programme, my area of interest expanded from technology in early childhood education to include the other areas of STEM (science, technology, engineering and maths). This interest was further fuelled by the publication of the *STEM Education Policy Statement 2017-2026* (DES, 2017b) as for the first time early childhood education was included alongside the other education sectors in a subject-specific government education policy. However, STEM is a broad area, and in preparing my penultimate EdD assignment, I decided to focus on science. Although I was aware that science modules are not commonly included in undergraduate programmes in Ireland, I knew, through informal conversations, that many early childhood educators 'do science'. I had many questions about educators' beliefs and interpretations of preschool science and how they enact their practice.

My philosophical and paradigmatic stance

According to Sikes (2004), researchers should consider how they are philosophically and paradigmatically positioned and be aware of how this influences their research.

The researcher's ontological and epistemological assumptions reflect an overall theoretical perspective and informs their choice of a research paradigm.

The vast and varied nature of education research can be categorised into several paradigms (Mertens, 2020). However, in order to explore my paradigmatic position I will consider four major research paradigms, including, positivism, interpretivism, critical, and pragmatism.

Positivism is characterised by an allegiance to the methods used in the natural sciences, where hypotheses are proved or disproved, and where data are subject to statistical analysis to produce generalisable findings (Cohen et al., 2011; Mertens, 2020). Positivism reflects the ontological assumption that social reality is objectively real; it exists external to individuals and is independent of their consciousness of it. From an epistemological perspective, positivism assumes that knowledge is objective, tangible and observable. In terms of human nature and agency, positivism accepts that as external universal laws govern human behaviour, it is characterised by underlying regularities (Cohen et al., 2011). The positivist researcher is 'detached' from the research and claims that their research is fact-based and therefore, value-free (Wellington, 2015). This claim is rejected by Eisner (1992), who argues that in research, "the facts never speak for themselves [as] what they say depends on the questions we ask" (p.14). According to Cohen et al. (2011), "[p]ositivism claims that science provides us with the clearest possible ideal of knowledge" (p.7). I disagree with this claim. I believe that attempting to apply the rules of the natural sciences to the complex and intangible qualities of human behaviour, and the interactions that occur in the preschool classroom fails to acknowledge the multiple perspectives and interpretations of events by the human beings in this imprecise world.

The interpretivist paradigm is characterised by its attempt to understand the subjective world of human experience. Interpretivism's philosophical foundation is reflected in its ontological assumptions that reality is socially constructed, subjectively experienced, and created in the mind of the individual and expressed through language (Pring, 2015; Sikes, 2004). The epistemological assumptions of interpretivism are that knowledge is subjective and experiential. In relation to human nature and agency, interpretivism assumes that human beings use their free will to act autonomously to produce their environment (Cohen et al., 2011). The interpretivist researcher acknowledges that they are part of the research, and as the observer, they make a difference to the observed (Wellington, 2015). Also, unlike positivists, interpretivist researchers do not claim their research to be value-free. Furthermore, Clough and Nutbrown (2012) suggest that the researcher needs to carefully examine their values in order to clarify the choices made throughout the research design. The researcher should, therefore, acknowledge the influence of values on the research process as part of their reflexive approach (Greenbank, 2003).

The critical paradigm stems from the belief that positivism and interpretivism fail to acknowledge the political and ideological contexts of educational research (Cohen et al., 2011). Critical researchers situate themselves alongside the less powerful in society in order to bring about social transformation (Mertens, 2020). From an ontological perspective, similar to interpretivism, the critical paradigm accepts that multiple realities exist; however, these realities are socially constructed, and some views are privileged above others. From an epistemological perspective, legitimate knowledge is culturally defined (Mertens, 2020). The critical researcher seeks beneficence through the promotion of human rights and pursuing issues relating to social justice.

The pragmatic paradigm adopts a ‘what works’ approach to research that is useful when a research design involves different approaches that are philosophically inconsistent (Frey, 2018). Pragmatism is not confined to a specific ontological or epistemological philosophy, but rather utilises the broad nature of pragmatism as a philosophical system (Morgan, 2014). Within the pragmatic paradigm, the researcher can study what is of interest to them in ways they deem to be appropriate. Therefore, according to Tashakkori and Teddlie (2016), pragmatism provides a philosophical framework for a mixed-methods approach.

From a personal perspective, interpretivism most strongly reflects my philosophical and paradigmatic position. There are three main reasons for this choice. Firstly, I concur with Clough and Nutbrown's (2012) assertion that the researcher's values always inform their positionality. I acknowledge that I bring my values, beliefs and experiences to this research project, and so I cannot presume to be detached from the research.

Secondly, this research involves people, and unlike the elements of the natural sciences, human beings are complex. Their perspectives and behaviour cannot be understood in the black and white terms of cause and effect as promoted by positivism (Pring, 2015). Also, this research project does not involve marginalised groups and issues relating to human rights or social justice, which are associated with a critical paradigm. Instead, I believe that to understand educators' beliefs and practices, I need to know what they do, and crucially, the reasons why. As actions are driven by beliefs (Pajares, 1992), the 'why' question will be explored through interpreting the educator's beliefs. As beliefs are hidden from the observer they cannot easily be measured, and therefore they must be interpreted through what people say and do (Pajares, 1992). I acknowledge that the broad nature of pragmatism allows for an interpretivist approach (Morgan, 2014). However, as the nature of evidence required to answer my research questions will only come through an interpretive approach, there are no grounds for the use of pragmatism.

Thirdly, interpretivism resonates with my sociocultural view that the social context in which teaching and learning take place cannot be ignored. Vygotsky's (1978) social constructivist theory, where learning leads development, places the educator as an active, autonomous participant in the teaching and learning process. Their active participation aligns with the idea that reality is a social construction, and knowledge is co-constructed through collaboration with others, all of which align with a sociocultural perspective (Rogoff, 2003; Vygotsky, 1978).

Lastly, I accept that it is impossible to suggest that during the research process researcher, I will adopt a neutral stance. After all, I have chosen to inquire into the issue of educators' perceptions and practices within the analytical context of the factors that influence the provision of science learning experiences in early childhood education. I have a background as an engineer and educator, and several years of teaching experience, all of which have contributed to my views about science in early childhood education. Therefore, I concur with Wellington (2015), who argues that the notion of a "'neutral observer' is a myth" and that "every researcher has a healthy bias" (p. 101).

3.3: Research Approach

In striving to generate appropriate data to answer the research questions, and in line with my philosophical and paradigmatic assumptions and social constructivist view of teaching and learning, this study is underpinned by a sociocultural perspective. Accordingly, this research project adopts a qualitative, naturalistic approach which is informed by an interpretivist theoretical perspective.

Qualitative research places the researcher in the world of the participants and reveals the relationships between multiple factors within the setting (Denscombe, 2017). It provides a deep and comprehensive understanding of meanings, attitudes, intentions and behaviours (Cohen et al., 2011), and best serves research that seeks to answer 'what' and 'how' questions (Silverman, 2017). As qualitative approaches explore "phenomena and capture individuals' thoughts, feelings or interpretations of meaning and process" (Given, 2008, p. xxix), it is particularly suited to exploring educators' perceptions of science education and to analysing how they and other factors influence practice within a sociocultural context.

The following section aims to provide a rationale for the choice of case study as the mode for reporting this research.

3.3.1: Case Study

According to Harrison, Birks, Franklin, and Mills (2017), case study research is agnostic in nature because it can be assigned to different ontological, epistemological or methodological positions. Therefore, a case study approach can be designed from an interpretivist perspective, where the researcher holds the view that multiple realities are constructed and co-constructed by the researcher and participants (Lincoln, Lynham, & Guba, 2011).

Although there is a broad consensus regarding the usefulness of case study as a research approach, there are many perspectives on what constitutes a case study (Thomas, 2016). According to Yin (2009, p. 18), “a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between the phenomenon and context are not clearly evident”. As my research project aims to examine the phenomena of educators’ perceptions and practices in science in the real life context of science education in the early childhood setting, the boundaries between the phenomena and context are indeed blurred.

The aim of case study research is "to provide a picture of a certain feature of social behaviour or activity in a particular setting and the factors influencing the situation" (Opie, 2004, p.74). My research project involves multiple elements including educators' perceptions, practices within the context of early childhood science education, and in order to answer the research questions a holistic approach is needed. According to Harrison et al. (2017), when human behaviour and social interactions are central to understanding the topic of interest, case study presents an appropriate form of inquiry. Similar to a jigsaw, a case study consists of various pieces that fit together, to create a satisfying and convincing picture (Remenyi, 2012). Furthermore, (Merriam, 2009) suggests that case studies are heuristic: "They can bring about the discovery of new meaning, extend the reader's experience, or confirm what is known" (p. 30). For all of these reasons, I believe that in this instance, using a case study approach is an appropriate choice.

Determining the case

Identifying the case, or unit of analysis can be challenging (Baxter & Jack, 2008).
In this research study the case or unit of analysis is the educator who engages in early childhood science education. The phenomena to be studied are the educator’s perceptions and practices in science education. According to Hamilton and Corbett-Whittier (2013) case study research “aims to capture the complexity of relationships, beliefs and attitudes within a bounded unit, using different forms of data collection and

is likely to explore more than one perspective" (p. 8). In this research study the case is bounded to include those educators who work in a room leader capacity with children aged from 3 to 5 years in a preschool environment; the preschools are located in a south-western region of Ireland. The sample was delimited to those working in a room leader capacity because they are responsible for curriculum planning, pedagogical practices and the provision of resources within the preschool setting. The location was selected for logistical reasons as it is within a reasonable proximity to my home.

Case study design

The design of a case study will depend on its purpose. According to Stake (2005) the purpose of case study work can be divided into three groups: intrinsic, instrumental and collective. An intrinsic case study is undertaken in order to gain a better understanding of the particular case in question. It is not undertaken because of its special traits or representativeness, but that particular case is of interest to the researcher. An instrumental case study is used to examine a particular case in order to elucidate a particular aspect or issue, rather than the case in its entirety. However, when there is less interest in the individual case, a collective case study involving multiple cases can be used to examine a phenomenon (Stake, 2005). According to Bishop (2010) the term 'multi-site case study' is used interchangeably with collective case study. A multi-site case study typically employs the same research design to investigate a defined phenomenon across a number of sites (Bishop, 2010).

As the current research project seeks to explore how early childhood educators' perceive and practice science, it adopts a multi-site case study approach. An advantage of this approach is that by illuminating educators' experiences of a phenomenon across multiple settings, a wider understanding of the phenomenon can emerge (Bishop, 2010). The same research questions, data collection, analysis and reporting methods are used for each setting.

The utilisation of a multi-site case study, will highlight similarities and differences across the sites, both of which point to the notion of generalisability. However, case study inquiry is not usually associated with generalisability, a point that is often raised in criticism of this approach (Wellington, 2015). Unsurprisingly, Stake (1995) rejects such criticism, claiming that "the real business of case study is particularisation, not generalisation" (p. 8). Moreover, as the approach to this research study is based on my ontological and epistemological assumptions that social reality is subjectively experienced and socially constructed, this study does not aim to produce generalisations.

3.4: Research Participants

This research study seeks to understand the factors influencing science education through the medium of educators' perceptions and practices. Therefore, the participant eligibility criteria were based on educators who work as room leaders and include science as part of their curriculum, and their willingness to participate. In this way, a process of 'purposive sampling' was used to select participants for this study. In purposive sampling:

> Researchers hand-pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought.
>
> (Cohen et al., 2011, p.156)

The sample was delimited to those working in a room leader capacity because they are responsible for curriculum planning, pedagogical practices, and resource provision. In Ireland, there are two cohorts of educators who qualify for the room leader role. The first group consists of higher education graduates holding a Bachelor of Arts in Early Childhood Care and Education (B.A. ECCE) Level 7 award. The second group are further education graduates holding a Further Education and Training Awards Council (FETAC) Level 6 award.

A pragmatic approach underpinned the participant recruitment procedure. I live in a provincial region of Ireland with 175 early years settings (Tusla: Child and Family Agency, 2018). I decided not to approach settings that I had visited in my professional capacity as they may have felt obliged to agree to participate. However, for logistical ease, I selected the 30 remaining settings within a 10 mile radius of my home. An email was sent to each setting, outlining the purpose of the research and what participation would involve. Nine responses were received. I visited each setting and spoke with the educators about the research and gave them an information sheet. After this visit, one educator withdrew from the process, leaving a sample of eight educators. In essence, this group of eight educators volunteered to participate in the research study. They may have had personal reasons for volunteering, such as interest in the research or hoping that it might broaden their knowledge of science in early childhood education. Whatever their reasons, the data gathered will be based on their inputs, and thus these individuals will inevitably shape the findings of this study. I cannot ignore this reality, and therefore will not claim that the findings represent the wider population of early childhood educators in Ireland.

The educators work in a range of settings, including full-day services and sessional preschools. I believed that eight was a manageable number and would provide a range of data on educators' views and practices. The children in each setting were also involved as data were also collected through classroom observations.

All settings adopt a play-based curriculum, with settings 5, 7 and 8 (S5, S7,S8) offering a combined Montessori and play-based curriculum. One educator holds a Masters degree in early childhood education, two hold a Level 7 B.A. in Montessori education, and the remaining four educators hold a Level 6 qualification. With the exception of Setting 8 (S8), which had ten children and one adult in the room, all other settings had 22 children with either two or three adults.

3.5: Data Collection Methods

The nature of case study research is that it involves the holistic study of people, events, or institutions, and one of its main strengths is that it can deal with different kinds of evidence, (Stake, 1995; Thomas, 2016). As data must be collected in order to provide evidence, the researcher is faced with making some decisions about appropriate methods. For Cohen et al. (2011) the principle consideration is that the chosen data collection methods must be fit for purpose.

The notion of fitness for purpose leads back to the research questions as the methods selected must generate data to answer those questions. However, Sikes (2004) cautions that as different data collection methods delimit the types of information that can be accessed, the choice is not a straightforward technical matter. How a researcher conceives and resolves the choices of data collection methods represents their assumptions about how the social world is constructed (Clough & Nutbrown, 2012). According to Opie (2004) data collection procedures can be qualified into two groups, qualitative or quantitative. Qualitative procedures seek to understand the social world and reflect an interpretivist perspective; whereas quantitative procedures reflect a positivist perspective, where objectivity and measurable criteria dominate (Opie, 2004).

As previously outlined, this is a qualitative study, which is underpinned by an interpretivist theoretical perspective, and uses a case study approach to explore how early childhood educators perceive and practice science in a preschool environment. There are many elements involved within the complexity of a case study, and to incorporate the implications of these elements, more than one data collection tool, and many sources of evidence are usually required (Cohen et al., 2011). In order to capture the relevant information about the various elements involved, this study employs two qualitative data collection methods, namely observation and interview. Using two data collection methods provides evidence from two sources that can supplement and be integrated with each other (Wellington, 2015). In the following section I will describe the rationale for these choices, outlining their individual strengths and weaknesses, and explain how they were used in this study.

3.5.1: Observation

Observation is one of the principal data collection methods used in case study research (Cohen et al., 2011; Stake, 1995). One of its central values is that it can complement information collected by other means. Observation can broaden the scope of information as it provides a means for the researcher to discover things that may not arise in interview situations. As Robson and McCartan (2016, p. 319) point out, there are often discrepancies between what people say and what they do in practice.

One of the unique features of observation is that it enables the researcher to capture data as it occurs in a natural situation. It deals with behaviour rather than second-hand accounts of reported behaviour (Wellington, 2015). Observation research is also sensitive to contexts (Moyles, 2002), which aligns with the sociocultural nature of this study, which views context as central to shared understandings (Rogoff, 2003; Vygotsky, 1978).

As my research requires information about how educators support children's science learning, observations will allow me to have access to the interactions and non-verbal behaviours that occur during science activities. This information will enable me to gain an overall sense and better understanding of the situation, and will therefore help with the critical inquiry needed to answer the research questions. Furthermore, Wellington (2015, p.249) argues that observations help to overcome the' the image presentation', which an interviewee may put forward during an interview. In designing an observation data collection method, the researcher is faced with a number of choices, including the type of observation, the role of the observer, and the observation instrument.

There are a number of observation types available to a researcher, ranging from structured to unstructured (Cohen et al., 2011). A highly structured observation involves the researcher creating categories in advance of the observation. In a semi-structured observation, the researcher will have a focus, but categories are not predetermined. The unstructured observation involves the researcher observing a situation before deciding what is significant for the research (Cohen et al., 2011). In order to gather relevant information for this research project, I used semi-structured observations. I gathered data to illuminate the educators' perceptions, practices and the context in which they were supporting children's science learning. To do this, I wanted to capture any science-related activities that occurred within the classroom, including those that were pre-planned or spontaneous. The pre-planned science activities were educator-led and so were easily identified. However, for spontaneous activities, the educators agreed that if they saw something that they interpreted as a science activity, they would alert me and an observation took place. A semi-structured observation also lends itself to theory generation as it involves reviewing the data before proposing an explanation for the observed phenomena (Cohen et al., 2011), and therefore is an appropriate choice for this case study research.

In designing the observation data collection method the role of the observer must be considered. The role of the researcher as an observer depends on their level of involvement in the activity (Opie, 2004). There are four classifications: the complete participant, who is a member of the group but their identity as a researcher is hidden; the participant as observer, who is also a group member but their status as a researcher is known; the observer as participant, is not a group member, but may superficially participate in the activity; and the complete observer, who only observes and is completely detached from the group (Cohen et al., 2011). In this research project, I adopted an 'observer as participant' role, where my identity as a researcher was known and openly recognised. In this role, I sought to strike a balance between involvement and detachment (Cohen et al., 2011). I engaged with the children when they spoke to me or asked me questions, and assisted the educators with some of the everyday tasks that occur in a busy preschool. I believe that doing this helped the participants to feel more at ease in my presence.

This research study involved observing educators and children engaging in science activities. In order to capture the essence of what was occurring, including the voices, and actions of the participants and children, I decided to use a video camera with a built-in microphone, as the observation instrument. A video camera is a powerful recording device, and it overcomes the limitations of a human's capacity to accurately record everything that happens during an activity (Cohen et al., 2011). There is no time gap between the event and the recording, and the video provides comprehensive material that can be viewed multiple times. Denscombe (2017) suggests that the recording of all verbal and visual information assists in the reduction of observer bias. However, the potential for bias still exists, as I chose where to point the camera. To mitigate this potential bias, I positioned myself so that I could capture all children and the educator as they were engaged in the science activity. In addition, as the educator was involved in identifying the spontaneous activities, their interpretations of what that means were also included. The device selected was a handheld camera, which was lightweight and easy to operate. These features gave me the freedom to capture activities as they occurred in both the indoor and outdoor environments.

Using a video camera as an observation instrument can present some technical difficulties (Cohen et al., 2011). Preschool classrooms tend to be busy and noisy environments. Hence background noise levels can pose a potential problem when using an audio recording device. On my first day in each setting I did a trial run and made a brief recording while everyone was in the classroom. I was quickly able to ascertain that my concerns about background noise levels were unfounded. The video camera has a good quality microphone, and the voices were clearly audible. I immediately deleted the video clips as they were not part of the research.

The observations were conducted in the preschool setting, and the challenge for the researcher is to retain the naturalness of the setting (Denscombe, 2017). I was aware that by entering the preschool classroom I will inevitably cause some disruption. The children will be curious and are likely to ask questions. The challenge to me, therefore, was to try to make this disruption as short-lived as possible. My experience as an early childhood educator helped in this regard; I spent a few minutes answering the torrent of questions from the children, and then gently encouraged them to return to their play. I minimised my interactions with the children and tried to make myself "socially invisible" (Denscombe, 2017, p. 230). In general, the children did not seem to take too much notice of me while I was in the setting.

I spent three days in each setting and did not collect any video observations on the first day. I did show the video camera to the children and let them have a look through it. Over the remaining days, I recorded any science-related activity that occurred within either the indoor or outdoor environments. In order to minimise disruption to the activities, I was always conscious of my positioning. I attempted to be as unobtrusive as possible while at the same time, having a clear view of the activity. This study used educators' perceptions and practices to explore the factors influencing science education. Therefore, the control of the video observations should lie with the educator. We agreed that they would indicate when to start the video recording and that it would cease when all children had finished the activity and left the table.

There are some limitations to using observations as a data collection method (Cohen et al., 2011; Denscombe, 2017). Indeed, Denscombe (2017) highlights the concept of 'observer effect', where people alter their behaviour in reaction to being observed. Participants may be self-conscious about having their actions scrutinised, and do not behave as they usually would. Some participants may exhibit the 'halo effect' where they act with a level of enthusiasm that would not normally exist (Denscombe, 2017). Others may view the researcher as the ‘expert’ and may try to help them by behaving in a way that they believe the researcher wants to see or hear. Indeed, these concerns are relevant as the current study participants volunteered to participate and may have ‘performed’ during the observations. In reality, it is impossible to say for sure whether this was the case. However, during my time in each setting, I was not conscious of a significant difference in any educator’s behaviour or interactions with children either before, during or after the video observations. Undoubtedly, when I first began filming, some educators occasionally looked directly at me and the camera, but this tended to stop after the first couple of minutes when they solely focused on the activity and interacting with the children.

The research questions posed in this study seek to understand the factors influencing science education through the medium of educators' perceptions and practices. While observation data will provide evidence about the practices surrounding early childhood science, it does not provide access to educators' articulated perceptions. Therefore, interview was chosen as the second data collection method for this research project. Combining both observation and interview data will enable me to explore how early childhood educators perceive and practice science. Each data collection method on its own presents a two-dimensional picture of the case being studied, however, when interview and observation data are combined it adds a third dimension to the picture as it captures the 'texture of reality' (Wellington, 2015).

3.5.2: Interview

The qualitative research interview “provides a unique access to the lived world of the subjects, who in their own words describe their activities, experiences and opinions” (Brinkman and Kvale (2018, p. 11). These descriptions reveal the interview participants’ interpretations of how they experience and understand their world. Interviews enable the researcher to access information that cannot be gleaned from observations. According to Wellington (2015, p.137),

> Interviewing allows a researcher to investigate and prompt things we cannot observe. We can probe a participant's thought, values, prejudices, perceptions, views, feelings and perspectives. We can also elicit their account of situations which they may have lived or taught through his or her story.

Indeed, Brinkmann and Kvale (2018) regard a research interview as an inter-view, where there is an inter-action of views, from which knowledge is constructed. Similarly, Cohen et al. (2011) suggest that an interview is neither objective nor subjective; it is intersubjective. Interviews allow both parties to talk about their interpretations of the world and articulate their views. These features of interviewing suggest that it is an appropriate method for exploring educators perceptions, beliefs and knowledge about science in early childhood education. Furthermore, from an epistemological perspective, as interviewing can be conceptualised as either a process of knowledge collection or knowledge construction (Brinkmann and Kvale, 2018), it can be designed to align with the interpretative assumptions that underpin this research project.

Interviews tend to involve close contact between the researcher and the participant. It is the responsibility of the researcher to make every effort to ensure that the participant feels at ease. According to Wellington (2015), the first task of the researcher is to establish a rapport with the participant. As my fieldwork involved spending a few days in the classroom I used this time to build trust and establish rapport with the participant. However, I acknowledge that the interview is a different scenario, and even though there was a level of rapport previously established, I had to ensure that the participants felt comfortable enough to express their views freely.

When designing an interview, the researcher must decide how the interview is conceptualised and the degree of structure. According to Wellington (2015), interviews can be conceptualised in three different ways. The first conception of the interview is that it provides a means for information transfer from the participant to the interviewer. Essentially the interviewer is a data collection device, acting as a receptacle, gathering the participants' responses. I did not contemplate using this type of interview as it jars with the interpretivist nature of this research project. In the second conception, Wellington (2015) describes the interview in terms of a transaction. In this instance, there is a sharing of information and the interviewer shares as much information as they receive. I did not select to use this transactional approach as I wanted the participants to take centre stage in providing data. The third conception is the interview as a conversation with a purpose. While similar to the transactional interview described above, this approach is more nuanced. As the purpose of the interview is to probe the participants' perspectives and make them known, there is not an equal exchange of views; instead, it is more heavily weighted in one direction than the other. However, Wellington (2015) cautions that it is not a platform for the researcher to dominate, and the participant should play the leading role. For these reasons, I used this type of interview as the basis for designing this research method.

The second consideration for designing the interview is the degree of structure. Opie (2004) identifies the levels of structure which sit along a continuum. At one end is the structured interview, which has a similar construct and use to a questionnaire in both form and use. The interviewer has a list of questions, which tend to be short and capable of eliciting immediate answers, and there is no deviation to their wording or order. The participant tends to have a passive role, as the interviewer sets the direction and leads the interview. This structured approach is often used in quantitative research, which may involve large sample sizes, and where the results are used to try to make generalisations. The structured interview is located within a positivist research paradigm (Opie, 2004), where reality exists 'out there' and its revelation simply requires the 'right' question to be asked. It is unlikely that this level of structure will elicit the type of information required to determine the educators' views, perceptions and knowledge. Also, the positivist leanings do not align with the philosophical assumptions underpinning this research, and so, the structured interview was not considered as an option for the interview design.

At the other end of Opie's (2004) degree of structure continuum is the unstructured interview. In an unstructured interview, while the interviewer has a topic area and aims, there is no predefined list of questions or order to follow. The interviewer does not set the direction and has no presumptions about what will be learned. In essence, the participant guides the interview rather than the interviewer. The unstructured interview is located within an interpretative research paradigm (Opie, 2004), where reality is socially constructed. Although there are many aspects of the unstructured approach that would suit my interview design, I did not use this approach. I reasoned that as an interviewer, I had concerns that I may not be able to keep the participant's focused on the subject at hand. The interview could potentially drift along in a direction that is not relevant to the focus of the research study, and could result in spending a long time gaining a minimal amount of usable information.

The third type of interview is semi-structured, and it sits in the middle of Opie's (2004) degree of structure continuum. The semi-structured interview overcomes the inflexibility of a structured interview and the potential aimlessness of the unstructured interview. One of its main advantages is flexibility (Wellington, 2015). Although the interviewer will have a prearranged list of questions, they can deviate from the wording and order. The semi-structured interview also allows the interviewer to probe and expand the participant's answers, thereby gaining a more in-depth understanding of the issue (Opie, 2004). Similar to the unstructured interview, a semi-structured interview is located within an interpretivist paradigm (Cassell, 2015), and therefore would be an appropriate option for my interview design. The flexibility of question types that this approach affords and its alignment with the interpretivist paradigm led me to use a semi-structured approach in my interview design. The overall advantage of a semi-structured interview is that the researcher can ensure that their agenda is fully explored, while at the same time allowing the participant to express their views and opinions (Cassell, 2015). This approach aligns with my research approach as I had some specific areas where I wanted responses from the participants. At the same time, I also wanted them to freely expand on points and raise issues that I had not included but that they felt were relevant.

An interview schedule and list of questions were designed for this project (see Appendix 1). I conducted a pilot interview with an ex-colleague, who is still working in early childhood education. The pilot interview was extremely valuable as it revealed some flaws in the interview design, including, ambiguous phrasing of questions, and repetition of responses to different questions. This pilot interview lasted approximately 90 minutes. I redesigned the list of questions and held a second pilot interview with the original and a second ex-colleague. Both interviews lasted approximately 60 minutes. The feedback was positive and when I reviewed the responses I felt that the evidence produced would yield relevant data for my research. I did not use the pilot interviews as sources for data analysis. The digital audio recorder I used worked perfectly and produced a clearly audible recording.

As with all data collection methods, interviews have some limitations. Similar to the observer effect outlined above, Denscombe (2017) suggests the existence of an 'interviewer effect', where the interviewee's perceptions of the interview will influence how they respond to questions. For instance, answers might be tailored to match with what the interviewee believes the interviewer wants to hear. To counter this effect, I started each interview by assuring the participant that there are no right or wrong answers to the questions and that in relation to their knowledge and practice, they are the expert. I was also careful to adopt a non-judgemental stance during the interviews and ensured that my facial expressions remained neutral (Denscombe, 2017).

A second limitation highlighted by Cohen et al. (2011) is interviewer bias. I was cognisant of this throughout the interview design and took great care not to include leading questions as they are likely to elicit a biased response (Wellington, 2015). Furthermore, during the interviews and observations I was careful never to state my position on any topic, as this may influence participants' actions and responses.

The final limitation considered here is that interviews do not provide evidence of the participants' practices. As previously mentioned, what people say and what they do in practice can differ. However, using 'between method' methodological triangulation, where different methods are used to provide different perspectives on the same issue (Wellington, 2015), can lead to a better understanding of the research topic (Denscombe, 2017). I am not using triangulation to pursue validity. Indeed, Silverman (2017) suggests, such an approach is unsound as it implies that in social constructivist research "' true' fixes on 'reality' can be obtained separately from different ways of looking at it" (p. 387). However, Flick (2007) points out that triangulation can be considered from a social constructivist stance as each method constitutes the research topic in a specific way, and therefore produces knowledge that goes beyond what one method can produce. Therefore a 'between method' triangulation aligns with the interpretivist stance of this research and so makes methodological sense. Richardson (2000) offers the concept of crystallisation as an alternative to triangulation. Decrying the appropriateness of the triangle with its fixed two dimensional approach, Richardson invokes the image of a crystal where, “what we see depends on our angle of repose” (p.934). While I aim to use triangulation to augment my findings in terms of their credibility, I also acknowledge Richardson’s (2000) point that viewing a topic from different angles provides the researcher with “ a deepened, complex, thoroughly partial understanding of the topic” (p. 934).

3.6: Data Analysis Methods

> Data analysis is the central step in qualitative research. Whatever the data are, it is their analysis that, in a decisive way, forms the outcomes of the research.
>
> (Flick, 2014, p.3)

As data analysis plays a critical role in the overall research process, the choice of which method to use requires careful consideration. All choices in the design of this research project, including the research questions, the theoretical perspective, the choice of a case study and data collection methods have been influenced by my philosophical stance and the principle of ethical research. These philosophical and ethical assumptions also influence the choices made about how to analyse the data. As Braun and Clarke (2006) posit, "researchers cannot free themselves of their theoretical and epistemological commitments, and data are not coded in an epistemological vacuum" (p. 84).

According to Cohen et al. (2011), there is no single correct way of analysing data, and therefore, researchers should adhere to the principle of fitness for purpose. The purpose of this research project is to explore how early childhood educators perceive and practice science. Specifically, it seeks to answer two research questions:

- What perceptions do a group of educators who work with children aged from 3 to 5 years have about science in early childhood education?

- What factors influence how educators support children's science learning?

In answering these questions, I do not seek to find an objective 'truth' in the data, but rather a subjective understanding. For these reasons, I have adopted a qualitative approach to data analysis. The qualitative data analysis approach used in this research project is thematic analysis, which is compatible with the project's interpretative theoretical perspective (Braun & Clarke, 2006). According to Watson (2018, p. 243),

> Qualitative modes of data analysis provide ways of discerning, examining, comparing and contrasting, and interpreting meaningful patterns or themes. Meaningfulness is determined by the particular goals and objectives of the project at hand: the same data can be analysed and synthesised from multiple angles depending on the particular research or evaluation questions being addressed.

Qualitative data analysis is not a scientific endeavour. It is a subjective and interpretative process that has been described as "intellectual craftsmanship", which requires methodological knowledge (Wellington, 2015, p.277). As a researcher I was faced with the task of interpreting data that is often "messy [and] ambiguous" (Marshall & Rossman, 2011, p. 207), I attempted to develop as Rapley (2011, p. 430) suggests, "a qualitative analytic attitude". In developing this attitude, I was helped by the consensus that there is no single correct way to analyse data, and used the research questions and my philosophical and paradigmatic positioning to guide my decisions.

3.6.1: Data Preparation

The data corpus for this research project includes a total of 31 data items, including 23 video observations and eight interviews. The duration of the videos ranged from 3 to 25 minutes and the interviews from 45 to 60 minutes. The data corpus consists of a large amount of raw data, which had to be organised into a format that is amenable to thematic analysis (Denscombe, 2017). As there were several hours of video recordings, it was not feasible to transcribe each video in its entirety. Choices had to be made about what to transcribe from the videos. Indeed, Derry et al. (2010) note the influential role of the researcher as they determine which clips will be selected for deeper focus. Furthermore, selecting clips has epistemological implications as the observed interactions are reframed by the researcher who views the event in relation to their research objectives and theoretical perspectives (Bezemer & Mavers, 2011). Therefore, in this research project, the knowledge produced in the data analysis of these clips results from my interpretation of what I saw and heard, in concert with the participants' construction of the situation.

From a practical perspective, the videos were uploaded to the qualitative data analysis software NVivo and viewed several times before the clip selection process began. Essentially the selection process was the start of the analysis as the software enables the researcher to code clips of video. Not all coded clips were transcribed as the process of constant refinement during the analysis led to the exclusion of some clips. In contrast to the selective transcribing of video data, the eight interviews were transcribed in their entirety.

3.6.2: Interview and video data transcription

Transcribing interview recordings transforms the data into a manageable format for analysis, and is regarded as a research activity (Silverman, 2017). Although transcription in qualitative research is ubiquitous, Flick (2014) cautions that no system can provide the researcher with a completely accurate account of the original spoken words, and should be approached with a "critical eye (and ear)" (p. 65). As researcher bias can play a role in the transcription process, I adopted a reflective approach throughout the analysis process in an effort to mitigate this bias (Flick, 2014).

The type of transcription convention used is influenced by the research design (Curtis & Curtis, 2011). There are a variety of transcription methods, which range from a full transcription where every pause and 'um' is included, to a transcription which only includes the key points raised (Curtis & Curtis, 2011). As my research seeks to understand educators' perceptions and practices, my priority for the transcription was to preserve meaning, and so I adopted a broad approach. I was interested in the words spoken, but not the pauses, and 'ums' that permeate speech unless they influenced my interpretation of the meaning (see Appendix 2 for a sample from an interview transcript). Although Denscombe (2017) warns of the laborious nature of transcription, he also points to its value as part of the analysis process because it brings the researcher "closer to the data", and "brings the talk to life again" (p. 307).

Once transcribed, I did not immediately check the accuracy and did not read the transcript for at least one day. I wanted to give myself some time between the transcription and accuracy check so that when I returned to the document, I was able to look at it afresh. I listened to the recordings and read the transcripts at the same time. I went through a couple of iterations of this process before I was happy that the transcriptions were a fair representation of what was said during the interviews. These transcripts were uploaded into NVivo in preparation for coding.

As this research project had a large volume of video data, decisions had to be made about transcription. Transcribing each video in its entirety was not feasible, and indeed not necessary as not all of the content was relevant. As NVivo facilitates the selection of video clips, I used this alternate approach to transcription to identify relevant material from each video. However, as the coding refinement progressed, I transcribed the coded video clips within NVivo. As this research seeks to explore how educator's support children's science learning, the transcripts attempt to recreate the images using words so that the reader can visualise how this support is enacted. I used a similarly broad approach that included all speech, interactions, actions, resources and excluded extraneous sounds (see Appendix 3 for a sample video transcription). Importantly, Bezemer and Mavers (2011) suggest that translating a social interaction from an image into words can never be a perfect representation as "images are not words" (p. 196). The accuracy of the transcripts differs from that used for interviews. In this case, accuracy is not determined by assessing the degree to which it replicates the reality contained in the video clip, but rather how it makes visible the social and cultural factors through which the researcher reconstructs that reality (Bezemer & Mavers, 2011).

3.6.3: Using NVivo

As previously mentioned, the interview transcripts, videos, and video clip transcripts were stored in NVivo, which is a qualitative data analysis software package. Although I was unfamiliar with this software, I opted to use it because I recognised that human error poses a significant threat when manually organising and managing large volumes of data (Cohen et al., 2011). Furthermore, I was cognisant of the clear warning, "that the software does not 'do' the analysis" (Gibbs, 2014, p. 278), and indeed it has been suggested that "Qualitative Data Management" software is a more accurate title (Silverman, 2017, p. 356). Nevertheless, the software provides a means of managing both the data and the analytic thoughts that are created throughout the process (Gibbs, 2014). Although NVivo provides the option for automatic code generation, I did not use this option. Using computer-generated codes does not align with my epistemological assumptions about knowledge creation, or the interpretative theoretical perspective that underpins this research. However, using NVivo did enable me to arrange codes into a visual hierarchical structure, which greatly assisted my analytical thinking around the creation and naming of themes.

3.6.4: The data analysis design

As outlined earlier in this section, a process of thematic analysis as described by Braun and Clarke (2006) was used in this research project. They describe thematic analysis as "a method for identifying, analysing and reporting patterns (themes) within data" (p. 79). As a thematic approach facilitates searching for themes across the entire data set (Braun and Clarke, 2006), this suggests that it is a suitable method for this project's multi-site case study. Thematic analysis offers the researcher a choice of coding methods, namely an inductive approach or a theoretical thematic approach (Braun and Clarke, 2006). An inductive approach means that themes are said to 'emerge' from the data. However, Wellington (2015) cautions that the emergence of themes is not some mysterious event that is independent of the researcher. Instead, he firmly acknowledges that the 'emergence' process depends entirely on the researcher. Inductive coding does not attempt to fit the data into pre-existing themes and can be described as data-driven. In contrast, a theoretical thematic approach is more researcher driven as data are coded to a theme which reflects a particular area of interest for the researcher (Braun and Clarke, 2006). In keeping with the interpretative theoretical perspective underpinning this research project, I used an inductive approach to coding.

Prior to starting the analysis, the researcher is faced with a further decision regarding the level at which the thematic analysis will be conducted. Braun and Clarke (2006) propose that thematic analysis occurs at either a semantic or latent level. Semantic thematic analysis explores the data at a surface level, describing what participants' say or do and explores the significance of patterns in the data. Latent thematic analysis goes to a deeper level examining the underlying ideologies, assumptions and ideas that go towards shaping the semantic content.

This research project seeks to explore educators' perceptions of science as well as the factors that influence how they support children's science learning. Its aim is to interpret the underlying beliefs, assumptions and ideas that shape what the participants say and do, therefore, a latent thematic analysis approach is the primary method used. However, one section of the analysis is at a semantic level, as it examines the availability of resources in the environment.

As an experienced early childhood educator, the process of data analysis presented me with an opportunity to consider events that are very familiar to me in a different way that will transform my knowledge. Clough and Nutbrown (2012) use the term "radical looking" to describe "exploration, which makes the familiar strange" (p. 26). I adopted this approach throughout the various stages of data analysis and beyond to the discussions and conclusion.

3.6.5: The data analysis process

The approach to thematic analysis offered by Braun and Clarke (2006) provided a useful guide. They suggest the following five phases:

1. Familiarising yourself with the data
2. Generating initial codes

3. Searching for themes
4. Reviewing themes
5. Defining and naming themes

Braun and Clarke (2006) advise researchers that thematic analysis is a recursive rather than linear process, and involves going over and back between the various phases. However, phase one is the starting point, and it involves immersing yourself in the data. The aim is to get an overall sense of the content, its depth and breadth, and to 'hear' what the data have to say to you (Wellington, 2015). My approach to this phase involved reading and re-reading transcripts and watching and re-watching videos several times. This immersion in the data was an active process and involved both searching for meanings and patterns, and a process of reflection. In reality, this immersion phase took a long time due to the volume of data, and Wellington's (2015) description of a drowning in data feeling certainly rang true.

The second phase involved generating initial codes. Codes can be described as "labels that assign meaning to the descriptive or inferential information complied in the study" (Miles, Huberman, & Saldana, 2014, p. 71). Codes provide a means to reduce and organise the data into meaningful groups. As advised by Braun and Clarke (2006) initial coding in this research project involved systematically working through the entire data set. NVivo offers a drag and drop facility for coding, where the researcher highlights a section of the text, or a video clip and drops the selection into a node (NVivo's term for code). In this phase, with the research questions to the fore, I coded for as many potential themes as possible. This open approach to coding identified 130 codes. A large number of codes can lead to what Gibbs (2014) refers to as a "coding crisis" (p. 285), and while not unusual, he cautions that it can be a barrier to developing an understanding of the data. However, Braun and Clarke (2006) voice no such concerns, and suggest that such data may well become more interesting as the analysis progresses. The data were coded inclusively, which means that if some of the surrounding material was relevant, it was included to provide some context.

The third phase in thematic analysis provides the researcher with a means to manage and further organise the data through the identification of themes. In clarifying what determines a theme Braun and Clarke (2006) suggest a theme "captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set" (p. 82). At this stage in the analysis, the researcher is analysing the codes and considers how they may be merged into overarching themes, which are a sort of "meta-code" (Miles et al., 2014, p. 86). The research questions guided this process, and helped to reduce the overall amount of data as some were not relevant and the merging of some codes that essentially contained the same data. This elimination and merging of data and codes typifies the "organic" nature of thematic analysis (Braun & Clarke, 2006, p.91). This process generated 16 themes, which can be seen in Table 3.1.

Table 3.1. Themes generated during phase three of thematic analysis

Attitude towards science	Lack of knowledge
Children's influence on practice	Lack of training
Confidence	Objective of science curriculum
Documented curriculum	Pedagogical strategies
Emergent curriculum	Planning
Environment	Science as a way of exploring the world
Fun and the wow factor	Sources for ideas
How children learn	Supporting holistic learning and development
Influence of Aistear	

Phase four of thematic analysis involves reviewing the themes. This phase involved revisiting each theme to refine them. However, the analysis was not confined to revisiting themes; it also involved re-reading the entire data set to ensure that the themes were an accurate representation of my interpretation of the data. As I read through all of the data stored under each theme, it became evident that some themes were focused on similar areas, for instance, 'emergent curriculum', 'documented curriculum', and 'planning', all relate to curriculum content. Braun and Clarke (2006) point out that some initial themes may be sub-themes, as was the case here. The three curriculum-related themes were, in essence, sub-themes within a curriculum content theme. A number of new themes were created during this process. The resultant phase four thematic map is shown in Figure 3.1.

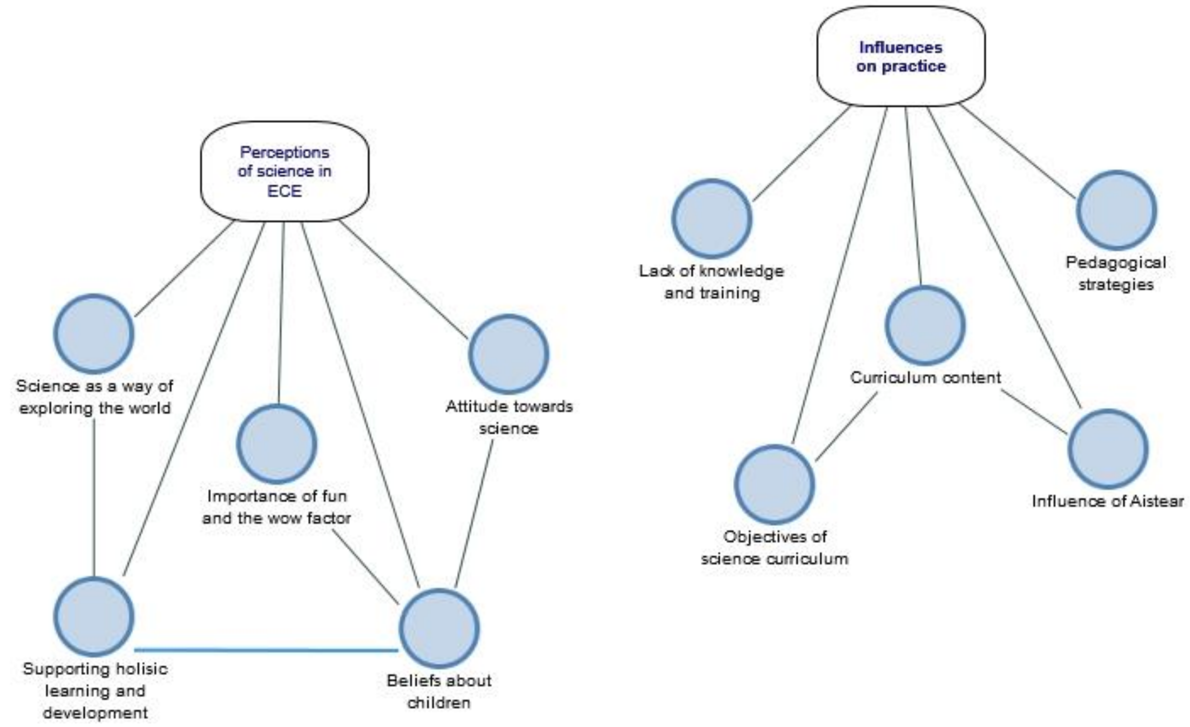


Figure 3.1: Thematic Analysis Phase Four - Reviewing the Themes

The final phase of thematic analysis involves defining and naming themes. A further examination of the themes took place, as I endeavoured to capture the essence of each theme. This process involved considering each theme and the relationship between themes. For instance, there was a strong relationship between the two themes: 'beliefs about children' and 'attitude towards science'. When educators' spoke about their attitude towards science, they frequently referred to the children and how their curiosity and excitement influenced the educator's attitude towards science. An extract from T4's interview highlights this point:

> You get curious and the kids get really curious and they are asking you questions, and you have to go and you have to find more information to feed their curiosity. So, you end up actually being hooked on it as well.

Identifying these relationships led to the amalgamation of these now sub-themes into a higher-level theme. The final result of the thematic analysis led to the creation of five themes. Two themes, interpretations of science in early childhood education (ECE), and educators' beliefs relate to the research question on educators' perceptions. Three themes, lack of knowledge and training, curriculum, and pedagogy relate to the research question on the factors influencing practice. The thematic analysis map for phase five is shown in Figure 3.2.

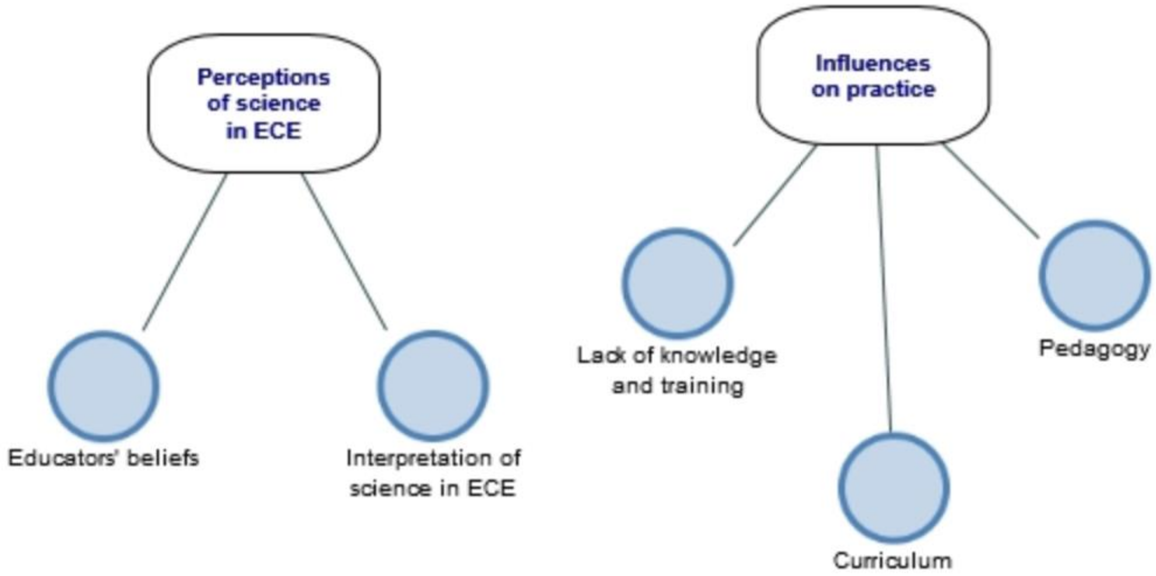


Figure 3.2: Thematic Analysis Phase Five – Defining and Naming Themes

On completion of the five phases of thematic analysis, the researcher has a refined set of themes and sub-themes. Braun and Clarke (2006) present a sixth phase in the data analysis process, producing the report, which relates the analysis back to the research questions. As the themes identified above link to a specific research question, the presentation and interpretation of the data will be presented across the following two chapters.

3.7: Ethical Considerations

A fundamental principle of educational research is that it should be ethical, and therefore ethical considerations should take precedence over all others (Wellington, 2015). Ethics in research can be defined as, "the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful, and to be fair" (Sieber, 1993, p. 14 cited in Sikes, 2004). As this research project involves collecting data from people, there is the potential for many ethical issues to arise. Therefore, a priority throughout the process was adherence to the British Educational Research Association's (BERA) ethical guidelines on educational research (BERA, 2018). Also, two fundamental and related ethical principles guide this research project, namely, non-maleficence, in other words to do no harm, and respect. The following sections will discuss the ethical issues that were considered before, during and after the research.

3.7.1: Before the research

Prior to the commencement of this research, ethics approval was sought and received from the University of Sheffield Ethics Review Board (see Appendix 4).

Terminology

In planning the research, one of the first considerations is the terminology used to refer to the people involved. According to Sikes (2004), the researcher must be conscious of their use of language as it reflects their assumptions, beliefs and understandings. Therefore, the term that I use to refer to the people who will be providing the data requires consideration as it will reflect my view of them and their role in the research process. Commonly used terms include, 'subject', 'respondent' and 'participant'.

The term 'subject' is closely associated with experimental research in the natural sciences, which is rooted in the positivist paradigm. The term 'subject' implies that the person is 'subjected to' the research, that it is 'done to' them, and consequently, they have a passive rather than an interactive role. The undertones of power that always exist in a relationship place the researcher in the dominant position with respect to the 'subject'. From an ethical perspective, Sikes (2004) condemns the usage of the term 'subjects' as it can carry "unfortunate connotations" which suggest that "these people are 'othered' and their humanity is neglected" (p. 27). From an ethical research perspective, I reject the term research 'subjects' as it depersonalises the people involved, implies a lack of autonomy and respect, and jars with the interpretivist approach of this research project.

The term 'respondent' implies, albeit to a lesser degree than for research 'subjects', that the flow of information in the research process is akin to that of a one-way street. The researcher initiates the process, the respondent chooses to respond, and in that sense, they have some autonomy and may play a more active role. However, this term does imply that the respondent is somewhat distanced from the research process. For example, as is the case when a person 'responds' to a survey. There are positivist connotations to using this term, and so for these reasons, I will not use this term.

The final term 'participant', suggests that the person is more involved in the research, and the flow of information is more bidirectional than the previous two terms imply. In this case, the emphasis is placed on the individual's contribution to the study, and the data they provide, which aligns with an interpretivist approach. Therefore, I have chosen to refer to the individual early childhood educators who have contributed to this study as research 'participants'. From an ethical perspective, I believe this term retains the humanity of the individual, and accurately reflects the value I place on the role each educator played in this study.

Early childhood educators are the primary focus of this research project and are the research participants. However, children are also involved as their participation in the science activities was also a source of data. The children are not referred to as participants; instead, I use the broad descriptive category of 'children'. The use of this term is not to suggest a lessening of the value of the children's involvement but rather is used for clarity.

Consent

Consent in research refers to "a conscious and deliberate agreement for an individual to participate in a study when that individual has reached the legal age of consent" (Garcia & Fine, 2018, p. 4). According to Oliver (2010), research participants should be fully informed before they agree to give their consent to participate in a research study. Fully informed means that the participants had been given all of the information that they may conceivably need to decide on their participation. To be fully informed, participants must be told about the following: the purpose of the research; a summary of the contribution that the participant will be required to make; potential risks/benefits; anonymity of the participant and confidentiality of the information they provide; and their right to withdraw from the process at any time (Coady, 2010; Cohen et al., 2011). An additional consideration is the language used to inform participants about the research. The researcher should ensure that they provide information in a format that is easy to understand (Sikes, 2004). In seeking to inform participants about the research, an information sheet with an attached consent form was created (see Appendix 5).

As voluntarism is a critical factor in ethical research (Cohen et al., 2011), I wanted to give the participants the time and space to freely make their own decision about their involvement. Therefore, I sent the information sheet and consent form to each participant a couple of weeks before the research was due to commence. I also included an additional note reiterating a request to contact me if they had any questions or concerns. A meeting was arranged with each participant to meet me in person the week before the scheduled research start date. The purpose of this meeting was to discuss any issues or questions they may have. As it turned out, all participants had signed their consent forms before our meeting. Nevertheless, in an attempt to ensure that participants fully understood the implications of the research, I decided to read through the information sheet with each person and encouraged them to seek clarity and ask questions. Each participant seemed to be very positive about the research and indicated that they and the children were looking forward to it.

Although the educators were the primary focus of this research, children were also involved. Their involvement consisted of being observed as they engaged in science activities in the classroom. In terms of research, children are regarded as a vulnerable group. In the case of preschool children, their vulnerability is considered in terms of their capacity to understand the implications of what is being asked of them (Oliver, 2010). In the spirit of 'ethical symmetry' (Mukherji & Albon, 2018), where children are afforded the same ethical considerations as adults, consent for their involvement was sought from their parents. In consultation with the research participants, we decided that they would talk to parents about the planned research and provide each with a copy of a parent/guardian information sheet and consent form (see Appendix 6). The parents were advised that I would be available to come in and talk to them about the research and answer any questions. No request was received from any of the parents across the eight settings. A total of four parents did not want their child to be filmed at all during the research. These children were from two settings, and the educators expertly managed the situations, as detailed in the 'During the research' section.

Another issue regarding the use of visual data concerned gaining consent for participants and children's faces to be included in any publication. Various options were provided on the consent form ranging from full consent to no consent for facial images to be used in any publication (see Appendices 5 and 6). All participants responded positively and gave consent for the usage of their facial image. However, there was a mixture of responses from parents, which presented me with a logistical issue. In reality, it would be very challenging now or in the future for me to match each child's name to their image and then cross-check that against the consent forms. In hindsight, I think my approach was too complicated. I should have just proposed to collect the visual data, and use the transcriptions for this thesis and any publications. As a consequence of this issue, I have made the decision not to use visual images in this thesis or any future publication that may arise from this work.

While parents make the first decision about their child's involvement, seeking assent from the child provides a way to recognise their rights and agency (Dockett & Perry, 2011). Assent is "the agreement of someone not able to give legal consent to participate in the activity" (Garcia & Fine, 2018, p. 4). Therefore, before starting the research, I spoke with the children and explained in straightforward terms what I would be doing and what their involvement would mean. I showed them my camera and made a short video clip of myself to show them how it works. The children watched the clip, handled the camera and asked some pertinent questions about why I wanted to make the video, and whether their friends and teacher would be involved. Their questions indicated to me that they had a relatively good understanding and were competent enough to give or withdraw their assent. As the preschool children involved in the research were pre-readers, gaining their assent through the provision of a written information sheet raises ethical issues about informed assent. Therefore, I adopted the approach highlighted by Coady (2010), where pictures are used as a means for the child to convey their feelings about being involved (see Appendix 7). In practice, many of the children just scribbled across the form, and so I asked them if they were happy or sad about me using a video camera and recording their words. No child indicated that they were unhappy. I also spoke with the participating educators who each assured me that the children were very familiar with a camera being used in the setting.

3.7.2: During the research

Minimising Disruption

Through my experience of working in an early childhood setting, I appreciate that it can take some time for the children and educator to settle into a comfortable co-existence. At this time, a sense of equilibrium exists between the educators and children, which Oliver (2010) refers to as "the social ecology of the setting" (p. 84). Disruption of the social ecology can have ethical and data quality implications (Oliver, 2010). In my experience, the social ecology in preschool tends to be at its most consistent during the spring/summer terms. Therefore, I chose this time for my data collection. Furthermore, as I was collecting data through naturalistic observations, I decided not to collect data on my first day in the settings. Instead, I used this time to get to know the educator and children. My experience in the field helped in this regard as the children soon appeared to be quite comfortable in my presence. After a short while, the novelty of my presence wore off, and the children started to play. While I did strive to minimise the disruption to the social ecology within each classroom, I acknowledge that even though it may have been negligible, my presence must have had an effect.

Data collection methods and the recording of data

The choice of data collection methods in research requires ethical consideration. According to Sikes (2004) "the acid test when considering methodologies and procedures is to ask yourself how would you feel if you or your children were 'researched' by means of them" (p. 25). As I had never been 'researched' this question provided cause for thought. I understood that I had a moral responsibility towards the participants. To meet this responsibility, I ensured that I was well informed about the potential ethical issues that may arise in educational research. I always kept the participants' well-being in mind.

As outlined earlier in this chapter, I used two data collection methods, namely, interview and observation. Both methods involve the recording of data, and I took all reasonable measures to ensure the peace of mind of the participants. During the observations, I positioned myself so as not to intrude upon the group activity (Silverman, 2017). In both the observations and interview I explained that the respective use of a digital recorder provides a degree of accuracy that note-taking would not achieve. The choice of time and location of the interview was given to the participant in an effort to minimise any inconvenience (Cohen et al., 2011).

The issue of power also had to be considered. Interviews by their nature involve asymmetries of power (Brinkmann & Kvale, 2018). The roles are unequal as the researcher sets the agenda, controls the direction, asks the questions, and concludes the interview. Throughout the interview, I was mindful of my influence on the participants and tried to maintain a positive, pleasant, yet professional approach. In addition, the participants were told that I would turn off the recorder at any point if they so desired. Although this research strives to produce knowledge that is co-constructed by both the participants and me, this knowledge is dependent on the social relationship between both parties. The participant must feel comfortable in the environment. This required a balance between my interest in obtaining relevant knowledge and ethical respect for the integrity of the participant (Brinkmann & Kvale, 2018).

Ongoing consent and assent

Although participants sign a consent form at the start of the research, the issue of consent is not resolved at this point, and it is an ongoing issue (Silverman, 2017). Similarly, children's initial assent can only be presumed to be provisional and must be renegotiated each time data are collected (Flewitt, 2005). To ensure ongoing consent and assent, I adopted a collaborative approach with the participants and children and always sought their assent before turning on the video camera during observations, and the voice recorder during the interview. In both cases I told the participants and children that if they felt unhappy at any time they could ask me to turn off the recording device. While the educators appeared to be conscious of the camera at first, this seemed to diminish after a few minutes as they became engrossed in the activities. As the children in the settings were free to leave the activity at any time or not engage at all, their continued involvement indicated ongoing assent.

As previously mentioned, some parents did not consent to the filming of their children during the research. Rather than deny these children the opportunity to get involved in the science activities, the educators put them into a second group who were not filmed.

3.7.3: After the research

Confidentiality and anonymity, and GDPR

The researcher's ethical responsibilities do not end when the data collection process is complete. Research participants have a right to privacy and should be accorded the right to confidentiality and anonymity (BERA, 2018). Confidentiality implies that private information relating to the identity of the participant will not be disclosed (Brinkmann & Kvale, 2018). The principle of anonymity means that information supplied by the participant cannot be used to identify them (Cohen et al., 2011). As part of informed consent, the participants were given assurances regarding the confidential and anonymous treatment of their data. One common approach is to use codes or fictional names in the report (BERA, 2018; Cohen et al., 2011).

To ensure confidentiality and anonymity and in line with Ireland's general data protection requirements (GDPR) as outlined in the *Data Protection Act* (Ireland, 2018), all electronic data were downloaded from either the video camera or the digital voice recorder and stored on my password-protected computer. Folders were created using a fictitious name for each setting, and the participants were identified using a code, for example, S1 for setting 1, and T1 for the educator in S1. Within this thesis, and any future publications, these codes are used to identify the participants, and pseudonyms will be used for the children.

Reflecting on the issue of anonymity and bearing in mind that all participants signed the informed consent form, there was an assumption on my part that the participants would not want their names to be used. I appreciate Brinkmann and Kvale's (2018) point that by using codes and fictitious names, the researcher retains the privilege of controlling and disseminating the information. Therefore, I decided to contact the participants after the research and asked whether they wished their real name to be used in this or any other publication, all declined.

Data accuracy

Ethical questions may arise about the accuracy of the transcribed interview and video data. Transcription is not merely a case of writing the words as heard on the recording. It also involves perceptions and interpretation of tone, pronunciation, emphasis, and pauses, all of which are encoded into the written transcript (Oliver, 2010). Therefore, in this research, the transcripts are intersubjective accounts of the participants' articulated interpretations and my interpretations of the recorded data. Each participant was asked to read their interview and video transcripts to make sure that they were an accurate portrayal of their views and actions. I received a positive response from all participants.

Ethical principles are a key factor in educational research. Throughout this research process, I have endeavoured to incorporate the principles of ethical research, along with my values, beliefs and ethical principles.

3.8: Chapter Summary

This chapter aimed to explain the rationale for the methodological approach and procedures used in this research study. I began by setting out how I am philosophically paradigmatically and positioned (Sikes, 2004). My ontological and epistemological orientation, and my sociocultural view of the research process, led to the adoption of a qualitative interpretative approach. The rationale explaining this choice was followed by an examination of case study as a mode of reporting research, and a justification for using this approach. Using a qualitative approach combined with case study methodology provided the opportunity for me to explore, in a variety of ways, the everyday realities of early childhood educators as they endeavour to provide science learning experiences. A critical evaluation of participant observation and semi-structured interviews provided the rationale for their selection as the data collection methods for this study. Selecting two data collection methods affords methodological triangulation, which not only provides different perspectives on the same issue, it also enables the combining of data from both sources. In order to answer the research questions, the data gathered through participant observation and semi-structured interviews were analysed using Braun and Clarke's (2006) thematic analysis approach. Both the data collection and analysis methods reflect the interpretative and sociocultural approach of this study. The chapter concluded with an explanation of the ethical considerations before, during and after the research.

For clarity, the data analysis and interpretations, and the subsequent discussion of the findings are presented across the following two chapters, each relating to a specific research question. According to Braun and Clarke (2006) the task of writing up the report of a thematic analysis, "is to tell the complicated story of your data in a way which convinces the reader of the merit and validity of your analysis" (p. 93). The following two chapters aim to tell that story.

Chapter 4: Findings, Analysis and Discussion of Educators' Perceptions of Science

4.1: Introduction

The aim of this chapter is to present, analyse and discuss the findings in light of the first research question:

- What perceptions do a group of educators who work with children aged from 3 to 5 years have about science in early childhood education?

These perceptions are derived from participants' understandings, attitudes, values and beliefs as articulated during their interviews, and observed during practice. Policy information is used to provide the current context as defined by *Aistear: The Early Childhood Curriculum Framework* (NCCA, 2009). The following excerpts provide evidence of the participants' understandings and perceptions of early childhood science education.

4.2: Presentation and interpretation of the data

The findings presented here seek to provide insight and understanding in relation to early childhood educators' perceptions of preschool science. A process of thematic analysis served to analyse and interpret the data. Such an approach provides, "a concise, coherent, logical, non-repetitive and interesting account of the story the data tell" (Braun and Clarke, 2006 p. 93). As mentioned above, observation data supports the analysis of educator perceptions. While a full discussion of the observed activities is covered in Chapter 5, a summary is included here to provide a context for the discussions that take place within the current chapter.

A total of 23 videos were analysed for this study. The breakdown is as follows: 8 videos captured the potential science learning resources available in each setting as indicated by the educator, see Table 4.1, and 15 videos of educator-led planned science activities, see Table 4.2. In the case of the educator-led activities, the role of the children is highlighted because it provides an insight into what the educator regards as important for children's learning.

Table 4.1: Potential Science Learning Opportunities Available in the Environment

Resources	Number of settings
Vinyl animals/dinosaurs	8
Books	8
Construction blocks	8
Plants (indoor/outdoor)	7
Wallcharts	7
Art corner	7
Nature puzzles	5
Trees (outdoor)	4
Nature table: Pinecones, leaves, seashells, horse chestnuts, acorns, stones	3
Sand table	2
Playdough	2
Car tyre (outdoor)	2
Live animals Caterpillars and goldfish	1
Magnetic shapes	1
Timers	1
Worm	1
Bird's eggshell, skate's egg case	1
Snails (outdoor)	2

Table 4.2: Educator-Led Science Activities

Name of the activity	Explanatory comments	Children's role
(Category 1) Making gloop	A mixture of cornflour and water is used to create gloop, which reacts in different ways depending on the force applied to the mixture.	Follow educator's instructions to make their own gloop Hands-on manipulation & sensory exploration
Tasting	A variety of sweet, sour and salty food is tasted.	Sensory exploration Turn-taking
Playdough		Observe the educator making playdough Hands-on manipulation & sensory exploration
Making a special kind of play dough	Adding sensory materials such as lemon juice, mint leaves and sesame seeds to the ingredients	Follow the educator's instructions when taking turns to add ingredients Hands-on manipulation & sensory exploration
(Category 2) Making a tornado	A commercially available 'Tornado Stop' is used to join two plastic bottles, one of which contains water. Shaking the bottle with the water creates a vortex which is the same shape as a tornado	Follow educator's instructions Turn-taking
Making a rainbow (observed in 2 settings)	Milk is placed in a shallow bowl, and various food colourings are dropped onto the milk. A cotton bud is soaked in washing up liquid and then dipped into the areas of food colouring, which causes the colours to disperse away from the cotton bud.	Follow educator's instructions Turn-taking
Planting seeds		Follow educator's instructions Turn-taking
Making a volcano	Sand is moulded into the shape of a volcano. A mixture of baking soda and vinegar are used to represent the lava.	Follow educator's instructions Turn-taking
Colour mixing and absorption	Mixing food colouring in water, placing a tissue into the water and observing the colour of the tissue.	Follow educator's instructions Turn-taking
An experiment	Floating and sinking. A variety of objects are tested to see if they float or sink.	Follow educator's instructions Predict-check (2 children) Turn-taking Observe
Magnets	A variety of objects are tested to see if they stick to a magnetic board.	Follow educator's instructions Turn-taking Observe
(Category 3) A science experiment	A Mentos (mint sweet) is dropped into a bottle of Coca Cola, and the reaction is observed.	Observe
A science experiment	Tealights are placed into three different size jars, and the different rates of extinguishment are observed.	Observe
Magic	Water absorption using a sponge.	Observe & count

During the process of thematic analysis two themes were identified, namely interpretations of science in early childhood education and educators' beliefs.

4.2.1: Interpretations of science in early childhood education

Defining science as the interplay between a body of knowledge and the processes used to establish that knowledge (Duschl et al., 2007) is well established. In the present study, the analysis showed some variation in participants' interpretations of what science is. There was no evidence to suggest that the participants consider scientific knowledge as being tentative and subject to change, which suggests that their understanding of the nature of science was limited. However, science as a way of exploring the world was articulated by most participants during the interviews.
In Setting 1(S1), when asked about her interpretation of what science is, T1 offered:

T1: *I think that science is a way of exploring the world, how the world works, how nature works, how things in the world work, how they all fit together, how we came into being…how things work and why.*

An extension to the idea of science as exploration and discovery was voiced by three participants who include experiments and sensory experiences as part of science:

T3: *We describe it as doing experiments with things like cornflour, bread soda, making different types of play dough, different smells, different touch, different sensory experiences*.

While one participant also spoke about science in relation to labs and technicians, she revealed that before participating in the research, science was not something she had considered for children:

T6: *When somebody mentions science, I always think of like a lab, a technician, somebody into making medicines and all. I never* *actually think of it around children. I think of it as something to do with maybe chemists or hospitals.*

It is important to note that while I did not explain anything about science to any of the participants, T6's colleague, who was present during my first day in the setting, spoke to T6 about water play and making playdough and gloop:

T6: *Now I realise that I have been doing it all along but never realised I was doing it. But when you came in and we were doing things, and then I realised this was science …you're measuring…they're thinking, they're exploring; they're mixing, it is all science.*

The previous accounts of what science is, relate to the understanding of science as a body of conceptual knowledge. Facts to be discovered. However, while some participants mentioned experiments, only one offered details on scientific-based inquiry. In the following excerpt, T8 describes how she encourages children to observe, predict and check during a floating and sinking activity.

T8: *What we would usually do for that is that we'd have a little chart written out with a little picture of everything on it or a drawing and then we'll record then what happens with the different objects that we have. So, we'd have maybe 7 or 8 different objects, and we tried the pasta, and we all had a theory first of all. So, I would ask them all individually 'who thinks it's going to sink who thinks it's going to float?' So, we ticked everything off, and then we compared it to what actually happened. With the pasta, we all thought the pasta was going to float because it's light, and it sank (laugh) straight down to the bottom.*

The importance of fun and the 'wow' factor

How children experience science learning opportunities was commented on by all participants. The analysis highlighted an emphasis on fun and enjoyment. While all participants commented on the importance of children having fun during the activities, they further suggest that fun is a prerequisite for learning. As T4 offers, "really, they won't learn from it (the activity) unless they have enjoyed it really, you know the fun in it. I mean you can't beat the fun". The value placed on fun within an activity is further emphasised by some participants who acknowledge that they always consider it when planning an activity. In the words of T2, "I will always try them at home just for my own sake as well just to have an idea that it will be fun enough and all that type of stuff".

Most participants conveyed the importance of inciting awe and wonder in children during some science activities. This view was expressed as the 'wow' factor, which is generated by the visual impact of the activity:

T4: *I think it's (science) kind of seen as exciting. Now, I know that's a little bit to do with when you present it in a kind of a 'wow' fashion it helps…Just to see their little eyes light up when something happens like with the volcano when the lava comes up. Just to see their expression and then to listen to all their questions, their curiosity. You can't beat a good visual.*

Indeed, for some participants, the visual impact was the priority in an activity, rather than providing causal explanations. As T5 explains, "I suppose for me it's a visual they just get the visual, rather than the cause or the why does that happen?". Given that science is based on providing causal explanations, this finding illuminates how these educators understand science and its purpose in early childhood education.

Most participants, therefore, interpret early childhood science education in terms of children exploring and discovering their world. While experiments are mentioned, it is only in terms of making substances such as playdough which is subsequently used for multisensory exploration. While many participants refer to experiments, only one suggested that she engages the children in using the observe-predict-check scientific process of inquiry. All participants emphasised the importance of science being fun and enjoyable for the children, with some further suggesting that fun is a prerequisite for children's learning. The entertainment value gained through the visual impact of activities was a priority for all participants.

Science education as a context for holistic learning and development

All participants expressed the view that science activities provide a context to support children's learning, particularly in the areas of language, literacy and numeracy. As T6 explains during her interview:

T6: *I think it's everything. It teaches them their numbers; it's everything. It's everything because it's language, it's literacy, and it's most obviously numeracy*.

This emphasis is understandable given the dominant position of language, literacy and numeracy within early childhood education policy (DES, 2017a; NCCA, 2009). Indeed, holistic learning and development are included as one of the twelve principles of early learning and development that underpin *Aistear* (NCCA, 2009).

Furthermore, one participant judges the success of a science activity on whether it develops children's learning in areas other than science.

T2: *I am kinda conscious that there's a good few children in the class who haven't that much of an awareness of numeracy or literacy or something whatever it is, I might be hoping that this [science] activity might develop that by the way and I would be trying not to be disappointed if it didn't. I would find myself judging it on that, whether it did tick a fair lot of boxes for children*.

Observations of practice also identified the emphasis on language and numeracy. For instance, in one science activity identified in Table 4.2 as ‘magic’, T4 demonstrated water absorption using a sponge, two bowls, and some water. During the activity, T4 encouraged the children to count with her each time she pressed the sponge down into the water, lifted it up, and transferred the water from one bowl to another. The children's role was to watch and count. The activity ended when all the water had been transferred. There was no mention of science concepts or processes; the focus was on counting.

Only two participants mentioned children learning scientific content, and in both cases, it was factual scientific conceptual knowledge, rather than process-related scientific inquiry. In one instance, T7 identifies this learning in relation to some live caterpillars in the classroom.

T7*:* *Or even like say with the caterpillars, they come in every morning waiting to see if there is a change gone on, they watched them since they came in and watched how big the caterpillars got. If that just stuck in their mind for when they do go on and learn more, that's what I hope.*

Analysis of the interview data revealed that most participants believe that science activities promote holistic development, including cognitive, social and emotional development. Furthermore, one participant also noted how science could be a source of fascination for some of the children in her class who have challenging behaviour.

T2: *There's huge concentration…through science, we can bring fun and curiosity and learning, and it's just a great tool*.

T3: *So, you know a number of kids who would be quite difficult to contain, difficult to keep occupied, difficult to be interested in things were fascinated with the cornflour today, with the floating and sinking, with the magnets. You know it was like their mind needed that thing to sort of think*.

In relation to social and emotional development, helping children to develop environmental awareness by learning about their world, and children working together were particularly evident among participants' views. Observations of practice corroborated these views. Indeed, developing social skills such as turn-taking and sharing was a prominent focus in science activities. The influence of policy is also clearly evident here as social and emotional development are core elements within *Aistear's* (NCCA, 2009) themes of Identity and Belonging and Well-Being.

T2: *You know the more we know about it, the more we feel comfortable in our world. The world will make a little bit of sense to us. We all like our environment to make a little bit of sense.*

T5: *Oh, huge benefits, even working together and helping each other*.

T8: *They have to learn to take turns; they have to learn a little bit of patience as well, so it's [science] good for them that way*.

Therefore, participants' beliefs about learning within science activities suggest they privilege literacy and numeracy over scientific conceptual and inquiry-based knowledge. While one aim within *Aistear's* theme of Exploring and Thinking refers to elements of scientific inquiry, such as observing, investigating, and problem-solving, the participants did not mention this type of knowledge. The focus on literacy and numeracy is understandable, considering that early childhood education policy also privileges these areas of learning. Participants also view science activities as opportunities for promoting cognitive, social and emotional development, all key areas within *Aistear* (NCCA, 2009). Furthermore, *Aistear* places little emphasis on substantive subject content; in other words, the knowledge, skills and understanding that define science. Interestingly, no participant had heard of the *STEM in Irish Education Policy Statement 2017-2026* (Department of Education and Skills, 2017b), which recognises that STEM learning starts in early childhood education.

4.2.2: Educators' beliefs

The second theme developed from participants' perceptions of early childhood science education relates to their beliefs. This section includes evidence of the participants' attitude towards science and their beliefs about children.

The attitude of participants towards science was overwhelmingly positive. Interestingly, this is despite many participants holding quite negative views about their secondary school science experiences. Of the six participants who studied science at school, only one spoke positively about her experiences, whereas four participants had negative views.

T8: *I found it [science in school] very interesting. We experimented with chemicals and Bunsen burners.*

T1: *I was terrified of my science educator. I was afraid to breathe inside the classroom…all I was focused on was please don't see me.*

T4: *We didn't do much in the line of experiments…there was too much caution. It was 'don't do this, don't touch that. It was very restrictive.*

T7: *I thought it was very, very boring. I didn't like it at all, it was basically watch the teacher cook up these ingredients, watch the teacher at the board. It wasn't very much hands-on approach. So yeah, I didn't really enjoy it at all.*

Interestingly, T 1 was quite exuberant in her current attitude towards science.

T1: *I just love science (laughs). I just love experimenting and making and seeing how things work. I just love learning myself, because as I said, I am learning stuff I never knew.*

One participant acknowledges the influence of a significant person on their attitude to science. In this case, the participant related to events that happened over twenty years ago when she met an early childhood educator in the United States whose positive attitude to science with young children made a long-lasting impression.

T3 *When the kids were in preschool in the States, they did those sorts of experiments and one woman, in particular, her name was [name supplied]. She was a very well-known educator in the States, and she was brilliant for doing that. She would have dead fish that the kids could cut the eyes out of the fish. She would have a pestle, what do you call it, mortar and pestle things to scrunch up seeds of flowers and stuff. She just had so many, you know, and I would use quite a few of her ideas. I baulked at the fish (laugh), but I have seen them.*

T5: *Well, I'd have to bring it back to my mother. I would have to because we always, always, always had flowers at home. They didn't have money or anything like that but the smallest thing, it looks lovely. So, definitely she was a huge influence on me doing it.*

All participants were asked to rate their confidence to teach science on a scale of one to ten: with one indicating that they lacked confidence, and ten indicating that they were extremely confident. This measure is not held out as a definitive measure of confidence, and it is used purely as an indicator of how confident each participant feels about supporting children's science learning experiences. Figure 4.1. shows the self-assessed scores.

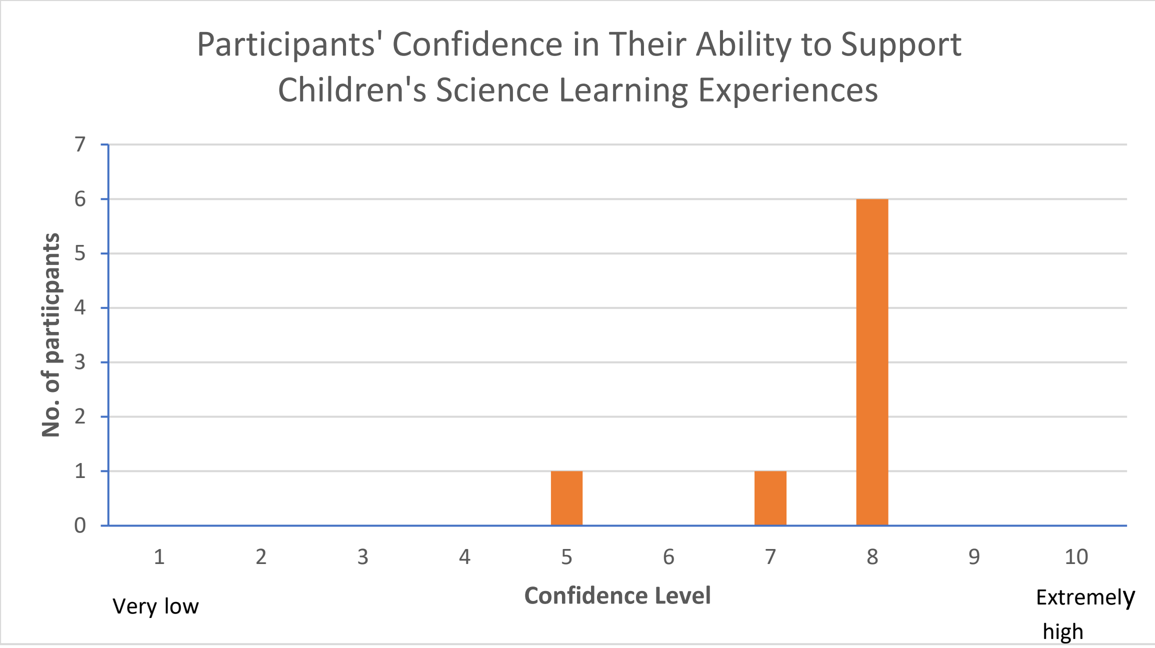


Figure 4.1: Participants' Level of Confidence in Their Ability to Support Children's Science Learning Experiences

Participants who rated themselves at a level of eight acknowledge that they do not know everything and are willing to do some research before doing activities. Interestingly, some participants did not feel that science activities require a pedagogical approach that is different from any other subject. Furthermore, one participant contends that the nature of science activities provides scope for things not to work out, and this should not be feared but rather embraced.

T1: *I would say that because there is a lot of things I don't know that I would have to go and research first. If they came up to me now, there's a lot of things I would know because I have done experiments before.*

T2: *To be honest I don't think that it needs to be presented any differently, you know hung up there as it's special, we're doing this any differently.*

T3: *Yes, so because the thing is it doesn't matter if it goes wrong, it's interesting. And you know who are we worried about? The* *kids don't care. You know things are always interesting to them. So often we get freaked out because something didn't work out the way we thought it would.*

The participant who rated herself at seven reflected on her lack of knowledge, while the participant who rated herself at five expressed a general lack of confidence. Observation data corroborates the views expressed by participants as all appeared to be relaxed and confident during their science activities.

In sum, despite participants' negative experiences of school science, they have a positive attitude towards science in early childhood education. Confidence levels were mostly high, which may be linked to their general confidence as an early childhood educator as, on balance, the participants do not regard science as being any different to other subject areas.

Educators' beliefs about children

The participants' beliefs about children fall into two categories, namely, their beliefs about how children influence their practice and how children learn. Educators believe that children have a positive influence on their practice. They seem to be motivated by children's love of learning, curiosity and general interest in science. Some participants also contend that the children's curiosity drives them to extend their learning:

T1: *I believe what influences me is that children are curious they're like sponges, they take in everything. And something that I feel that I can give to them by showing them science experiments. Something that I can give to enhance their curiosity, to enhance their learning.*

T4: *What you find is that kids are very curious too. You get curious, and the kids get really curious, and they are asking you questions, and you have to go, and you have to find more information to feed their curiosity. So, you end up actually being hooked on it as well.*

Children's reaction to science activities also plays an influencing role as educators get a sense of satisfaction and positive reinforcement when they see how the children react. This satisfaction and positive reinforcement also influence educators' attitudes and confidence to teach science.

T2: *I suppose children's attitude enables us in that it's a great sense of satisfaction for us that we know that through science we can bring fun and curiosity and learning and it's just a great tool for all of that and there's great satisfaction in that, so I'd say that is an enabler*.

Educators' beliefs about how children learn will impact on the science learning opportunities they provide in the classroom. According to Piaget (1964), learning is a solitary activity for the child, which is initiated through a process of exploration and discovery. In contrast, Vygotsky (1978) emphasises the social context of learning where the child learns from a more knowledgeable other, which may be an adult or peer. Analysis in this study reveals that all participants articulate interpretations of Piaget's view that children learn through active participation, which primarily involves physical hands-on and multisensory experiences. Learning as a social process with peers and adults was given little emphasis, other than putting children into groups where each individual interacted with materials and the environment.

T2: *Children learn through doing it's certainly not listening and us standing talking about stuff that does not work in this environment at all… let them explore it and manipulate it and see results from their ideas.*

T8: *Well it (science) gives them a kind of a practical a hands-on view of what you are talking about and what's happening in the world, so they can actually see it for themselves, they can feel it, they can use their senses to learn about it and they will retain that information much faster than if you sit and tell them a story out of a book*.

Considering the significant emphasis on play in early childhood education, it was not unexpected that all participants expressed the view that children learn about science through the medium of play, primarily sensory play.

T2: *They (children) learn everything through play really because play is their, it's their everything. There is no other way for them to learn I am convinced except through play. Play is their method, totally. It is the only way.*

T8: *They learn during the sensory experiments, this is fun, it's good fun, it's playing, it's kind of not a science experiment as such.*

The views expressed by participants about the centrality of play to children's learning is also actively promoted in *Aistear* (NCCA, 2009), where a complete section of the curriculum framework is dedicated to learning and developing through play. Observation data provides some interesting comparisons between what people say and what they do in practice. Despite all participants expressing their beliefs about play and children's learning, of the 23 science activities observed for this study, only 4 involved the children getting a chance to play. This play consisted of an individual exploration of objects or materials, where, for example, each child had their own piece of playdough to 'play' with. This solitary play generally involved each child making shapes with the playdough. In all cases, the educator adopted the role of facilitator rather than acting as a mediator in children's learning.

Educators' perceptions about their role within the classroom seem to be influenced by their beliefs about how children learn. Considering the participants' emphasis on the child as a solitary learner requiring opportunities in the environment for physical manipulation and multisensory experiences and *Aistear's* promotion of learning through play, exploration and discovery, it is not surprising that they describe their role in terms of providing resources and facilitation.

T3: *I see my role as to provide stuff for them to experiment with and not to be giving them the answers. To try and make them* *wonder themselves, I think there is not enough wonder in the world. There isn't enough 'Wow, how did the grass grow?' I think we tell the kids too much and I think we rush them through too much.*

T8: *Generally, my role would be to provide the equipment (laugh), to give them instructions, instruction in what we're doing and how to do it and then I let them work away to explore for themselves. So, I'd be a kind of a facilitator, I suppose.*

In conjunction with the provision of resources, some participants also felt a responsibility to come up with new ideas. As T4 offers, "you have to feed their curiosity, and keep the entertainment value going". It was also apparent that for some participants, the pressure to provide something novel for the children proves challenging. As T5 reflects "I find that it's very hard to surprise them with something. If I buy something new and I'd say 'oh, this is fabulous' and they'd love it for 5 minutes, and then they're back to whatever".

In this section, the focus of the analysis was on the individual participants and their perceptions of early childhood science education. The process of analysis identified two themes, *interpretations of science*, and *educators' beliefs*. The findings indicate that participants' knowledge, beliefs, attitudes and assumptions influence their daily practice. The excerpts provide evidence that there were many commonalities in participants' perspectives on early childhood science education. There was significant evidence of some shared pedagogical values and beliefs, such as their commitment to exploration and discovery as the means by which children learn.

Participants' interpretations of early childhood science as a way of exploring the world and the emphasis on fun, the visual impact of the activity and the essential requirement for hands-on or multisensory exploration provide striking evidence of what they deem to be necessary for children's learning. Furthermore, participants' beliefs about how children learn seem to be a significant factor in how they perceive their pedagogical roles. The participant’s view the child as a solitary learner who constructs knowledge, and consequently describe their role in terms of planning activities, providing resources and facilitation of learning. The social or cultural context of learning was not mentioned. Regarding the content of children's learning in science activities, participants seem to privilege a holistic approach with an emphasis on language, literacy, numeracy, and social skills. Scientific conceptual knowledge and scientific inquiry knowledge receive minimal attention. Despite a lack of scientific knowledge, most participants feel quite confident about their provision of science learning experiences.

4.3: Discussion

The analysis and findings presented in this section highlight educators' perceptions of science in early childhood education under two themes: interpretations of science in early childhood education, and educators' beliefs.

Interpretations of science in early childhood education

When researching educators' perceptions of early childhood science education, the starting point must be their interpretation of what science is. Educators are unlikely to provide meaningful science learning opportunities for children if they do not have a coherent understanding of what science is (Fleer 2009b). The educators in my study had little appreciation for the tentative nature of science; instead, they seemed to consider science as a body of facts about the world. Indeed, McNerny and Hall (2017) noted a similar initial finding with a group of nursery educators in England. According to Duschl et al. (2007), science involves an interplay between science concepts and skills. In this study, analysis of the interview data showed that the participants interpret science as a way of exploring the world to discover new knowledge. Seemingly, their interpretation resonates with Duschl et al. 's (2007) definition. However, there was some evidence to suggest that while these educators understand that science involves investigation, they only consider it in terms of children engaging in embodied processes, including hands-on manipulation and multisensory exploration. No participant mentioned scientific conceptual knowledge, which conflicts with what contemporary literature suggests should underpin preschool science (Gelman et al., 2010; Harlen, 2010, 2013). Science is based on providing causal explanations and challenging children to use cognitive processes, in other words, to think. Providing children with a means to investigate science concepts using inquiry skills such as observation, checking, predicting and so on, are the cornerstone of early childhood science (Ashbrook, 2016; Gelman et al., 2010; Harlan & Rivkin, 2014).

The participant's beliefs about science in early childhood education are influenced by Piagetian theory about how children learn, as highlighted by their privileging of hands-on manipulation and multisensory experiences in science activities. However, this appears to be the extent of their appreciation of how children learn, and reflects a partial interpretation of Piaget's theory. No element of Piaget's mechanism of learning, equilibration, was mentioned by any participant. The planned science activities provided by the participants shown in Table 4.2. ranged from hands-on sensory experiences such as playing with gloop to activities such as the Mentos mints and Coca Cola, where the children's role was that of an observer. The former activity is very familiar to the children as demonstrated by their excitement when the educator told them they were going to play with gloop. As the children engaged in this familiar sensory experience, it is unlikely to have presented a cognitive challenge to their 'gloop' schema. In terms of equilibration, this familiar activity is unlikely to trigger disequilibrium, and therefore, learning will not occur (Schunk, 2014). In contrast to this experience, the Mentos mints and Cola activity involves complex scientific concepts, including chemical reactions, which are likely to be beyond the children's current stage of cognitive development. The cognitive conflict caused in this instance is too great to trigger disequilibrium, and as a consequence, learning will not occur (Brainerd, 2003). However, it could be argued that one of the pedagogical challenges in early childhood education is to find accessible explanations for complex concepts, assuming that the educator understands the concept at an adult level. The concept of change, how materials change when they are mixed or combined would be relevant to both the gloop and Mentos/Cola activities.

It seems that these educators are more concerned about what children are doing rather than what they are thinking about during science activities. It can be argued that what children are doing is important. However, as the inquiry skills used in the activities observed in this study do not extend beyond sensory exploration, there is a limited challenge and therefore, little scope for children to develop their working theories about science. As Hedges (2014) suggests, children need to challenge their current understanding to build their working theories. Nevertheless, it is important to note that Piaget's ideas sit within a wider professional culture that draws on a range of theories and ideologies that also emphasise play, exploration, discovery, and hands-on experiences. These ideas continue to be influential in early childhood education to the extent that they may prevent consideration of alternative theories such as those proposed by Hedges and colleagues.

When beliefs are considered from a sociocultural perspective, the educator can be instrumental in challenging children's current understanding. Affording children the opportunity to engage in science activities that are cognitively challenging but attainable, activities that are within their zone of proximal development enables children to develop their working theories with the support of the educator (Hedges and Jones, 2012). When educators collaborate with children, they can base these challenging science activities on the children's existing understanding, their everyday conceptual knowledge. Then through active inquiry, the children have an opportunity to test and refine their working theories, which, according to Hedges and Jones (2012), will eventually develop their conceptual understanding.

When considering the role of science in early childhood education, these educators believe that it provides a means for supporting holistic learning and development as T2 said, the broader the learning, the better. *Aistear* (NCCA, 2009) plays an influencing role here as it promotes the notion of holistic learning and development, which it proposes should be integrated across its four themes. In essence, the participants are acting in compliance with this policy. Analysis of the findings in my study indicates that these educators place significant emphasis on the development of social skills, and literacy and numeracy as part of science activities. Regarding the development of social skills, these educators view science activities as an opportunity for children to practice turn-taking and sharing. Indeed, observation of practice showed that in the science activities, much of the focus was on social skills, with little emphasis on the science content. This focus on social skills mirrors Westman and Bergmark's

(2014) findings whereby a science project became the platform for working with social skills, as prioritised by the educators.

Educators in the current study also prioritise literacy and numeracy skills. As T6 expressed, science is everything, language, literacy and above all, numeracy. Once again, this was born out in observations of practice, where T4's water absorption activity turned into a counting exercise, with little attention paid to science learning. These findings conflict with Gerde et al. 's (2013) cohort, who, although they recognised that the process of engaging in scientific inquiry supported children's oral language development and maths skills, science learning was prioritised.

I suggest that the reasons behind the significant focus of these early childhood educators on literacy and numeracy and negligible attention given to scientific knowledge and skills are twofold. Firstly, while Irish early childhood education policy places considerable emphasis on literacy and numeracy, limited attention is given to scientific knowledge and skills (DES, 2015, 2017a; NCCA, 2009). The exception being the *STEM in Irish Education Policy Statement 2017-2026* (Department of Education and Skills, 2017b), which recognises that the foundations for STEM subjects begin in early childhood as children engage in exploration and discovery learning. However, as no participant had heard of this policy it has had little impact in the early childhood education sector.

The second reason relates to an area that will be fully explored in Chapter 5, and that is the educators' lack of knowledge and training in science. Nevertheless, it is important to make the point here that a lack of training means that early childhood educators have inadequate knowledge and skills to teach science or integrate it with literacy and numeracy learning. When the educators try to integrate science with literacy and numeracy, they seem unable to sustain attention on science concepts, skills and understanding. Indeed, science learning seems to get lost, as clearly evidenced by the counting in T4's 'magic' sponge/water activity, where no attention was paid to any science content such as absorption, volume and capacity.

Educators' beliefs

> *Few would argue that the beliefs educators hold influence their perceptions, and judgements, and in turn affect their classroom behaviour*.
>
> (Pajares, 1992, p. 307)

Analysis of the data in my study presents no resistance to Pajares' claim as educators' beliefs seem to influence their attitudes towards their classroom practices. Educators' beliefs about how children learn not only impacts their attitudes towards the provision of science activities but also how they view their pedagogical role in early childhood science. Although beliefs are complex and studying them presents many challenges (Hsiao & Yang, 2010; Kim & Han, 2015; Pajares, 1992; Rubie-Davies et al., 2012), a thorough investigation of the nature of beliefs and belief systems is beyond the scope of this study. However, as I believe in the socially constructed nature of beliefs, I have drawn on the work of Nespor (1987), Pajares (1992) and Rokeach (1968) to assist me in understanding and characterising the beliefs that have influenced the participants' attitudes towards early childhood science.

As "beliefs are hidden in people's hearts" (Hsaoi and Yang, 2010 p. 299), people often have difficulty in explaining how their beliefs influence their actions (Rokeach, 1968). Considering this difficulty, Pajares (1992) contends that to understand beliefs, researchers must, therefore, make inferences that take into account what participants say and their related behaviour. To that end, I have made every effort to ensure that I understood participants' beliefs by seeking clarification of meanings or further probing areas of discussion during interviews. Ultimately, the discussion of the analysis presented here reflects my inferences.

Nespor (1987) identifies four features which characterise beliefs, namely, existential presumption, alternativity, affective and evaluative loading, and episodic structure. I will use these four features to examine how participants' beliefs influence their approach to early childhood science.

Existential Presumption

According to Nespor (1987), belief systems often contain existential presumptions which are deeply held personal truths. While belief in God is a commonly cited example, Nespor (1987) acknowledges that existential presumption can exist at a more temporal level, such as educators' beliefs about how children learn. Beliefs vary in intensity and exist along a central-peripheral dimension; and those more central beliefs are more resistant to change than those on the periphery (Rokeach, 1968). In my study, existential presumptions about how children learn pervade both the interview and observation data.

In early childhood education, developmental theories of learning dominate discourse, policy and pre-service educator training (Hatch, 2010, 2020; Wood & Hedges, 2016). Although Vygotsky's sociocultural theories have gained much prominence in recent years, when it comes to assumptions about the relationship between learning and development expressed by educators in this study, a Piagetian view of development leading learning dominates. While the existential presumption (Nespor, 1987) that development leads learning was not overtly stated, educators' beliefs to that effect were apparent through their comments about how children learn. All participants said that children learn or 'discover' new knowledge for themselves through hands-on and other sensory explorations. In considering science learning, the participants prioritised their role as facilitating children's learning by providing materials and resources. While they did express the view that children learn about science through sensory play, there was no mention of educator mediation through interactions, or indeed any social or cultural context. This finding concurs with Fleer (2009a), who also found that educators who prioritise the provision of resources to promote science learning tend not to mediate children's learning through focused interactions. Such an approach ultimately impacts on children's science learning, as Vygotsky (1978) proposes that without interactions with more knowledgeable others children's science learning is likely to remain at the everyday conceptual level. Furthermore, Fleer (2009a) suggests that a knowledgeable educator can effectively mediate children's science learning. As children engage in inquiry-based learning experiences, the educator can introduce information on scientific concepts that is dialectically related to children's everyday conceptual knowledge (Fleer, 2009b).

According to Pajares (1992, p. 326), "belief substructures, such as educational beliefs, must be understood in terms of their connections not only to each other but also to other, perhaps more central, beliefs in the system". In my study, participants' beliefs about how children learn is a central belief that impacts on other more peripheral beliefs, such as how they view their pedagogical role in early childhood science. All educators stated that the priority for any science activity is that it must facilitate individual exploration and discovery, with primary emphasis on a hands-on approach. Their role within the activity is to provide resources and facilitate experiences.
Emphasising a hands-on approach to early childhood science is not unusual and has been noted in the literature (Gelman et al., 2010; Inan and Inan, 2015; Worth, 2010). However, to further understand why the participants in this study hold this view, I draw on the work of Hatch (2010, 2020) who explores the prioritisation of Piagetian views of development leading learning in early childhood education. In discussing the consequence of these Piagetian views, Hatch (2020) directly reflects the findings of my study as he notes, "the role of children is to act as explorers and discoverers, while educators are to be guides and facilitators" (p.44). These beliefs have a significant impact on what happens in the early childhood environment. As Hatch (2010) notes, the Piagetian notion that children are 'little scientists" who should be given opportunities to construct their understanding independently, is promoted in many early childhood settings. However, in contrast to Piaget's view, Karpov (2003) maintains that "Vygotsky held that children should not and cannot be required to understand the world by way of rediscovery of the principal explanatory laws already discovered by humankind" (p. 66).

Many researchers have examined how young children learn the concepts and skills of science and demonstrate the shortcomings of expecting children to use their play and explorations to independently construct complex understandings (For example see Dejonckheere et al., 2016, Fleer 2009a, 2009b). Furthermore, children are more likely to extend their science learning if they are supported by a knowledgeable educator (Hong and Diamond, 2012; Samarapungavan et al., 2008).

A further point relates to educators' beliefs about the role of science content within activities. In the current study, the dominant emphasis was on facilitating individual exploration and discovery with minimal attention given to teaching science content or indeed extending scientific inquiry beyond hands-on exploration. This approach mirrors the Piagetian view of learning as adaptation and individual acquisition of schemas, with the child requiring opportunities to explore and as a result, discover knowledge for themselves. However, it can be further argued that from a Piagetian perspective this approach is also lacking. As the hands-on activities are familiar to the children they are unlikely to present a cognitive challenge to existing schemas and therefore the process of equilibration is not triggered. Furthermore, as educators do not appear to consider science content, it is questionable as to how much science learning is actually happening. In reality, the educator's role is to provide the resources to facilitate these exploratory experiences, without much attention to their conceptual potential. However, merely exposing children to hands-on exploration or a visual display does little to challenge their current understandings and develop their working theories about science. As Fleer (2009a) suggests, educators' beliefs about what and how children learn is one of the most significant contributory elements in children's science learning.

Alternativity

The second characterisation of beliefs that became apparent through the analysis of participants' interview data is the concept of alternativity. According to Nespor (1987 p.319) "'alternativity' refers to conceptualisations of ideal situations differing significantly from present realities". In the current study, alternativity means that educators may have an idealised view of what they would like children to experience as they engage in science education. This idealised view may be based on their personal experience of such education, or it may reflect what they wished had been their experience. In my study, the latter seems to be the case as most participants had quite negative experiences of science in school. As T1 said, she was so terrified of her science teacher that she felt unable to breathe during the class. Others also had negative views, T4 spoke about the restrictive nature of school science, and T8 found it very boring because it lacked a hands-on approach. Alternativity is apparent in these educators' beliefs about how children should experience science as evidence through their prioritisation of fun, enjoyment, excitement and hands-on exploration in activities.

Furthermore, T4 suggests that children will not learn unless they are having fun. Literature explicitly relating to this topic is scarce. However, the study by Edwards and

Loveridge (2011), which examined how six early childhood educators in a New Zealand preschool support children's scientific learning, found that educators' negative school experiences can result in an avoidance of the subject. This finding contrasts with those from my study where, despite negative school experiences, the educators were very enthusiastic towards science, albeit with limitations in their understanding and their interpretation of the substantive content and methods of inquiry in science. In addition, the privileging of the entertainment factor over science learning suggests that the participants in my study may have some deeply held assumptions about young children's capacity to learn about science. Once again, the influence of Piaget is apparent, as his stage theory of development positions the preschool child in the preoperational stage where they are incapable of concrete logic or mental manipulation (Piaget, 1964). However, Delaney, Whyte, and Graue (2020) suggest that with the support of educators and peers, children can build the foundational capacity to engage with new content and conceptual knowledge. Therefore, "we cannot set false boundaries for what children 'can' or 'should' be learning, or not, in EC settings" (p. 199).

Affective and Evaluative Loading

The third characterisation of beliefs that emerged from the interview data was affective and evaluative loading. According to Nespor (1987), beliefs are strongly reliant on affective and evaluative components, such as feelings and personal evaluations. How an educator feels about a subject area will influence their beliefs, so positive feelings will influence beliefs in a positive way and vice versa. The participants in my study had positive feelings about science in early childhood education, with many expressing how much they loved doing science. The roots of these feelings link to participants' beliefs about the positive influence that children have on their feelings towards science. Many participants spoke about how children's positive attitude towards science activities provides both motivation and positive reinforcement. T2 captured this point well when she talked about the great sense of satisfaction she gets from the children during the science activities because she knows they have fun and are learning.

Interestingly, although these educators lack science knowledge, this does not seem to impact on their attitude to science. This finding contrasts with the literature which suggests that educators lacking science knowledge tend to have a negative attitude towards science and in many cases avoid it (Edwards and Loveridge, 2011; Greenfield et al., 2009; Roehrig et al., 2011). According to Bell and St. Clair (2015), educators who lack scientific knowledge also lack confidence in their ability to teach science. However, analysis in my study found conflicting evidence as most participants, who recognise their lack of scientific knowledge, expressed confidence in their ability to teach science. This confidence presents a conundrum as in reality, the educators in this study are not really teaching science. Their confidence may relate to the fact that they are using generic approaches to learning such as play, exploration and discovery for activities that they interpret as science. The provision of activities that provide opportunities for play, exploration and discovery without challenging children to think reflects a somewhat limited early childhood education ideology. This limited view of science teaching extends beyond the Irish context. Indeed, a US based study of 51 pre-kindergarten educators found that while most of the educators' self-reported efficacy to teach science was between moderate and high, very few were able to identify the steps involved in scientific inquiry (Hollingsworth & Vandermaas-Peeler, 2017). This finding led the researchers to conclude that very little scientific inquiry took place in these preschool settings.

To further explain why I believe the participants in my study have such positive attitudes and are so confident, I return once more to their interpretation of early childhood science, their beliefs about how children learn and the role of the educator. As previously discussed, the participants interpret early childhood science as a way of exploring the world and discovering new knowledge, which fits with their interpretation of how children learn. They believe their role is to provide resources and facilitate children's explorations. Once the activity is underway and they see that the children are exploring, having fun and possibly being 'wowed' by a visual display, this provides the educator with positive reinforcement which is likely to bolster their positive attitude and confidence. In essence, the educators experience what Bandura (1977) describes as performance accomplishment, which he suggests is one of the most important sources of self-efficacy.

In sum, this finding indicates that the participants have a limited interpretation of pedagogy in early childhood education. One that is not consistent with contemporary literature, which suggests that an inquiry-based pedagogy effectively supports children's science learning (Gelman et al., 2010; Harlan and Rivkin, 2014). It also raises questions about whether these educators understand progression in science learning, particularly when they do not have a good understanding of the structure of the subject. Analysis of the data from observed practice in Chapter 5 will provide scope for a further critique of educators' interpretation and enactment of pedagogy.

Episodic Structure

The final characterisation of beliefs evident in my study is the episodic foundation of beliefs. Nespor (1987) suggests that beliefs can be based on episodic memories, which often derive from personal experience. Significant experiences in a person's life can influence their beliefs in the future, and this influence can be quite powerful. "These critical episodes then continue to colour or frame the comprehension of events later in time" (Nespor, 1987, p. 320). Past experiences have certainly influenced the beliefs of all participants in my study, particularly their personal experiences of science in school. However, one participant, T3, placed significant emphasis on her experience of preschool in the United States, and the time she spent with one educator while there. These experiences happened over twenty years ago, and yet they still impact on T3's beliefs that science learning involves letting young children independently explore and investigate nature. As all of these experiences, both positive and negative happened many years ago, they add weight to Pajares (1992) assumption that "beliefs form early and tend to self-perpetuate" (p. 324).

4.4: Chapter Summary

In this chapter, I have presented the findings, analysis and discussion in light of the first research question: *What perceptions do a group of educators who work with children aged from 3 to 5 years have about science in early childhood education?* Importantly, the findings have been discussed within the context of relevant research and literature.

Regarding educators' perceptions of science, there was little evidence to suggest that they consider scientific knowledge as being tentative and subject to change, indicating a lack of appreciation for the nature of science. All participants interpret early childhood science education as a way for children to explore the world, to discover facts. However, this exploration is limited to hands-on manipulation and sensory exploration. Children are not challenged to think about science by engaging in scientific inquiry-based learning, and consequently, they have little opportunity to explore, develop and refine their working theories. The participants' beliefs about how children learn reflect a Piagetian orientation, which resides within a wider professional culture that also emphasises play, exploration, discovery, and hands-on experiences. Indeed, it was suggested that the influence of these ideas in the field of early childhood education may prevent consideration of other explanations such as working theories.

These beliefs are further endorsed by *Aistear's* stance on how children learn. All participants consider science as a platform for holistic learning and development, a position that is also promoted in *Aistear*. Participants place particular emphasis on developing language, literacy, numeracy and social skills, whereas scientific knowledge and skills receive minimal attention. Once again, the participants are compliant with early childhood education policy, which endorses the focus on literacy and numeracy.

All participants have a positive attitude towards early childhood science education and include science-based activities among the range they provide in the setting. Significantly, the participants' beliefs about how children learn impacts on the type of science learning opportunities participants deem to be appropriate for young children, and indeed, their role as a facilitator in the activity. In all cases, the participants’ main requirements for science-based activities is that they provide the opportunity for the children to engage in hands-on manipulation and sensory exploration. They do not seem to consider presenting the children with cognitively challenging experiences that will, according to Piaget’s (1964) theory initiate the mechanisms of learning, namely disequilibrium, assimilation or accommodation. The participants also perceived the affordance of an activity to provide fun and entertainment for the children as important factors. However, minimal attention was paid to the requirement for activities to promote scientific conceptual knowledge and inquiry skills.

The participants' beliefs were examined in light of Nespor's (1987) four features which characterise beliefs. In this study, the participants' existential presumptions about how children learn, form a central belief which significantly pervades the findings. The Piagetian orientation of educators' beliefs positions the child as a solitary learner and the educator as merely a facilitator. This view contrasts with contemporary thinking which adopts a sociocultural perspective where learning is viewed within a social context, and the educator acts as a mediator. From a science learning perspective, this means that during children's inquiry-based experiences, the educator can provide information on a scientific concept that is dialectically related to the child's everyday experiences.

Other peripheral beliefs, such as alternativity, were evidenced through participants' attempts to create fun and entertaining science activities, which are the polar opposite to their own school experiences. I suggested that this approach may also reflect participants' deeply held assumptions about children's capacity to learn science. Despite their negative school experiences of science and in contrast to much of the literature, the participants rated themselves as being confident to teach science. The participants have a very positive attitude to science. While most cite the children's curiosity and enthusiasm as a contributory factor, one participant related her attitude to a positive encounter with a preschool educator over twenty years ago. However, the participants have a limited interpretation of pedagogy that is not consistent with contemporary understandings of science learning. There was no evidence to suggest that the participants consider the use of educator mediated scientific inquiry. Furthermore, as they do not have a good understanding of science, this raises questions about their understanding of progression in science learning.

The issues raised within this discussion and their implications for how early childhood educators support children's science learning will be further reflected upon in the final chapter.

Chapter 5: Findings, Analysis and Discussion of Factors Influencing Educators' Science Practices

5.1: Introduction

This chapter aims to present, analyse and discuss the findings in light of the second research question:

- What factors influence how these educators practice science education?

The data for this section was gathered during video observations of science activities and participants' semi-structured interviews. Exploration of practice is important given that what participants think and perceive may not always be corroborated through classroom practices. Also, exploring practice provides information that the participant may not consider important and so not mention during their interview, or indeed, they may not even be conscious of its existence. The context of early childhood education practice in Ireland is provided through policy information from *Aistear: The Early Childhood Curriculum Framework* (NCCA, 2009), and *Síolta: The National Early Childhood Quality Framework* (CECDE, 2006). The following excerpts provide evidence of participants' understandings, perceptions, and practices surrounding what they consider to be the significant factors underpinning early childhood science provision.

5.2: Presentation and interpretation of the data

The findings presented here seek to provide insight and understanding in relation to the factors that influence early childhood educators' perceptions and practices of preschool science. A process of thematic analysis was used to analyse, interpret and tell the story of that data (Braun & Clarke, 2006). This story is told using the three themes that were identified during the analysis, namely educators’ lack of knowledge and training, curriculum, and pedagogy.

5.2.1: Educators' lack of scientific knowledge and training

Educators' lack of scientific knowledge and training is often cited as one of the primary obstacles to the provision of science learning opportunities (Fleer, 2009a; Gropen et al., 2017; Park et al., 2016; Pendergast et al., 2017). In the Irish education system, science at Junior Certificate level (GCSE equivalent) has been a compulsory subject since 1989. This general science course incorporates biology, physics and chemistry. At Leaving Certificate level (A-Level equivalent), individual science subjects while offered are optional. Analysis in the current study found that participants had various levels of school science education. One participant did not study science; four studied science up to Junior Certificate level and three studied biology up to Leaving Certificate level. Further analysis of the interview data shows that only participant T8 received formal science training as part of her early childhood qualification. T8 recalled her training in Montessori education, which involved learning about the various experiments they, as educators, could do with children.

T8: *You could do things like volcanoes, how you would make volcanoes. We did all about the solar system, so how you would bring the solar system to life. Experiments you can do, there's various experiments you can do with all sorts of things. So, how to introduce experiments into the classroom for the children*.

The only other reference to training was made by two participants who attended a one night course on science in early childhood education, which was run by the local Childcare Committee[1]. The following excerpt from T2's interview explores the extent of the training.

[1] There are 31 government funded Childcare Committees in Ireland. They offer a wide range of advisory and support services including training to local early childhood care and education settings.

T2: *They were very practical. We sat around a table, it was in a setting like this, and it was very hands-on. You did the experiments, got a little bit of the science, very similar to what we were doing ourselves here*.

Researcher: *So, when you say a little bit of the science, what do you mean?*

T2: *They might just explain why the washing up liquid made the fat and the milk attract towards the washing up liquid. Just explain, throw in a few little words, like Marie (assistant educator) did with her electrons. Just keep it simple.*

Researcher: *Did they cover pedagogy, ideas around how to teach science to young children?*

T2: *No, not in those, no.*

According to Shulman (1986, 1987), educators need to know the 'what' and the 'how' of teaching. He described this as Pedagogical Content Knowledge (PCK). However, concerns have been raised in the literature that early childhood educators lack science content knowledge, in other words, the 'what' of science teaching (Fleer, 2009b; Nilsson & Elm, 2017). Findings from the present study suggest that while educators recognise their lack of knowledge, they often articulate it in different ways. For instance, T1 said, "Sometimes I don't know the answer, and sometimes I have to go and Google the answer and come back to them the next day". Whereas T7 linked her lack of knowledge to not having the right vocabulary, "I haven't got the keywords. I'm talking about key science words". There was an awareness among most participants about their lack of scientific knowledge. Some also identified this as a reason for not explaining the science underpinning the activities. As T5's remarks demonstrate:

T5: *I don't explain the science behind it. I suppose I'm not great at that because I don't know myself. I probably don't know enough scientific, you know, evidence of stuff that I probably wouldn't try*.

The broad agreement among participants about their lack of science content knowledge, the 'what' of science teaching, did not extend to the 'how' of science teaching. Indeed, only two participants recognise their need for more training on 'how' to teach science.

T1: *I would like to go to these people that have run these courses for ages and are probably more qualified than I am to show me, well what way would you introduce it to the children.*

T2: I don't know exactly how to teach science to this age group. I don't know what the scientific outcomes necessarily should be.

Despite all participants recognising their lack of science content knowledge surrounding the 'what', and for some the 'how' of science teaching, all participants regularly include science activities as part of their curriculum.

5.2.2: Curriculum

The second theme developed from the analysis of educators practices and perceptions was curriculum. This section includes the influence of *Aistear*, curriculum objectives, and curriculum content.

The Influence of Aistear

In Ireland, there is no prescribed national early childhood education curriculum, but rather a curriculum framework, *Aistear* (NCCA, 2009). According to MacLachan, Fleer, and Edwards (2018), curriculum frameworks are intended to guide early years educators in their development of a curriculum. *Aistear* broadly defines curriculum in terms of children's experiences in the environment. Play is a dominant theme within *Aistear* and forefronts the participants' conceptions of curriculum. Most educators commented that they follow a play-based curriculum, as T1 stated, "in the setting now we follow *Aistear*, it's all play-based". Two participants use a hybrid of play-based and Montessori curriculum. As T5 explains,

T5: *Montessori would be the main one, but we have had play for quite a long time you know so we do play-based as well, but we follow the Montessori curriculum mainly.*

Aistear is particularly influential in early childhood education for children aged from 3 to 5 years in Ireland. Its implementation is linked to the receipt of government funding, and it is the guiding framework for early years education-focused inspections (Department of Education and Skills, 2015). The data from my research revealed that most participants consider that *Aistear* has positively influenced their practice. Indeed, T3 sees *Aistear* as "a very good philosophy for preschools. I do, I think they've covered everything, absolutely everything". There was general agreement among most participants about the influence of *Aistear* on early childhood science education. Beliefs about *Aistear's* promotion of the child as a constructor of knowledge and the privileging of exploration and discovery through a hands-on approach to learning were evident.

T1: *Aistear is all about the children having their own choice and learning for themselves. So, science would because we are letting the children explore and learn themselves through science. So, it would have an influence on that.*

T7: *I started doing the Aistear programme. I learnt that I could let go and not be so rigid and let them have hands-on. That's why I said to you before about science that it has to be hands-on.*

However, one educator was critical of *Aistear's* lack of information about practical ways to implement science.

T8: *I find Aistear is very good for giving ideas but not practical solutions. So, it doesn't give you a practical way to look at science. It doesn't* *give you ideas of what you should be doing. You know you have to come up with all of that yourself.*

While participants' views about *Aistear's* influence on their implementation of science were mixed, they were unanimous about their use of *Aistear* when documenting children's learning. As T7 explains, "we would do lots of observations and when we write up the children's learning journal, we would link it to the four themes (of Aistear)". Although planning is a key pillar within Aistear, participants did not mention the framework when speaking about their planning.

All settings have an *Aistear* poster on display which shows the aims and learning goals associated with the four themes of Well-being, Communicating, Exploring and Thinking, and Identity and Belonging. Each setting also had *Aistear* documentation available, but no specific in-house curriculum document.

Curriculum Objectives

Although no setting had a science curriculum available, the data revealed that participants had various objectives in mind for science activities. General learning was important for some, whereas for T7, the focus was on children learning science facts and developing their physical skills. Two participants did not mention learning at all but instead focused on the visual display and completing the activity.

T2: *No one objective because if there was it certainly wouldn't work that way. I'm long enough at this to know that. So, I suppose my objective, the way I myself would measure the success of it would be you know the broader the learning, the happier I am.*

T7: *Well you'd hope they learnt the fact, what you're actually doing. All this week its been about the plants and how they get the water and mixing the colours and things like that, but no it doesn't have to be a product at the end of the day. It's the process, we're using our pincer grips, we're pouring, we're mixing colours and where have those colours come from?*

T8: *An end objective yeah usually just for the experiment to be completed so they have a result at the end of it or they've seen what's happening so that they can kind of work through fully and see the end as to what I hope is going to happen.*

Focussing science learning on the 'facts' can place a significant burden on the educator to be the expert, and this can influence how they approach teaching science (McNerney & Hall, 2017). Although using scientific reasoning to investigate phenomena is strongly promoted as a focus for early childhood science (French and Woodring, 2013; Gelman et al., 2010), this was not alluded to by any participant. There was no mention of children learning about or engaging in any scientific inquiry skills such as reasoning and problem-solving as an objective of science activities.

Curriculum Content

Aistear (NCCA, 2009) describes the curriculum in terms of all the experiences in the environment, which contribute to children's learning and development. The science learning opportunities afforded to preschool children within the environment are perceived and created by the educator (Fleer et al., 2014). The provision of resources and activities, the classroom layout, and the interactions that occur within this space will determine what and how children learn. This section presents an analysis of the science learning opportunities that are available across the eight settings involved in this study. The data are divided into two sections, unplanned and planned science learning opportunities.

Unplanned science learning opportunities

Unplanned science learning opportunities refers to the resources that are freely available for science learning within the environment. A total of 23 videos were analysed for this study. The breakdown is as follows: 8 videos captured the potential science learning resources available in each setting as indicated by the educator, see Table 5.1 for a summary of the findings. There were 15 videos of educator-led planned science activities, see Table 5.2. It is important to note that there is no guarantee that the educator captured all instances of informal science learning expereinces. Therefore, the data provide is an indicative rather than absolute representation. The data have been analysed using the two categories described by Tu (2006), namely, informal sciencing and incidental sciencing. Informal sciencing refers to resources that facilitate exploration by children and are freely available within the environment; incidental sciencing refers to spontaneous science-related events in the environment. In line with Fleer et al., (2014), who suggests that science learning opportunities also exist within traditional early childhood education areas, these resources are also included. Table 5.1. also includes the number of times the educator engaged in science-related activities with children.

Table 5.1: Potential Science Learning Opportunities Available in the Environment

Resources	Number of settings	Number of times educator involved in science-related activities
Informal sciencing		
Vinyl animals/dinosaurs	8	0
Books	8	1
Construction blocks	8	0
Plants (indoor/outdoor)	7	0
Wallcharts	7	0
Art corner	7	0
Nature puzzles	5	0
Trees (outdoor)	4	0
Nature table: Pinecones, leaves, seashells, horse chestnuts, acorns, stones	3	0
Sand table	2	0
Playdough	2	0
Car tyre (outdoor)	2	0
Live animals Caterpillars and goldfish	1	1
Magnetic shapes	1	0
Timers	1	0
Incidental sciencing		
Worm	1	1
Bird's eggshell, skate's egg case	1	1
Snails (outdoor)	2	2

There were a variety of freely available informal sciencing opportunities across the eight settings. Some of the most common resources included vinyl animals, plants, and wall charts. These items were also popular in the classrooms examined by Tu (2006). However, Tu did not provide data for science-related books, construction blocks, art corner or nature puzzles, which were available in most settings in my study. Three settings had nature tables which contained a variety of natural items, and most settings had plants in the classroom. The plants were evidence of planned science activities. There was a plant pot with each child's name on it, and all were at the same level of growth. The loose items such as pine cones, leaves, and seashells, were intended to provoke unplanned exploration; however, no child was observed interacting with these items.

Over the 24 days spent across the eight settings, educators were observed to engage with informal science-related activities on two occasions. The activities involved, T1 reading a book about space and planets with a small group of children, and T7 supervising the feeding of goldfish. While the book reading activity involved questions from the educator, the latter interaction was more superficial and did not include any scientific inquiry or conceptual learning. There was only one occasion where a child selected an activity that was science-related and played with it by themselves. This magnetic shapes activity consists of triangles and squares, which the child can use to construct a shape. The low level of informal sciencing found in this study bears some similarity to previous Irish-based research conducted by Neylon (2014). While I acknowledge that the two studies are different in their structure and remit, the findings tell a similar story in that engagement in informal sciencing is low.

Four incidental sciencing opportunities occurred, and each involved the educator interacting with children. These incidences included:

1) T2 encouraged a child to draw a picture of the worm he had found in the garden.
2) T6 encouraged children not to hurt the snails and to put them back amongst the plants so that they could eat the leaves.
3) T3 posed questions about a skate fish's egg case and a bird's eggshell.
4) T5 posed a question which resulted in one child endeavouring to build a leaf bridge for the snails.

In the first two incidences, the interactions were momentary and superficial, each lasting less than a minute. Neither included scientific inquiry, follow up, or extension activities. In the case of T3, she asked closed-ended questions to determine what the child knew about the skate egg case and the bird's eggshell. If the child did not respond, T3 provided the answer. Once T3 stopped asking questions, the child moved away. There was no attempt to explore what the child may have discussed about the items with her parents or others, and so the potential use of her funds of knowledge (Moll et al. 1992) was missed. In contrast, T5's open question resulted in spontaneous engagement and exploration that lasted for several minutes. The use of questioning is relevant, and the theme of pedagogy will include a more detailed analysis of its use as a pedagogical strategy.

Planned science learning opportunities

Providing science learning opportunities for children in early childhood education requires careful thought and planning. *Aistear* (NCCA, 2009, p.11) advocates the use of developmentally appropriate activities based on the interests of the children. According to Smith and Trundle (2014), meaningful scientific inquiry starts with the educator carefully observing the children to identify their interests. Using a child-centred approach was expressed by most educators.

T2: *You listen to the children every day and you know what they are interested in, then you source the material and bring it in… if they are into ducks then its ducks.*

T7: *We do lots of observations and plan activities around what the children are interested in, and that would include science as well.*

There was no evidence to suggest that the educators considered the children's interests beyond the play-based environment of the early childhood setting. No participant mentioned engaging with parents or the community to gain a deeper understanding of the origin of the children's funds of knowledge-based interests. As Hedges et al. (2014) contend, "funds of knowledge provide a critical lens to explore the notion of [children's] interests" (p. 199).

All participants consider the children's age to be a significant factor that must be taken into consideration when planning science activities. As T5 explains, "I think you also have to look at the age range you are dealing with. I do more of the visual with them I feel myself because of their age". All participants also link the children's age to the provision of sensory activities. As T6 offers,

T6: *Gloop is fantastic for this age; they love the feel and the touch. Shaving foam as well, if you mix paint and glitter they can see the glitter shining through, and they love that.*

All participants expressed a need to seek out ideas for new science activities, and the internet seems to be their primary source. As T1 explains,

T1: *I would Google online a lot because there is so much information out there…say they were interested in sand or mud, then I would go what science experiments can I do with mud for preschoolers?*

Unsurprisingly social media applications are also popular conduits for sharing ideas, as T3 explains, "Now we have a WhatsApp group called 'classroom ideas' so anyone who sees something online puts it up". However, not all activities are researched, and most participants have several staples that they use each year. As T4 explains,

T4: *There are certain ones we do every year like the floating and sinking and magnets, so if we are doing something about the ocean we might then do floating and sinking, it all ties in.*

Interestingly, the participants' lack of science content knowledge was not referred to when they spoke about searching for ideas. It seems that the participants focus on providing activities that are interesting to the children with little or no consideration given to the conceptual content. The gloop, paint and glitter example above is similar in that the activity is sensory but did not appear to be understood in terms of scientific conceptual or investigation potential.

During the video data collection phase, 15 formal sciencing learning opportunities were observed across the eight settings. Formal sciencing refers to deliberately planned and educator-led learning opportunities (Tu, 2006). Table 5.2. presents a summary of the findings. The name of each activity reflects the description given by the educator. The explanatory comments provide clarity in instances where the activity may not be apparent. The final column shows the role played by the children. The activities listed in Table 5.2. are divided into three categories based on the children's role. In category one activities, the children engaged in sensory exploration or hands-on manipulation of the materials. Category two activities involved the children following the educator's step-by-step instructions in order to achieve the desired result. The third category includes educator-led activities with no significant involvement by the children other than observation. In activities where resources were shared, turn-taking was prioritised and became a point of focus for many of the children.

One notable activity in category one was 'making playdough'. The educator took sole control over making the playdough, and the children had little option but to watch and wait. However, once made the educator divided up the playdough and distributed one piece to each child. At this point, the children had an opportunity to explore and play. Interestingly, this was one of only three activities that involved play. The other two, 'gloop' and the 'special playdough', were also category one activities. Although all of the activities listed in Table 5.2. present opportunities for exploring scientific concepts, in most cases, this did not happen. An exception was the 'Colour Mixing and Absorption' activity in which T7 drew the children's attention to mixing colours and the resultant colour change. This action ties in with T7's stated objective that she wants the children to learn the facts during an activity.

Most of the activities in Table 5.2. facilitate some form of sensory exploration, which is a key element of early childhood education practice. It seems that for these participants the purpose of the activity was facilitating the children's sensory exploration, which according to Spektor-Levy et al. (2013) assists scientific thinking as children engage, explore, manipulate and interact with their environment.

Table 5.2: Formal Sciencing Opportunities

Name of the activity	Explanatory comments	Children's role
(Category 1) Making gloop	A mixture of cornflour and water is used to create gloop, which reacts in different ways depending on the force applied to the mixture.	Follow the educator's instructions to make their own gloop Hands-on manipulation & sensory exploration
Tasting	A variety of sweet, sour and salty food is tasted.	Sensory exploration Turn-taking
Playdough		Observe the educator making playdough Hands-on manipulation & sensory exploration
Making a special kind of play dough	Adding sensory materials such as lemon juice, mint leaves and sesame seeds to the ingredients	Follow the educator's instructions when taking turns to add ingredients Hands-on manipulation & sensory exploration
(Category 2) Making a tornado	A commercially available 'Tornado Stop' is used to join two plastic bottles, one of which contains water. Shaking the bottle with the water creates a vortex which is the same shape as a tornado	Follow the educator's instructions Turn-taking
Making a rainbow (observed in 2 settings)	Milk is placed in a shallow bowl, and various food colourings are dropped onto the milk. A cotton bud is soaked in washing up liquid and then dipped into the areas of food colouring, which causes the colours to disperse away from the cotton bud.	Follow the educator's instructions Turn-taking
Planting seeds		Follow the educator's instructions Turn-taking
Making a volcano	Sand is moulded into the shape of a volcano. A mixture of baking soda and vinegar are used to represent the lava.	Follow the educator's instructions Turn-taking
Colour mixing and absorption	Mixing food colouring in water, placing a tissue into the water and observing the colour of the tissue.	Follow the educator's instructions Turn-taking
An experiment	Floating and sinking. A variety of objects are tested to see if they float or sink.	Follow the educator's instructions Predict-check (2 children) Turn-taking Observe
Magnets	A variety of objects are tested to see if they stick to a magnetic board.	Follow the educator's instructions Turn-taking Observe
(Category 3) A science experiment	A Mentos (mint sweet) is dropped into a bottle of Coca Cola, and the reaction is observed.	Observe
A science experiment	Tealights are placed into three different size jars, and the different rates of extinguishment are observed.	Observe
Magic	Water absorption using a sponge.	Observe & count

Importantly, engagement and exploration is only the beginning of scientific inquiry (Bybee et al., 2006). The challenge for the educator is to develop such explorations by guiding the children's interests and everyday experiences into further science learning. However, analysis of the data indicates that this development did not happen. There was no focus on scientific concepts or the skills of inquiry.

5.2.3: Pedagogy

To effectively support children's science learning, educators need knowledge and understanding of the scientific concepts and the process of inquiry (Worth, 2010), in other words, science-based pedagogical content knowledge (PCK). Educators will have different discipline-based pedagogical content knowledge, and so the approach used to support children's language learning will differ from that used to support science learning (Shulman, 1986). Many scholars suggest that inquiry-based learning is a very effective way for young children to learn about science. However, analysis of the observation and interview data suggests that educators do not have the requisite scientific knowledge and do not design activities to promote inquiry-based learning. The participants use a generic approach to pedagogy, as described by T3:

T3: *It's how you present everything not just science. To be honest I don't think that it needs to be presented any differently.*

Pedagogical strategies

The educators used a range of pedagogical strategies to support children's learning, including questioning, instructing and demonstrating. However, didactic interactions, where the educator controlled the process, dominated the execution of the strategies. Inciting wonder in children is regarded as an important element in the design of science activities (Hadzigeorgiou, 2001). However, care is needed that inciting wonder does not become the sole focus, with activities ending up as little more than magic show science (Gelman et al., 2010). All participants in this study were enthusiastic when introducing the activities, and this seemed to engender anticipation in the children.

However, as the following extract from a teacher-led science activity shows, invoking 'magic' to incite wonder was evident in one setting.

The science activity involved the transfer of water from one bowl to another using a sponge. T4 sits on the floor in front of a group of 18 children who are also sitting on the floor. She has a sponge and two bowls, one of which is filled with water.

T4: *Today, we are going to do magic. We are going to do magic with a sponge, two bowls and water. So, if we're going to do magic, what am I?*

David: *A magician.*

T4: *Watch this now guys. I'm going to lay the sponge. I'm going to press it down to fill it up with water. I'm going to make the water disappear out of this bowl, little by little and I'm going to put it into this bowl, and I'm not going to pour it.*

David: *I know you're going to squeeze it.*

T4: *Well, you are very clever. Watch now, watch the water going over, and did I pour it?*

Children: No!

Dora: *That's actually magic*

T4: *That's actually magic. That's probably my best trick*

Dylan: *That's not magic*

T4 *Watch this now Dylan and I'll convince you I'm a magician. I'll squeeze it again. Will we count how many times I have to fill the sponge?*

Children: Yes!

Children: One

The activity continues with the children watching and counting.

The focus of this activity started with 'magic' and then moved on to counting. Ultimately, these actions distracted from the scientific principle of absorption. T4 did not mention absorption, and indeed such was the focus on the magic that she did not explore Dylan's rational comment 'that's not magic'. Instead, T4 set about convincing Dylan that it was magic, and missed an ideal opportunity to explore and extend Dylan's working theory about absorption.

Questioning

According to Harlan and Rivkin (2014), educators' questions play a fundamental role in scientific inquiry learning and directly impact on the quality of that learning. Analysis of the observation data in the current study revealed that questioning was the most common pedagogical strategy used during science activities. All educators asked questions, and of the 96 questions coded during analysis only one was open-ended, which represent 1.04%. This finding is significantly lower than the 5.5% of open-ended questions reported by Siraj-Blatchford and Manni (2008) in their analysis of the REPEY data. In the context of preschool science activities the current study supports the findings of Günay Bilaloğlu et al. (2017) who report a disparity between the use of open and closed-ended questions of 10% versus 90%. The participants in the current study used closed-ended-questions as a form of assessment. They asked questions either to establish the children's existing knowledge or to assess whether they could recall the steps of the activity. In the first instance, where questions were used to elicit factual responses, some of these questions were quite complex and abstract, which often led on to abstract explanations by the educator as the following extract demonstrates.

Eight children are sitting at a table, and T1 is standing at the top of the table, she is holding a tablet computer. There are no resources on the table

T1:	*Do you remember there recently we had a big storm? Can anyone remember the name of it?*
Aidan:	*Storm Ophelia!*
T1	*Storm Ophelia, very good. And did anything happen during storm Ophelia?*
Anna:	*No (pause) I think some trees fell down.*

T1: They did, they got knocked down didn't they because the wind was very strong.

Anna: It blew down the oak tree with the swing on

T1: Oh, it blew down the oak tree with your swing on. Daddy will have to find another oak tree for a new swing. Now that was a big strong wind and there are lots of different kinds of winds. ***Does anyone know what kinds of winds there are?***

Anna: No

T1 No. Say if we went outside and there was a small little breeze that just ruffled your hair. That's only a small wind isn't it? But today we are going to do a really strong wind, look (holds up the tablet computer, which has a black and white image of a tornado on the screen). ***Does anyone know what this really strong wind could be?***

Aidan: No

Amy: A blizzard

T1: No it's not a blizzard. Alice ***do you know what it could be****?*

Alice: Snow

T1: No, it's not snow. It looks like snow because it's white, but it isn't it's wind. ***Does anyone know what that could be called****?*

Anna: No

T1: ***What does it look like? It looks like a whirlpool, doesn't it****?*

Anna: The wind is blowing down the trees

T1: It is a wind blowing down. It's called a tornado, and it's a really strong wind. And ***do you know how a tornado is made?***

(no response from the children)

*T1: Do you know warm air****?*** *Do you know when you go over to the radiator, and you can feel the heat?*

Aidan: Ya

T1: So, when the warm air goes up, it meets the cold air and makes a tornado. Lots of tornados are made during thunderstorms. What happens is they meet and begin to swirl around, and when they get really strong, and they swirl around *they come down and touch the ground, and when they touch the ground, it's called a tornado.*

In other instances, the educators' questions focused on more straightforward concepts that the children could relate to, as evidenced in the following extract from the 'Colour Mixing and Absorption' activity in S7. The second part of this extract also reveals one of the few instances observed when a child asked a question. During the activity, Glen was puzzled by the colour of the tissue and asked T7 about it. However, T7 did not provide an answer or suggest further investigation; instead, she reverted to asking Glen closed-ended questions aimed at recalling the steps of the process.

Two children were seated at the table. Each child had a glass jar on the table in front of them. The children poured water from a jug into their jar and added a few drops of yellow food colouring using a small pipette. Each child had a white tissue. T7 was sitting at one end of the table.

T7: *Ok now dip your tissue into the water.* ***What colour did you get****?*

Glen: *Yellow.*

T7: *Ok, so now let's add some of the other colour. (holds up the blue food colouring).* ***What did we call this colour****?*

Glen: *Blue*

The children proceed to add a few drops of the blue food colouring to the jar of yellow coloured water.

T7: ***What colour did you have before****? (T7 points to the part of the tissue with the yellow colour)*

Glen: *Yellow*

T7: *Yellow, and* ***what did you add into the yellow****?*

Gerry: *(looks into the jar which now contains green coloured water) Green*

T7: *No, you made green.* ***What did you add-in****?*

Glen: *(no response)*

Gerry: *Blue*

T7: *Blue, that's right.* ***So now if you put in a tissue see what colour you get?***

Glen: *(dips his tissue into the jar). Oh, I got green.*

Glen continues immersing and removing the tissue for a few minutes and then added some more water to the jar. He immersed the tissue again and lifted it out.

Glen: *It's kind of yellow! It's kind of yellowy now!' (turns and looks towards T7) 'it's yellowy now!*

T7: *(Retrieves a cloth from a shelf and attends to a water spillage).*

Glen: *(Spends the next three minutes squashing the tissue into the jar and lifting it out).*

Glen: *(Holds up the jar of green coloured water). The water is light green.*

T7: *Yes, it's light green.*

Glen immerses the tissue in the jar of water and lifts it out. He holds up the wet tissue, which is yellow.

Glen: *It turned yellow. (Looks at T7) '**How did it turn yellow?**'*

T7: *How does it turn yellow? (Points to Glen's jar) Who put the water in there?*

Glen: *I did.*

T7: *You did didn't you? And what else did you put into the jar?*

Glen: *Tissue.*

T7: *What colours did you put in?*

Glen: *Blue and yellow.*

T7: *What colour did it make?*

Glen: *Green.*

T7: *It did, didn't it.*

Glen pours the coloured water into another jar, looks at T7, stands up and walks away from the activity.

The only open-ended question revealed in the observation data was asked during an incidental science learning opportunity. This incident involved T5 and two children who had just found some snails in the garden. The following extract highlights the effectiveness of a single open-ended question in promoting children's thinking and reasoning, even when other closed-ended-questions surround it.

Evan and Eoin have found some snails in the garden. The snails are on top of a tree stump, which has a large hole in the middle. The children call T5 who comes over, kneels beside the children and looks at the snails.

Eoin:	*Look at the snails and the big hole.*
T5:	***How is he going to get across?*** *Could he jump across?*
Eoin:	*He can't he might just fall down there (pointing to the hole).*
T5:	*He might just crawl all the way down there.*
T5:	*Will we give him something to eat? We will try a little leaf to see if he would like that.*
Evan:	*They need a parachute.*
T5:	*They need a parachute, would they, to parachute over there?*
Evan:	*They need a bridge for crossing.*
T5:	*Oh you're going to build a bridge for crossing*
Evan:	*(places two leaves over the hole)*
Eoin:	*They might fall down the bridge.*
T5:	*Well, he's going to try.*
Evan:	*(places a snail on a leaf, and both fall into the hole)*
Eoin:	*It fell.*
T5:	*He's inside, but he's ok. He'll be able to crawl all the way back out.*

Despite the wind frequently blowing the leaves away, Evan continues building the leaf bridge for a further 5 minutes. He finally tests the construction by placing two snails on top of the leaves. The snails remain in situ, Evan then presses down on the snails, and they fall through the leaves.

T5: *(Laughs) Oh, you are unbelievable.*

T5 takes Evan by the hand, and they walk away.

This activity highlights how an open question can initiate science learning. Evan was engrossed by the problem posed by the hole in the tree stump. He started to engage in the process of scientific inquiry as he investigated the possibility of building a bridge made from leaves and tested out his ideas. This activity involves the first two steps in Bybee et al. 's. (2006) 5E (engage-explore-explain-elaborate-evaluate) model, unfortunately, the investigation ceases at this point. There is no attempt made to move from incidental to intentional science learning, such as, encouraging Evan to explain what happened, trying other possible solutions and reflecting on establishing his understanding.

Instructing

The pedagogical strategy of instructing involves the educator giving specific instructions which the children must follow. Most of the planned activities in Table 5.2., in particular those under category two, involved the educator instructing the children. These activities, for example, 'making a tornado' or 'planting seeds', require multiple steps to complete the activity. The educator gave specific instructions, which meant that the children had little autonomy in the process. All of the category two activities in Table 5.2. involve complex scientific concepts and contain multiple steps. While finishing the activity appears to be the ultimate goal for some educators, for others completing the steps within the activity are as important.

Demonstrating

The final pedagogical strategy observed was demonstrating, which involves the educator showing the children an activity. The use of demonstrating can be effective when used as one of a range of strategies (MacNaughton & Williams, 2009). Most participants used this strategy at some point during science activities. These instances ranged from showing the children how to perform a particular skill to demonstrating the complete activity. During the tornado activity, T1 demonstrated how to shake the bottle to create the tornado shape in the water. Whereas in the three activities listed under Category 3 in Table 5.2. (Coke and Mentos, Candles in a Jar, and the Magic

Experiment) the educators demonstrated the activity from start to finish, and the children's role was to observe. The following extract from the Coke and Mentos activity highlights the didactic approach taken by T5, and the passive role of the children. Further, it seems this activity was designed as a form of entertainment for the children, rather than science learning.

(T5 had just finished reading a story to the children)

T5: *Would you like to see something special?*

Children: *Yes (shout)*

T5: *Ok, everybody outside*

(T5, her assistant and the children go outside)

T5: *Ok, stand at the edge of the grass.*

(The assistant educator hands a large bottle of coke and a packet of Mentos mints to T5)

T5: *(Holds up the bottle)*
What is this?

Emma: *Coke*

T5: *How many of you drink coke?*

(Most of the children raise their hands)

T5: *Oh no. Coke is so bad for you and do you know what the dentist told me? It's one of the worst things you could have for your teeth.*

T5: *(Unscrews the bottle cap and places it on the ground).*
Ok, that's a bottle of coke and these are Mentos sweets, mints
(Holds up mints).
Are we ready?

(Some children have turned away from T5 and are looking at some wood blocks that are on the ground)

T5: *Everyone should be looking here*
(Points to bottle of Coke, and then takes a sweet out of the pack).
Everybody watching
(places the sweets into the bottle).

(Everyone watches the coke fizzing up and out of the bottle. The fizz extends about 5 cm above the bottle)

T5 & assistant: *Wow*

Children: *Woooaah*

T5: *It usually goes up more. I'll try it again with more Mentos*

T5: *(Opens a second bottle of coke, and adds in this several Mentos)*

T5: Watch everyone

(The coke fizzes up a little higher this time)

Children: *Woooaaah*

T5: *That was better. Did you enjoy that?*

Children: *Yes (shouted)*

T5: *Ok, everyone back inside. It is nearly home time*

(Everyone returns to the classroom)

In this section, the focus of the analysis was on the individual participants and the factors that influence their practices in science. The process of analysis identified three themes, *educators' lack of knowledge and training, curriculum, and pedagogy*. The findings and analysis indicate that there was a broad agreement among participants as to their lack of science content knowledge, the 'what' of science education. Few recognised their lack of science pedagogical knowledge, the 'how' of science teaching. All participants acknowledge the influence of *Aistear* on their provision of activities. This influence was evidenced through their belief in the importance of sensory exploration and play. Interestingly, there was limited evidence of children engaging in play-based science learning experiences. Although the provision of science learning activities was varied, there was a consistency in the pedagogical strategies used by all participants. The educators used instruction and demonstration to guide the children through the complex, multi-step activities where completion seemed to be the end goal. The children had limited autonomy to investigate or develop their working theories during these activities. Questioning was used most frequently as a form of assessing what the children know or could remember. Closed-ended questioning dominated, and when combined with the participants' commitment to exploration and discovery, the extent to which children are progressing their science learning is questionable.

The following discussion will examine the issues illuminated by the findings and analysis in light of the current literature, early childhood policy and ideology.

5.4: Discussion

Educators' lack of scientific knowledge and training

The types of learning opportunities educators provide for children are directly linked to their knowledge and understanding of science (Fleer, 2009b; Pendergast et al. 2017). The educators in this study had little awareness of appropriate pedagogical content knowledge (PCK) in early childhood science education. Appropriate in this sense means that the educators did not mediate the children’s science learning through focused educator-child interactions within inquiry-based activities that were framed around scientific concepts and linked to children’s everyday conceptual understanding (Cremin et al., 2015; Fleer, 2009b; Gelman et al., 2010). In addition, the activities were not presented in such a way as to provide a cognitive challenge that was within the children’s zone of proximal development (ZPD). Concepts were not introduced or explained. Indeed, the concept of change, which underpins several of the planned activities could have been introduced and developed through other activities such as freezing and melting, and cooking. Then, actvities such as making gloop or playdough, and adding the Mentos Mint to Cola could build on the children’s conceptual understanding of change.

The educators lack of knowledge and understanding links back to a lack of training, where educators should gain their "knowledge-*for*-practice" (Cochran-Smith and Lytle, 1999, p. 53). Only one participant received formal science training as part of her Montessori based early childhood education qualification. However, this training centred around activities such as making a volcano, and the solar system, all of which involve complex scientific concepts and are far removed from the children's everyday experiences. The educators' lack of training concurs with several studies reported in the literature. These studies conclude that many early childhood educator pre-service training programmes do not adequately prepare students to support children's science learning (for example see Campbell & Jobling, 2010; Greenfield et al., 2009; Park et al., 2016; Roehrig et al., 2011). While the particular studies quoted here took place in the United States, research from elsewhere including the UK (McGuigan & Russell, 2017) and New Zealand (Blaiklock, 2010; Hedges & Cullen, 2005), highlight the historical lack of focus on science content knowledge within the field of pre-service early childhood educator training.

It is important to consider the fact that many of the participants acknowledged their lack of science content knowledge, the 'what' of science teaching (Shulman, 1986). This finding indicates a level of self-awareness that was not apparent in Garbett's (2003) cohort who were unaware that they lacked such knowledge. More recent research by Zhang and Birdsall (2016) found that early childhood educators in their study did recognise their lack of science content knowledge. However, these educators reconciled that a focus on content knowledge would compromise children's exploration of their environment (Zhang and Birdsall, 2016). Saçkes (2014) presents an alternate view of the importance of science content knowledge. In a nationally representative study involving Kindergarten teachers in the U.S., Saçkes (2014) found that teachers' science subject knowledge predicts children's engagement with science. The consequence of my participant's lack of science subject knowledge training is that they have no frame of reference to gauge what is appropriate scientific conceptual knowledge or how to conduct scientific inquiry-based learning within an early childhood education context. The participants rely on children gaining science knowledge solely through experiential learning. They provide what they consider to be science experiences for the children, but these activities lack any purposeful framing around scientific concepts.

When confronted with 'doing science', the findings indicate that the participants' Piagetian beliefs inform the decisions they make about how children learn. They provide activities that involve exploration and discovery, as they believe this is how children learn. However, this exploration and discovery may simply involve the children engaging in some form of hands-on activities, such as pouring liquid or playing with playdough. There is little to suggest that the educators consider how the activities present a cognitive challenge for the children. Indeed, as the children appeared to be familiar with the hands-on element and performed the actions with ease, it is unlikely that a process of equilibration was triggered. The participants' role is that of a facilitator who provides the required resources and directs the activity. There was no evidence to suggest their beliefs reflect a Vygotskian sociocultural approach to science learning. For instance, although the educators in this study were in the role of a more knowledgeable other, they did not collaborate with the children to solve problems other than to ask closed questions that required a specific answer.

Early childhood educators' beliefs develop through many experiences, including professional training and development (Duran et al., 2009; Saçkes et al., 2012). As there is a Piagetian orientation to the beliefs held by all participants about how children learn, it is likely that they were formed during their training. In essence, it seems that the training institutions are providing early childhood education graduates who rely on Piaget's theory of learning and development to interpret *Aistear's* (NCCA, 2009) curriculum framework. I suggest that either the training institutions are privileging a Piagetian view, or the complexity of sociocultural theory and its application in early childhood education presents a significant barrier to student educators. Therefore, when the graduates go out into the real world of the workplace, they default to the less complex development leading learning, ages and stages Piagetian view. Educators' beliefs and their lack of knowledge and training in early childhood science also have implications for participants' pedagogical and curriculum practices.

Pedagogy

The pedagogical decisions educators make as they support children's learning reflect their beliefs about how children learn, their values, and the knowledge and skills attained during training and through experience (Alexander, 2008). Determined by Shulman (1986, 1987) as the 'how' of teaching, pedagogy forms an integral part of PCK. I have already established that the participants lack the 'C-K' element, science content knowledge. Their lack of training also extends to the 'P-K' element, pedagogical knowledge. Inquiry-based learning is currently regarded as an effective pedagogical approach for science in early childhood education (Cremin et al., 2015; Gelman et al., 2010; Harlen, 2013). However, the educators in this study received no such pedagogical training. In their interviews, most participants did not identify a need for training on 'how' to teach science. According to T3, she presents science in the same way as everything else. In addition, the educators' belief in children learning solely through exploration and discovery transcends all subject areas. When they see children exploring the prepared science activity materials, it is reasonable to assume that the educators believe the children are learning. Furthermore, by privileging the provision of resources, the educator effectively assigns the resources to act as mediators for science learning (Fleer, 2009a). Therefore, from the educator's perspective, a need for training on the 'how' of science teaching does not arise.

Although the participants in my study used various pedagogical strategies, there was a tension between their beliefs in exploration and discovery learning and their practices. Throughout the planned activities, the educators assumed direct control of the process, and didactic interactions dominated the pedagogical practices. This tension between participants' beliefs and practices draws attention to the challenge educators face when presenting children with complex scientific concepts and providing explanations that children will understand. Yet, Bruner (1960) posits that much time is wasted by delaying the introduction of subject content to young children because it is too difficult. He contends, "that any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (p.33). Indeed, by linking Bruner's concept of an intellectually honest form with a sociocultural approach, the basic ideas of science can be presented in a way that the young child can comprehend, within their zone of proximal development, and with support from the educator. The child will gain a level of knowledge that although partial and emergent in the first instance, can be progressed through engaging in science-based inquiry learning. Indeed, much of the contemporary literature promotes such an approach, contending that the 'big' (basic) ideas of science should underpin activities (Gelman et al., 2010; Harlan and Rivkin, 2014; Harlen, 2010). Importantly, however, the findings also suggest that participants' may have implicit assumptions about the capability of children to engage in science activities beyond physical exploration. The big ideas of science and inquiry-based learning did not feature in the activities. Nevertheless, educators did use various pedagogical strategies throughout science activities.

Inciting wonder is deemed to be important for children as it motivates them to learn science (Hadzigeorgiou, 2001). However, one participant attempted to achieve this by presenting science as magic. During this visually appealing and entertaining activity, the educator did not mention the science concept of absorption, focussing instead on counting. Counting is an everyday activity in the early childhood setting and is a more tangible concept than absorption. Therefore, although the activity was presented as science, in reality, this was not the case. This activity exemplifies “magic show science” (Gelman et al., 2010, p. 26) and raises two important issues. Firstly, the educator did not critically evaluate the intellectual content of this activity for children, which highlights the influence of developmental theory on curriculum and pedagogy (Hatch, 2020). Secondly, educators who lack science knowledge are likely to find it very challenging to introduce the concept of absorption in an intellectually honest way.

Questioning is one of the most important strategies that an educator can employ with children for developing their understanding and inquiry skills (Harlen & Qualter, 2014). However, it is the type of questions the educator uses that will determine their efficacy. Open questions are linked to sustained shared thinking and can stimulate creative thinking, reasoning and problem-solving (Harlan & Rivkin, 2014; McNerney, Carritt, Dealey, & Ladbury, 2020; Siraj-Blatchford & Manni, 2008). In contrast, closed-ended questions are limited in this sense, although they can be used to direct thought and recall facts. Of the 96 questions asked by the participants in my study only 1 was open-ended, which represent 1.04% of the total questions. Although the REPEY study (Siraj-Blatchford et al., 2002) did not focus on science activities, it is interesting to note that my findings indicate a lower percentage of open-questions than the low level (5.5%) found by Siraj-Blatchford & Manni (2008) in their analysis of the REPEY data. The participants in my study used closed-ended questions for one of two purposes. To elicit a specific answer, or to establish what the children already know. While there is limited research available on educators’ use of questioning during preschool science activities, my findings support those of Günay Bilaloğlu et al. (2017), who also found that the dominant use of closed-questions. However, they found that 10% of their educators’ questions were open-ended, which is significantly higher than the 1.04% found in my study.

The participants in my study interpret science as a body of knowledge and do not consider the tentative and changeable nature of science and when combined with their lack of training, this may explain the predominant use of closed-ended questions. Furthermore, the use of such question types also has implications for children's learning as they either confirm or refute their working theories, but do little to stimulate further investigation.

The participants’ use of quite complex and abstract closed-ended questions provided further evidence of their lack of PCK. These questions usually proved too challenging for the children. For example, T1's question about how a tornado is made was met with silence from the children. In line with the findings of Günay Bilaloğlu et al (2017), the participants in my study also seem to appreciate the importance of questioning yet the quality of their questions receives little consideration. Furthermore, the participants' responses to children's answers also influenced the effectiveness of the strategy. In most cases, the responses were as Alexander (2008) suggests, 'pointless', as the educators merely repeated the given answer.

In contrast, open questions can provide the opportunity for sustained shared thinking and challenge children to test and develop their theories through scientific reasoning. However, the mere asking of an open question is not to imply that the conditions for effective science learning are in place. The educator must also take an active role in supporting learning (Lazonder & Harmsen, 2016). Furthermore, the use of a pedagogical strategy such as open-ended questions is underpinned by the educator’s philosophical beliefs about how children learn, as the single example within this study exemplifies. T5's posing of a 'how' question initiated inquiry learning by Evan as he engaged in the task of exploring how to make a bridge out of leaves. However, the process ended after the exploration stage, and there was no encouragement for Evan to further his inquiry, whereby he could explain, elaborate, or evaluate the leaf bridge. Furthermore, this example highlights that posing an open-ended question does not always promote sustained shared thinking and can be challenging for educators (McNerney et al., 2020; Siraj-Blatchford et al., 2002).

Two other strategies, instructing and demonstrating, were also dominant during formal sciencing. These two didactic strategies position the educator as the expert who leads and shapes the action and dialogue during the activity (Fisher, 2007; MacNaughton & Williams, 2009). All of the activities listed in Table 5.2. under category two (children following the educator's step-by-step instructions and category three (educator-led activities with no significant involvement by the children), involved either instruction or demonstration. Most of these complex activities involved multiple steps, and the children's opportunity to participate when following instructions merely included actions such as pouring liquid, using a pipette or adding an ingredient into a mixture.

In the demonstrated activities, the children's involvement was limited to that of a passive observer. Indeed, relying on instruction and demonstration meant that there was little room for the children to experiment or innovate. However, using such strategies is perhaps understandable in light of the participants' objectives and their lack of science-based PCK. As T8 points out, she wants to complete the activity so that the children could see a result. Assigning the children to follow specific instructions or to watch a demonstration ensured the achievement of a result. For instance, when T5 put the Mentos mint into the bottle of Coke, the children saw the fizz of liquid and bubbles; when T3 placed the lids on the jars, the children saw the candles extinguish. All visually appealing, but with minimal science learning. At no stage did the educators attempt to explain what was happening, or indeed, gauge the children's understanding. Demonstration and instruction can be useful in early childhood education when used in tandem with other pedagogical strategies (MacNaughton and Williams, 2009). However, in this study, they were the sole strategy used in several activities. Furthermore, demonstrating and instructing were used by the educators to ensure the completion of the activity so that the children could see a result.

Overall, the implementation of pedagogical strategies in this study reflects a lack of understanding of PCK in early childhood science education. There was no evidence of educators' mediating children's learning through using an inquiry-based approach within the activities. Indeed, the various methods adopted by the educators led to the children experiencing the materials in a physical rather than conceptual way. Furthermore, Fleer (2009b) suggests that unless scientific concepts underpin activities, children's thinking will remain in what Vygotsky termed 'unorganised heaps' at the everyday conceptual level. The progression to a scientific conceptual level of thinking is unlikely to happen if educators have little understanding of the dialectical process involved (Fleer, 2009b). The situation is further compounded if the educator has little understanding of science-based PCK. The direct control over the progression of the activities assumed by all participants presents a contradiction to their strongly held beliefs about the importance of exploration and discovery in children's learning. In essence, the educators took centre-stage in the activity, and the children were passive assistants. The children were not presented with science activities in an intellectually honest form that reflects their capability to engage with the basic ideas of science in a meaningful way. Furthermore, the high level of control and the didactic nature of the educators' interactions with the children may, in effect, present a barrier to learning as they leave little or no scope for children to develop their working theories. Indeed, Hedges (2012) suggests that as well as developing children's everyday conceptual knowledge, working theories also provide a potential mediating link between children's everyday and scientific conceptual knowledge.

So far, this discussion has highlighted the considerable impact of the educators' lack of training in science-based PCK, and indeed the following section will raise further issues regarding the content of science activities.

Curriculum: The influence of Aistear

Government policy in Ireland mandates adherence to *Aistear* (NCCA, 2009) for those educators working with children aged from 3 to 5 years, and the findings suggest all educators acknowledge the influence of this policy on their practice. *Aistear* uses a non-prescriptive approach to curriculum and therefore does not specify the type of conceptual knowledge that is appropriate for children, or indeed educators. This approach to curriculum means that effective implementation of *Aistear* is highly dependent on educators' theoretical, content and professional knowledge. However, as already suggested, the participants in this study lack science knowledge and training. This lack of knowledge exists at a time when there is a consensus in the literature that the most effective way for children to develop their scientific skills and concepts is with the support of a knowledgeable educator (Fleer, 2009b; Fleer et al., 2014; Gelman et al., 2010; Harlan & Rivkin, 2014; Stylianidou et al., 2018). However, without science-based PCK, the provision of effective support becomes an almost impossible task. From a policy perspective, it is reasonable to assume the absence of specifying conceptual knowledge in *Aistear* was a conscious act on behalf of the authors. To understand why this stance was adopted, I will briefly consider the era during which the development of *Aistear* took place, the early to mid-2000s.

In 2001, Bowman and colleagues published an authoritative work on curriculum and pedagogy in US-based early childhood education. Their findings state, "children who have a broad base of experiences in domain-specific knowledge (for example, in mathematics or an area of science) move more rapidly in acquiring more complex skills" (Bowman, Donovan, & Burns, 2001, p. 8). Providing children with opportunities to engage with subject content knowledge was seen as positive for young children as they have a natural motivation to learn, experiment and explore. However, from the latter part of the 1990s onwards, concerns were raised about how the links between preschool and primary school impact on early childhood education curricula and pedagogy (Nutbrown, 1999). The potential inclusion of curriculum subjects in early childhood education caused much concern. Indeed, Bowman et al. (2001) noted that in preparing children for school, the preschool should not adopt "the methods and curriculum of the elementary school" (p.8). On an international front, the Organization for Economic Cooperation and Development (OECD) (2001) echoed these views in their cross-national thematic review of early childhood education and care. In their final report (OECD, 2006), they introduce the term 'schoolification' to describe the downward pressure on early childhood education to mirror primary school practices.

The term 'schoolification' has become synonymous with a negatively held view that the primary purpose of early childhood education is to get children ready for school. As Moss (2008) points out, school readiness presumes that children must meet specific standards before they can enter primary school, and therefore, it is the role of early childhood education to deliver such children. Countries, such as the UK, who have adopted a standards-based approach have also introduced baseline assessment of children as they enter the primary school system (Brogaard Clausen, 2015). This move has received strong criticism in the literature. Indeed, Bradbury (2019) suggests that schoolification and datafication are two sides of the same coin, and have ultimately led to children being 'datafied at four' when they are deemed to either fit into the norm or deviate from it. The negative connotations associated with schoolification or school readiness remain in the field of early childhood education and care today. According to Brooks and Murray (2018), a schoolification or school readiness approach privileges a prescribed curriculum and a focus on academic skills development to the cost of a child-centred curriculum and pedagogy. Indeed, Ring and O'Sullivan (2018) leave the reader in little doubt as to their views when they refer to the 'schoolification epidemic'. However, less frequently heard are opinions such as those voiced by Bennett (2005) who, although advising against an undue focus on academic goals, also cautions against an "excessive suspicion of 'schoolification' and reluctance to orient children toward learning goals that are valued by parents, schools and society" (p.14). Indeed, these emotive discussions about schoolification may well be masking the need for critical debate about early childhood curriculum content and the types of pedagogies that contemporary literature suggests are most effective for supporting science learning.

As the development of *Aistear* took place in this climate of concern over schoolification and school readiness, it is not surprising that in Ireland the NCCA was drawn towards the New Zealand curriculum framework *Te Whāriki* (Ministry of Education (MoE), 1996). *Te Whāriki* offers a broad, multi-theoretical, non-prescriptive framework which focuses on the holistic development of the child, and does not mention subject content knowledge. The NCCA adopted these principles and incorporated them into *Aistear*. It must be acknowledged that subject content could be interwoven across *Aistear's* themes, aims and learning goals to reflect the integrated nature of children's learning. However, my study shows that from a science perspective, holistic learning is foreground in activities while science content knowledge barely features. A significantly revised version of *Te Whāriki* was published in 2017; however, Aistear remains in its original form.

Prior to its revision, *Te Whāriki* (MoE, 1996) was critiqued for its lack of attention to subject content knowledge (Blaiklock, 2010; Hedges and Cullen, 2005). In their New Zealand based study of teachers', parents' and children's curriculum and pedagogy beliefs and practices, Hedges and Cullen (2005) conclude that "a curriculum's lack of emphasis on subject content knowledge may limit learning and teaching opportunities including children's inquiry-based learning" (p. 75). A superficial level of knowledge is not sufficient, as Hedges and Cullen (2005) point out, teachers need sufficient subject knowledge in order to provide children with meaningful interest-based activities and to guide their inquiries further.

Furthermore, in a report based on ten years of national evaluations on the education and care of children in early childhood settings, the New Zealand based Education Review Office state:

> We have consistently found that when teachers have good subject and pedagogical knowledge they can show greater intentionality in the approach they take to teaching and learning; and through doing so, respond meaningfully to children's learning experiences.
> (Education Review Office, 2016, p. 26)

The revised version of *Te Whāriki* (MoE, 2017) remains a non-prescriptive, holistic and integrated curriculum, which provides little guidance for teachers about integrating subject knowledge within interactions and activities that are based on children's interests. Therefore, the assertions of Blaiklock (2010) and Hedges and Cullen (2005) that teacher education programmes need to ensure that their graduates have sufficient PCK to support children's learning effectively remain relevant today. Indeed, if one considers the propensity of graduates to rely on their Piagetian view of learning and combine this with their lack of training, it shines a dim light on the training institutions who do not provide their students with the requisite knowledge, skills and competencies associated with science-based PCK.

Schoolification remains a dominant narrative, and it is eclipsing important questions such as what and whose knowledges are valued in early childhood provision. Although there is a policy emphasis on equity of access and provision in many early childhood systems, denying or not providing children with access to important forms of knowledge can be seen as inequitable. Within this context, curriculum content remains a contentious issue, and of particular relevance to the current study is the extent to which young children can and should engage with scientific concepts and inquiry skills. It seems that the shadow cast by the schoolification narrative surrounding pedagogy and curriculum has led to a failure to engage with what contemporary research tells us about young children and their capabilities to engage in science-based learning. Noteworthy among this research is Fleer's work on interpreting Vygotsky's theory of conceptual development. Through exploring the dialectical relationship between everyday and scientific concepts, Fleer illuminates how, with support from a knowledgeable educator, children can develop their scientific conceptual understanding through playful inquiries (Fleer, 2009a, 2009b; Fleer et al., 2014). The knowledgeable educator in such instances will focus attention on developing children's scientific conceptual understanding, rather than on resource provision (Fleer, 2009b; Hatch, 2010, 2020). In other work, Fleer and colleagues note that the role of the more knowledgeable other is not limited to the educator. Their research which adopts a cultural-historical perspective investigates how peers and families can also support children's scientific conceptual development (Fragkiadaki, Fleer, & Ravanis, 2019; Hao & Fleer, 2017).

Furthermore, Helen Hedges provides other important contemporary research on the development of children's conceptual understanding through her research on children's working theories (Hedges, 2011, 2012, 2014; Hedges & Cooper, 2014). The concept of working theories provides the educator with a means for understanding children's science learning. Throughout their inquiries, children develop and refine their working theories as they strive to make connections between prior and new experiences. Hedges (2012) provides the early childhood education field with further insights into Vygotsky's theory of how children develop their conceptual understanding, suggesting that children utilise their working theories as a mediating mechanism to connect their everyday understandings and scientific knowledge. Importantly, Hedges (2012) stresses that while educators need to understand the concept of working theories and be able to recognise them in practice, to lead learning effectively, they must also have relevant pedagogical content knowledge (PCK). In relation to the current study, *Aistear* provides little guidance for educators on how to recognise and support children's developing working theories.

Interestingly, the original *Te Whāriki* (MoE, 1996) had two main overarching learning outcomes: dispositions and working theories. However, Hedges and Jones (2012) point out, the notion of dispositions has received far greater attention from researchers and teachers than its 'neglected sibling' working theories. In the revised version of *Te Whāriki* (MoE, 2017), working theories and dispositions remain as the key educational learning outcomes for children; however, their interwoven relationship is now highlighted. The commitment to working theories in *Te Whāriki* is further evidenced by its inclusion as one of the 20 learning outcomes.

Curriculum objectives

Aistear's broad definition of curriculum focuses on children's experiences and the environment. As a curriculum framework, *Aistear* should act as a guide to educators when developing their curriculum. However, in this study, no in-house curriculum documents were available in any setting. Although *Síolta: The National Early Childhood Quality Framework* (CECDE, 2006) states: "The curriculum or programme of activities is documented and the documentation is available and in use" (p.54), no such guidance appears in *Aistear*. While early childhood settings who avail of government funding for the free preschool year are required to adhere to the principles of *Síolta,* early childhood educators have received little or no training on the quality framework, and as a consequence, the above statement appears to hold little weight. Nevertheless, *Siolta's* commitment to a 'programme of activities' seems to endorse the participants' approach to curriculum.

Despite not having an in-house curriculum document, the participants consider their curriculum objectives in terms of activities based on the interests of the children. *Aistear* actively promotes this child-centred approach with approximately 73 references to the child's interests. While basing science activities on the interests of the child is a good starting point, the integration of these everyday concepts with scientific concepts is needed to develop children's scientific understanding (Fleer, 2009b; Gelman et al., 2010; Siry and Kremer, 2011). Therefore, how educators interpret *Aistear*'s child-centred ideology is important. As previously mentioned, *Aistear* is a multi-theoretical framework. It incorporates both Piagetian and Vygotskian perspectives, and there is an assumption that educators have the theoretical knowledge and understanding to meld these perspectives and create a meaningful curriculum. The educators in this study interpret *Aistear's* child-centred ideology through a Piagetian lens and do not seem to consider Vygotsky's sociocultural approach. An appreciation for the role that family and community can play in children's science learning was not evident among the participants in my study. Instead, they developed a curriculum of activities based on what they observed children doing and saying within the setting. There was little to suggest that when interpreting the children’s interests, the participants included their family or community-based funds of knowledge.

Children’s funds of knowledge are important when considering what and whose knowledge is valued in early childhood provision. Research by Hedges et al. (2011) suggests that as interactions with families and communities stimulate children's interests, the notion of a curriculum emerging solely from children's play within the early childhood environment provides a superficial interpretation of children's interests. Instead, they advocate that using funds of knowledge as a theoretical framework provides educators with a more analytical way to assess children's interests (Hedges et al., 2011). It can be argued that such an approach adds depth to the interpretation of children's interests and should lead to the provision of a more meaningful curriculum for children.

From an Irish policy perspective, the phrase 'funds of knowledge' does not appear in either *Aistear* or *Síolta*. There are broad guidelines on supporting children's learning through partnership with parents in *Aistear*. However, most of the suggestions are for the educator to share information with parents about the setting's curriculum and what they consider to be the child's interests based on their observations. Educators are encouraged to ask parents for information on what interests their child at home and how their culture and traditions might be useful in supporting the child's learning and development (NCCA, 2009). However, there is little guidance on how the educator can use such information to develop a curriculum that emerges from the children's funds of knowledge-based interests.

Curriculum content

The preschool environment affords a myriad of science learning opportunities. In this study, these opportunities were divided into informal (child-led), incidental (unplanned interactions between the educator and children) and formal (teacher-led) sciencing (Tu, 2006). It is within these opportunities that the science curriculum content is revealed. The picture formed by this study concerning the science curriculum is one of missed opportunities. The overarching finding from the informal and incidental sciencing opportunities is that although they exist in the early childhood environment, educators did not avail of them to any significant extent in terms of scientific skills, knowledge and concepts. Educators seem to lack awareness of how to use these everyday opportunities to develop scientific understanding. This lack of awareness may have influenced the children as well, as they also had limited engagement in informal or incidental sciencing. Furthermore, while open-ended activities such as the sand or magnetic shapes offer children opportunities for exploration, it is unlikely that their conceptual understanding will develop through discovery learning without some input from the educator (Fleer et al., 2014).

Missed opportunities for science learning also occurred throughout the formal sciencing, where the children's role was either to sensorially explore materials, follow step by step instructions, or simply to observe the educator. Some of the formal activities are sourced from the internet, while others are commonly regarded as preschool science staples. Although children enjoy these activities, it appears that educators do not evaluate their quality in terms of their opportunities for conceptual or scientific inquiry-based learning. Moreover, complex scientific concepts underpin many of these planned activities. For instance, floating and sinking involve buoyancy, displacement, density and volume. Concepts which Roychoudhury (2014) points out that secondary and sometimes tertiary level students often struggle to understand. Educators' lack of knowledge and training and the lack of guidance in *Aistear* lies at the heart of these missed opportunities. All of these factors result in these educators relying on their belief in the primacy of physical experiences in children's learning as a frame of reference for evaluating the appropriateness of science activities. It is, therefore, understandable that the activities are selected based on their affordance for hands-on exploration and discovery learning, rather than intentional science learning.

5.5: Chapter Summary

This chapter aimed to present and discuss the findings in light of the second research question: *What factors influence how these educators practice science education?* Importantly, the findings were considered and discussed within the context of relevant research and literature. What is clearly evident from the findings is that there are multiple, interconnected factors that influence educators' provision of science learning experiences. One of the first factors to be discussed was the educators' lack of scientific knowledge and training. All participants have little awareness of what contemporary research suggests is appropriate science-based PCK, they do not frame the activities around scientific concepts, or indeed scientific inquiry. Furthermore, there is limited evidence of the participants' devising activities that provide a cognitive challenge within the children's zone of proximal development. The primary reason for the participant's lack of science-based PCK is that the participants received little or no pre-service or in-service training. This dearth of scientific training is not limited to the Irish context and has been highlighted in several other jurisdictions. Nevertheless, just because a lack of training was found elsewhere, does not detract from the significant impact it had across every dimension of this study. Questions must be raised about how training institutions are preparing student-educators in relation to their understandings about how children learn and their science-based content and pedagogical knowledge.

The Piagetian orientation of participants' beliefs about how children learn as described in Chapter 4, significantly influences their decision making around the provision of science activities, and their perceptions about the role of children. The participants focus on activities that facilitate exploration and discovery. However, the children's role in these activities, at best, involves hands-on exploration of materials, and at worst, involves passive observation. The participants' role is that of a facilitator who provides the resources and directs the activity. Although the participants were the more knowledgeable other, there was no evidence of a Vygotskian sociocultural approach to science learning. There was no collaboration with children to co-construct knowledge. The dominance of Piagetian views about children's learning among these participants suggests that the training institutions either privilege Piaget's theory, or the complexity of sociocultural theory, and its application, leads educators to default to the less complicated development leading learning, ages and stages Piagetian approach.

Tensions were evident between the participants' beliefs in exploration and discovery learning and their practices. During the planned activities, the participants assumed control of the process, and didactic interactions dominated. This tension highlights the difficulties educators face when challenged with presenting complex scientific concepts along with appropriate explanations to young children. Indeed, one participant resorted to presenting an absorption activity as a magic show, with no reference made to the scientific concept, and no attempt made at an explanation.

The pedagogical approach adopted by the participants does not reflect what contemporary literature suggests is most effective. No inquiry-based learning was initiated or encouraged during the activities. There was no evidence to suggest that the participants appreciate that science learning involves a dialectical relationship between children's everyday and scientific conceptual knowledge. Strategies that apply within an inquiry approach, such as questioning, were used albeit in a predominantly closed-ended way, thereby inhibiting inquiry-based learning. Although one example of open-ended questioning was observed it did not promote sustained shared thinking between the educator and child. Thus the lack of questioning limited the potential of sustained shared thinking to direct children’s attention towards concepts or curriculum goals. Other strategies used, including instructing and demonstrating, evidenced the tensions between participants' beliefs in exploration and discovery and their didactic practices. The planned activities were not presented in an intellectually honest way and provided children with little scope to develop and refine their working theories. The findings also suggest that although the participants base activities on the children's interests, they do not consider the children's funds of knowledge when interpreting what those interests might be. Indeed, *Aistear* provides little guidance for educators on supporting children's developing working theories or how to integrate a funds of knowledge approach into curriculum development.

All participants acknowledge the influence of *Aistear* on their practice. However, the findings highlight that, despite what contemporary literature tells us about the importance of underpinning activities with scientific concepts, and children's capacity to learn science, scientific conceptual knowledge remains elusive in Aistear. Tensions are apparent between what contemporary literature advises regarding science content knowledge and the absence of any reference to such knowledge in *Aistear*. The advent of the school readiness debate and the associated fear of schoolification propagated during the time of *Aistear's* development are likely to have influenced the NCCA's (2009) decisions. It should be noted that curriculum policy in other countries such as *Te Whāriki* in New Zealand has been similarly criticised.

I will reflect more fully on the issues raised in this discussion and their implications to the field of early childhood education in the final chapter.

Chapter 6: Conclusion

6.1: Introduction

According to Duschl et al. (2007), science can be described as both a body of knowledge that represents current understanding and the processes used to generate that knowledge. The aim of this study was to investigate the factors that influence the provision of science learning experiences in early childhood education. As educators are tasked with providing these experiences for young children, their perceptions and practices were considered as an appropriate medium through which to explore this phenomenon. The following two research questions were posed:

- What perceptions do a group of educators who work with children aged from 3 to 5 years have about science in early childhood education?

- What factors influence how these educators practice science?

A multi-site, qualitative case study involving both video observations of practice and semi-structured interviews with eight early childhood educators generated the data for this research project. Thematic analysis of the data revealed a number of interrelated factors that influence educators' perceptions and practices in science education. These factors include educators' philosophical beliefs about children, a lack of science-based pedagogical content knowledge (PCK) and training, and a lack of guidance around subject content and pedagogy within *Aistear: The Early Childhood Curriculum Framework* (NCCA, 2009).

I will begin this chapter by presenting a summary of the findings presented in this thesis. The research project's contribution to knowledge, its limitations and some potential areas for further research will then be discussed. The chapter will conclude with a final reflection on this research project’s findings and the participants who gave so generously of their time during this study.

6.2: Summary of Findings

The first aim of this study was to understand what perceptions educators have about science in early childhood education. The investigation began by exploring educators' understanding of what science is; my analysis found that they had little appreciation for the tentative nature of science, which is consistent with other studies. Instead, these educators consider preschool science as a way of exploring the world to discover new knowledge. Although contemporary literature promotes the role of scientific investigation in developing children's conceptual knowledge, this was not considered by the participants. In practice, the provision of exploration and discovery learning experiences was limited to activities involving sensory manipulation and exploration of materials with minimal cognitive challenge. Such practices indicate that these educators are more interested in what the children are doing rather than what they are thinking (Gelman et al., 2010).

A second related finding is that educators perceive early childhood science education as a medium for promoting holistic learning, with a focus on social skills, literacy and numeracy. I argued that this focus is in line with much of Irish policy, which privileges literacy and numeracy, and gives limited attention to scientific knowledge and skills (DES, 2017a; NCCA, 2009) . The exception being the *STEM in Irish Education Policy Statement 2017-2026* (DES, 2017b), which recognises that the foundations for STEM subjects begin in early childhood. Disappointingly, this policy does not mention the role of scientific investigation in developing preschool children's scientific conceptual knowledge and instead perpetuates the view that their learning occurs solely through exploration and discovery. Nevertheless, no participant had heard of this policy, which raises questions about dissemination which are beyond the scope of my research study.

A key finding in this study relates to the participants' beliefs about science in early childhood education. These beliefs reflect the various characteristics identified in Nespor's (1987) study, with a principle belief based on their existential presumptions about how children learn. All educators believe that children are solitary learners who construct their science knowledge through physically manipulating their environment.

These beliefs reflect a Piagetian orientation and can be described as a central belief (Pajares, 1992), one that is so profoundly embedded it is not easily changed (Rokeach, 1968). They also reflect a limited understanding of Piagetian theory in the sense that the participants do not seem to consider the role of equilibration, and its influence on the type of learning activities that could trigger this mechanism. Moreover, these beliefs explain why the participants view their role in early childhood science education as that of a guide and facilitator who provides resources for children to engage in discovery and exploration (Hatch, 2010). In such instances, it is the resources rather than the educator that are considered to mediate children's learning (Fleer, 2009a). How the participants' perceive science in early childhood education, including its place in the curriculum, and the roles they and the children play, was strongly influenced by their beliefs about children and how they learn and will be further discussed below. These findings align with Pajares' (1992) assertions about the links between beliefs and perceptions, and their influence on practice.

Participants also hold beliefs about the importance of fun and entertainment in young children’s science education. As most participants had quite negative experiences of science during their education, I posited that the desire to create their idealised version of science education for the children, reveals the alternativity feature of beliefs as described by Nespor (1987). Furthermore, I argued that prioritising fun and entertainment in activities, with little mention of scientific content or investigation, indicates that the educators may hold certain assumptions about preschool children's capacity to learn about science. Once again, Piaget's (1950) influence is evident as these assumptions reflect his ages and stages theory of development and learning.

The participants were found to have positive attitudes towards science and were confident in their ability to teach it. Interestingly, their lack of scientific knowledge did not impact their positivity and confidence. This finding contrasts with other studies which indicate that educators who lack scientific knowledge tend to have a negative attitude towards science, lack confidence to teach it, and in many cases avoid doing science (Bell & St.Clair, 2015; Edwards & Loveridge, 2011). I argued that a likely reason for my research participants' positivity and confidence relates to their limited interpretation of early childhood science education and their beliefs about how children learn. In essence, when the participants provide children with resources to facilitate learning through exploration and discovery, they experience performance accomplishment (Bandura, 1977). I also argued that such practices do not really support children's science learning as they present limited cognitive challenge. Instead, they are facilitating the children's engagement in generic approaches to learning such as play, exploration and discovery, all of which reflect a somewhat limited early childhood education ideology.

The second aim of this study was to understand the practices of educators; in other words, their provision of science learning experiences, and what factors influence those practices. Although the participants perceive science as being all around us, it takes a highly trained and knowledgeable educator to support children's science learning effectively. My analysis showed that the science learning activities provided by the educators lacked purposeful framing around scientific concepts, and the focus did not extend beyond exploration and discovery experiences. A critical influencing factor was that these educators stated that they received little or no training in science. As a consequence they lacked an understanding of science-based pedagogical content knowledge (PCK). The paucity in science training for early childhood educators identified here is not limited to Ireland and is well documented in other countries (Blaiklock, 2010; Park et al., 2016).

The findings show that the lack of training in early childhood science-based PCK places these educators in a difficult position. Although the early childhood environment provides many opportunities for children to engage in both informal and incidental or spontaneous science learning there was limited evidence of this occurring. Despite the abundance of opportunities for science learning, educators did not use them to develop the children's learning in terms of scientific knowledge, skills and concepts. The prevalence of missed opportunities raises questions about whether these educators can possibly progress children's science learning. The educators do not consider where the children are currently positioned in their science learning. On a more theoretical front, the educators had little appreciation for the dialectical relationship between children's everyday and scientific conceptual knowledge. I argued that as the activities are not provided with this relationship in mind, they fail to give the children opportunities to develop and refine their science-based working theories. Importantly in Ireland, *Aistear: The Early Childhood Curriculum Framework*

(NCCA, 2009) does not guide educators on how to support the development of children's working theories.

Furthermore, this study found that the pedagogical approaches used during science activities do not reflect what current literature suggests are the most effective practices, namely, scientific inquiry-based learning mediated by a knowledgeable educator (Lazonder & Harmsen, 2016; Rossi et al., 2014). There was no evidence to suggest that the educators consider, or are even aware of how to adopt an inquiry-based pedagogical approach through which the children can progress and develop their working theories. While several pedagogical strategies were used, questions and demonstrating were most dominant. The study found that educators' use of questioning as a strategy was limited, and provided no scope for scientific reasoning or sustained shared thinking between the educators and children. The planned science activities were educator-led and didactic interactions dominated.

Ultimately, when the participants 'do science', they rely on their limited Piagetian-based interpretation of development and learning and provide activities for sensory manipulation and exploration. These activities present limited cognitive challenge that is unlikely to trigger equilibration. The activities also encourage the children to engage with the materials as individuals. There is little evidence of sociocultural practice where educators mediate inquiry-based learning or indeed collaborate with children to co-construct knowledge. Instead, the educators believe that children are solitary learners, and the resources will act to mediate their discovery-based learning. I argued that the evidence from this research strongly indicates that further and higher education institutions are training educators who seem unwilling or unable to move beyond a Piagetian oriented interpretation of *Aistear* (NCCA, 2009). I suggested two possible explanations. Either the training institutions privilege Piaget's theory, or due to the complexity of sociocultural theory, student-educators default to their limited Piagetian-based understandings when they graduate into the workplace. Either way, a dominant approach remains, and therefore I also argued that the training institutions must be held to account. They have a role to play in ensuring that their graduates have sufficient understanding of the various theories of how children learn and science-based PCK so that they can effectively support young children's science learning. Indeed, contemporary theories of learning, such as recognising and supporting children's developing working theories might usefully inform future iterations of *Aistear* (NCCA, 2009).

A final key finding relates to the far-reaching influence of *Aistear* on how educators support children's science learning. *Aistear's* non-prescriptive format contains no subject content or specific pedagogical guidance. Therefore, its implementation is dependent on educators' theoretical, content and pedagogical knowledge. However, as the educators in this study lack science-based PCK, their capacity to effectively support children's science learning is compromised. Tensions are apparent between what contemporary literature advises regarding scientific content knowledge and the absence of any reference to such knowledge in *Aistear*. Indeed, I argued that the advent of the school readiness debate and the associated fear of schoolification, propagated within the literature during the time of *Aistear's* development, were likely to have influenced the NCCA's (2009) decision not to include subject content knowledge. Indeed, the lack of guidance around subject content knowledge within other nations curriculum policy such as *Te Whāriki* in New Zealand has been similarly criticised (Blaiklock, 2010; Hedges & Cullen, 2005).

Additionally, I maintained that an unintended consequence of the decision not to include subject content in *Aistear*, combined with a lack of training, has led to formal educator-led science activities that are underpinned by very complex scientific concepts. During these activities, the educators adopt a didactic approach, and the children end up either as passive observers or at best performing some physical activities such as pouring or stirring. I contended that the lack of guidance around subject content knowledge in *Aistear*, combined with a lack of training, has resulted in some unforeseen consequences. Indeed, they have led to the adoption of some of the very practices that opponents of schoolification warned would happen as a result of adopting a school readiness approach. I also argued that the emotive discussions about schoolification might be masking the need for critical debate about early childhood curriculum content and the types of pedagogies that contemporary literature suggests are most effective for supporting science learning.

Despite what contemporary literature tells us about children's capabilities to learn science (Gopnik, 2012), content in the form of scientific conceptual knowledge remains elusive within *Aistear's* curriculum framework. I argued that the absence of such content raises questions about what and whose knowledge is valued in early childhood provision. The findings suggest that while the participants base activities on the children's interests, they do not consider the children's funds of knowledge when interpreting what those interests might be. Interests are determined by what the children say and do within the setting, but little attention is given to the meaningful knowledge and interests children bring from their families and community. Significantly, *Aistear* provides little guidance for educators on how to integrate a funds of knowledge approach into curriculum development.

6.3: Contribution to knowledge

Much of the existing research in this area originates from larger western nations and examines individual factors that influence science education. This thesis provides unique insights into this topic from the perspective of early childhood education in Ireland. It uses both educators' perceptions and practices to ascertain the various influencing factors. The findings show how the combined influence of educators' beliefs, knowledge and understanding about how children learn, their science-based pedagogical content knowledge (PCK), and the national curriculum framework, Aistear (NCCA, 2009) lead to the provision of limited science learning experiences.

From an Irish perspective, this thesis shows that while the educators' beliefs about how children learn had a Piagetian orientation, they had a limited understanding of his learning theory regarding concept development. Significantly, when this combination exists, the educators provide resources and activities for exploration and discovery that do not present a cognitive challenge. Therefore, Piaget's suggested mechanism for learning concepts, equilibration, is not triggered. This thesis also highlights that although contemporary literature suggests that a sociocultural approach has gained prominence in early childhood education, it is not evident as a theoretical framework in early childhood education policy in Ireland, and in educators' practice in this research.

The importance of PCK is well documented (Shulman, 1986, 1987; Gelman et al., 2010; Siraj-Blatchford et al., 2002). However, this thesis shows how a lack of science-based PCK critically impacts educators' pedagogical practices. These practices do not involve an inquiry-based approach. Instead, they are dominated by didactic interactions and closed-ended questions, neither of which provided opportunities for children to build their working theories in science through pedagogical processes. These processes involve firstly identifying children’s working theories and then providing activities through which children can create and solve problems, investigate, and ask inquiry-oriented questions. In addition, opportunities for sustained shared thinking were limited because the eduactors were not directing the children’s attention or thinking towards scientific concepts. Notably, this thesis also shows that when educators lack science-based PCK, activities can focus on their entertainment value rather than developing children's scientific conceptual understanding.

Educators' confidence to teach science is recognised as a significant contributing factor to early childhood science education. As there is a lacuna of research on educators' confidence in Ireland, the findings from this study are unique. Contemporary research indicates that educators who lack scientific knowledge have low confidence in their ability to teach science and tend to avoid it (Gerde et al., 2018; Roehrig et al., 2011). However, this thesis identifies that despite a stated lack of training and lack of science-based PCK, the educators in this study have confidence in their ability to plan and implement science activities. However, I argue that their confidence illuminates a misplaced belief that what they are doing is science. The educators provide predominantly sensory exploration experiences, which, in reality, reflect a limited understanding of science in early childhood education and underestimate young children's capacity to learn scientific concepts and inquiry skills.

A further significant influencing factor is the non-prescriptive nature of Ireland's national early childhood curriculum framework, *Aistear* (NCCA, 2009). There is the underlying assumption within *Aistear* that educators have the requisite science-based PCK to interpret and implement its content meaningfully. This thesis shows that when educators lack the relevant PCK and operate under the remit of a non-prescriptive curriculum framework such as *Aistear*, their provision of science learning experiences is limited and lacks the cognitive challenge that would stimulate conceptual learning. The wider issue within early childhood education is lack of agreement on the content knowledge of curriculum frameworks, and ongoing debates about planned and intentional teaching of curriculum content (Wood & Hedges, 2016).

Recommendations

As stated at the start of this chapter, a web of interrelated factors influence educators' provision of science learning experiences. The findings from this research study elucidate that these educators are placed in a difficult position when it comes to early childhood science education. Their predominantly Piagetian knowledge and understanding with respect to how children learn, and lack of science-based PCK, operate within a non-prescriptive curriculum framework. Although Science is not a discrete subject in *Aistear*, educators are expected to develop children's dispositions, skills, knowledge and understanding, as children "make sense of the world around them" and "use skills and strategies for observing, questioning, investigating, understanding, negotiating, and problem-solving" (NCCA, 2009, p. 44). Therefore, a key recommendation is that training institutions design programmes to ensure that their graduates have the necessary knowledge, skills, and competencies to provide and effectively support children's science learning experiences. Furthermore, these institutions could also devise continuing professional development training courses on learning theories and science-based PCK to support practicing early childhood educators.

A further key recommendation relates to *Aistear*. This curriculum framework adopts a non-prescriptive approach to science content knowledge that is predicated on educators' having the requisite PCK to support children's science learning. This mutually inclusive relationship is critical to achieving learning outcomes. While many national early childhood education policies also adopt a non-prescriptive approach to their curriculum goals and outcomes, this needs to be revisited in an Irish context considering the limitations of PCK identified in this study. This recommendation is put forward on the basis of a continuous review and update process designed to improve young children's science learning experiences. Considering that no review of *Aistear* has taken place since its publication in 2009, such a process would be timely in light of these findings.

6.4: Limitations of the study, dissemination of the findings and suggestions for further research

This small-scale study involved eight early childhood educators from a region in the south-west of Ireland. All of the educators' work in a room leader capacity with children aged between three and five years. I acknowledge that limiting the participant cohort naturally narrows the focus of the study. Therefore, this study does not claim to be representative of all preschool educators in Ireland. Indeed, the participants' expressed perceptions and their observed practices in science education are particular to this group alone, and the findings do not seek to be generalisable. Moreover, there may be other early childhood educators in Ireland who understand the tentative nature of science and have the relevant science-based PCK to mediate children's learning experiences effectively. Therefore, to gain a better perspective, future research could investigate a larger sample of educators from a wider geographical area.

A limitation of this study is that it did not seek the perspectives of either the children or their parents. While the focus was on the educator, this study also questioned the incorporation of children's funds of knowledge into the activity planning process. Therefore, a recommendation for future research would be to investigate the perspectives and practices of children and their parents, regarding everyday science learning experiences that occur outside of the preschool environment. This research would be beneficial to educators as it would provide valuable information about the funds of science-related knowledge that children may bring with them into the setting.

The dissemination of research findings is important as it provides for the building on previous research and a catalyst for discussion among key stakeholders. Therefore, I plan to submit applications to present these findings to a broad audience of policymakers, academics and early childhood educators at conferences organised by national bodies such as OMEP Ireland, and Early Childhood Ireland. OMEP Ireland also produces an annual peer-reviewed academic research journal, 'An Leanh Óg', (the young child), which is a potential avenue for a future publication.

This research project has highlighted two issues concerning the training of early childhood educators, each of which present opportunities for future research. Firstly, there was a distinct Piagetian orientation to participants' beliefs about how children learn. As such beliefs strongly influence practice a key area for future research should investigate undergraduate students' philosophical beliefs about how children learn. This research will provide valuable information for the pre-service training institutions as it will highlight possible gaps in student-educators' understandings of the more complex theories of learning such as Vygotsky's sociocultural theory, working theories and funds of knowledge. Secondly, this study found that educators have little or no understanding of science-based PCK. The reasons for this need to be further investigated. Therefore, further research could investigate why graduate early childhood educators have limited science-based pedagogical content knowledge. Once these reasons are understood, it opens up the possibility for the training institutions to implement change.

Science in early childhood education can be viewed from many different perspectives; however, this study used educators' perceptions and practices as the medium of investigation. One of the key findings in this study highlights the significant influence of policy, in this case, *Aistear*, on science practices. Indeed, the absence of subject content and pedagogical guidance in *Aistear* combined with educators' lack of training appear to contribute to educators' limited approach to science education. These deficiencies identify that a key area for further research would be to examine the relationship between early childhood education policy, training and science education practices. Critically, this would provide training institutions and policymakers with a holistic view of the current system and identify areas of focus for policy review and educator training. Other research involving an in-depth policy analysis would provide insights into the views about how children learn that are implicit within such policies and how this may influence both training institutions and educators' approaches to science education.

6.5: A final reflection

> *And what, Socrates, is the food of the soul? Surely, I said, knowledge is the food of the soul*.
>
> Plato

In reflecting on the main findings, this study shows that a complex interaction of factors influence the provision of science learning experiences in early childhood education. While the opportunities for science learning in preschool were found to be limited, I am particularly conscious that this should not be seen as a criticism of the participants. Instead, I believe that the findings highlight the very difficult position these educators find themselves in. The impact of *Aistear's* vagueness around subject content knowledge and how educators can facilitate science learning is compounded by their lack of training in science-based PCK.

Without the appropriate PCK, educators cannot be expected to understand where a child is currently positioned in their science learning, or indeed how to progress their learning. At present, these educators provide activities that either involve sensory exploration or are underpinned by complex scientific concepts where the focus is not on science learning but rather is on entertainment. Educators provide science experiences that they consider to be appropriate for how children learn science. In the words of T4, 'just to see their little eyes light up…you can't beat a good visual'. I fully accept that children may enjoy playing with playdough, or watching the Coca Cola fizz and spurt up out of a bottle. However, when this is the extent of children's science learning experiences, they are missing out on the opportunity to explore their world in scientific ways. In contrast to these practices, the knowledgeable educator can mediate children's science learning and can encourage them to raise questions about their world and to investigate possible solutions. Such actions can inspire children's imagination and creativity and in the process, begin their journey towards developing scientific literacy.

Finally, I believe that the findings of this research place a responsibility on all stakeholders, including educators, training institutions and policymakers to work towards the common goal of providing effective science learning experiences in early childhood education.

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APPENDICES

APPENDIX 1: Interview schedule

Welcome and sincere thanks for participating in this research.
You signed the consent form permitting me to record this interview – is that still ok?
Before I start asking questions I want to emphasise that there are no right or wrong answers, I am only interested in your opinion.
I will start off with a few general questions about your background in early childhood education.

1. Can you tell me a little bit about yourself, your training and experience in early childhood education and care?
    - How do you describe your role in ECE?
    - How many years have you been working in the ECE sector?
    - ECE qualifications?
    - Training in EC science education?
2. Please talk me through a typical day in your setting?
    - What activities do the children particularly enjoy/don't enjoy/ find stimulating etc.?
    - OK, thank you. How many children and how many adults are in the room?
3. Can you describe the curriculum in your setting?
    - Do you have a written curriculum?

➢ **Now, I would like to talk about science, but before I get into discussing science in ECE I would like to ask you a few general questions – and again please be assured that there are no right/wrong answers.**

4. What do you think science is?
5. Can you tell me about your experience of science in school?
    - Do you think your experience of science at school has influenced your attitude to science now?

➢ ***Moving on, I would like to hear your thoughts on science in ECE***

6. How would you describe science in ECE?

7. How would you describe your attitude to science in ECE?
8. What do you think has the most influence on your science teaching?
9. How do you think children learn about science?
10. How would you describe your role in supporting early childhood science education?
11. How confident, on a scale of 1-10, do you feel about teaching science in ECE? (1 = totally lacking in confidence and 10 = extremely confident)
12. Where do you get your ideas for science activities?
13. When planning your teacher-led science activity is there an end objective in mind when you embark on science-based learning with the children?
14. To what extent do you think that children learn about science during play?
15. What would help you to further support children's science learning?

- **Finally, I would like to ask a few questions about policy**

16. How, if at all, does Aistear influence your implementation of science?
17. A final question - is there anything else that you would like to add, anything that you think we haven't covered?

- Thank-you so much for participating in this interview.

APPENDIX 2: Sample interview transcript

1. Can you tell me a little bit about yourself, your training and experience in early childhood education and care?

My job title would be childcare worker, or facilitator. I think my role is to, really is to watch the children, observe them see what they are interested in and then build on that, build on their interests. Build on their interests and maybe add, extend it. Say if they are interested in the outdoors we could bring in flowers and the earth and living things, we could extend on that. Keep extending on that as far as it could go then get another and extend on that again. I think children love learning, they love hands on, they love…. I always believe children learn best when they are participating, not observing, participating. So, I love doing stuff letting them lead and I just help out if needed and when needed.

- How do you describe your role in ECE?

My job title would be childcare worker, or facilitator. I think my role is to, really is to watch the children, observe them see what they are interested in and then build on that, build on their interests. Build on their interests and maybe add, extend it. Say if they are interested in the outdoors we could bring in flowers and the earth and living things, we could extend on that. Keep extending on that as far as it could go then get another and extend on that again. I think children love learning, they love hands on, they love…. I always believe children learn best when they are participating, not observing, participating. So, I love doing stuff letting them lead and I just help out if needed and when needed.

Lovely, Thank you. How many years have you been working in the ECE sector?

Fifteen years

- ECE qualifications?

FETAC level 6 in Supervision in Childcare

- Training in EC science education?

No, no. We wouldn't have covered science. Science is something that I like myself. I love doing it. I love (pause) actually I love learning myself. There were things about the rainbow today that I never knew. I never knew that a rainbow was actually a full circle, I thought it was just an arc and that was it. So, I am actually learning with the children. I didn't know that the rainbow was just one light and it was different colours. So, I am enjoying learning with the children. I find it fascinating. So, I love to see them enjoying the learning and explaining to them why. I know now we have a few that get it and we have a few that don't get it but I am hoping that (pause) because their minds are absorbent that somewhere in the back of their mind it is there and someday it will all just come all just click together, clicking like a jigsaw fit into place. And they will say 'Oh yeah, that is what she was talking about, raving on about all those many years ago'

2. Please talk me through a typical day in your setting?

A typical day, well we come in in the morning, we greet the children, we greet the parents. The children will put up their lunches and their bags and if they need assistance we do, but mostly we encourage independence, they will do it themselves. They will help us bring in the trolley, they will help the staff put away the lunches. Then they will come out, each will gravitate to their own favourite area. Some will go the castle, some will go to the cars, some love the kitchen, some the doctors. A child will come up to you and say you're sick today, so you will go to the hospital, you will be their patient and you will use that to extend on their learning. Then another child will be cooking for you and you go there and go to the restaurant and you do the, and then you extend on there to the restaurant into the people in our community and then the children then might want to go and have their lunch. They will chose which time they want lunch and then we will ask the children do they want to go outside. Some might want to stay in. So, one of us will go out with the children and will the activities out there the balancing beams, the sand, whatever they choose. Someone else will stay in then the children might want to paint or do puzzles, so someone sitting in with the children they will extend on that again. And at home time then we try to keep a little bit of structure just because of health and safety reasons so we try get them at the table and we will give them like a…ask them what activity they would like to do, books puzzles. So we will set that up for them and they can work on that then when the parents come cos we find it a lot easier to have them sitting when the parents come because (pause) just for health and safety, there is no child is running off with a different parent because we have a few that could (laugh) disappear on us. So, that would be a typical day

- What activities do the children particularly enjoy/don't enjoy/ find stimulating etc.?

They love painting, they love mixing colours. They love (pause) doing science (laugh). They love doing that. If they see you bringing out anything they will all come in and they will want all come in they will all want to join. They love that they love messy play. They love if we set up sensory things, they love to help in setting them up, like flour, dough and all. They love to get their hands into a mess. I think they enjoy that the most, more so than anything.

- OK, thank you. How many children and how many adults are in the room?

22 children and 4 adults

3. Can you describe the curriculum in your setting?

In the setting now we follow Aistear, it's all play-based. Basically the children choose what they want to do and we extend on that. The children have the choice. Now sometimes we might do a little bit of structure and we bring the children, but they still have a choice. We will give them a specific area and they can work in that area, but the choice is still the child's, it is not ours. It is whatever they want to pick, and we will go along with them and help them to extend on that. It's all play-based and it is all child, children's choice and it is all what the children want to do and we just extend on that.

- Do you have a written curriculum?

No, we don't have it written, because we follow the interests of the child, so we come up with ideas based on what they're interested in.

- **Now, I would like to talk about science, but before I get into discussing science in ECE I would like to ask you a few general questions – and again please be assured that there are no right/wrong answers.**

4. What do you think science is?

I think that science is a way of exploring the world, how the world works, how nature works, how things in the world work, how they all fit together, how we came into being. That is what I think science is. And I just love exploring that with the children do you know how the world came about and how it is still working and what we can do to help the world at this stage cos it needs it now and how we can help it through recycling or what we do. Maybe they can take it home to Mammy and Daddy explain to them about do you know about cars and walking and all that stuff like and just how the world works and nature works and how we all fit into it.

5. Can you tell me about your experience of science in school?

I did and that was a long time ago but I did do a bit of science. I only went as far as Junior Cert I didn't go whatchacallit but back then we were just given the things and told 'do this and that' we were never allowed really explore it. That's why I think children have to do, be able to explore it and mess and do as much as they want themselves, they have to.

- Do you think your experience of science at school has influenced your attitude to science now?

No, no, I don't, no. I think that came actually from working with the children, actually seeing their interests. It didn't come from school cos as I said, I was terrified of my science teacher. I was afraid to breathe inside the classroom. He used to stand their looking down and I was afraid to move and all I was focused on was please don't see me. I found it more came so with the children, their natural curiosity made me curious, so no, it was the children I think.

- ***Moving on, I would like to hear your thoughts on science in ECE***

6. How would you describe science in ECE?

I would say it is a way we can teach the children about the world and how the world works. A fun way, a fun and experimental way and a messy way. We can get messy children love to get messy. A fun and messy way children can learn about the world how it works and how they fit into the world into their environment.

7. How would you describe your attitude to science in ECE?

I just love science (laughs). I just love experimenting and making and seeing how things work. I just love learning myself, because as I said I am learning stuff I never knew. Now I probably (pause) I got to whatever age I am and I just never knew because when we were at school, as I said, we were just told put the acid in here and if that paper turns blue it is neutral, it is what-do-you-call-it acid. We were never like told, we were just told what to do but never explained why we are doing it or how. Well go figure that out yourself there like it was always kind of ‘do, do, do’ (tapping table). Now I know today a lot of things are changing like the children are even with maths they are going out and they are getting more hands on and they are learning more which I just think is brilliant. As I said children learn by doing they don’t learn by watching. I certainly didn’t learn by watching.

8. What do you think has the most influence on your science teaching?

I believe what influences me is that children are curious they’re like sponges, they take in everything. And something that I feel that I can give to them by showing them science experiments. Something that I can give to enhance their curiosity, to enhance their learning. Just something that (pause) I’m interested in. That I feel that maybe some of them might want to listen to me (laugh). That some of them do like it so I feel maybe that’s my little bit of contribution outside of their regular extended learning. That I can bring in as well, help them learn in a fun way.

9. How do think children learn about science?

I think it’ has to be fun first of all. It’s fun and they are learning. They are learning about the world and they are having fun. They are naturally, children are naturally curious, and they love learning. We have a couple of children out there and they just love learning new things. They will come up and they will ask you. Sometimes I don’t know the answer and sometimes I have to go and Google the answer and come back the to them the next day. But their just their curiosity, their eagerness to learn. I think what is important is to let the children do it themselves the children are learning by doing, by not me actually doing, by doing, by mimicking, because they will mimic the adult, and they will copy, and they will watch, and they will listen and take it in. Well some will take it in some will eventually it will come to them. And they could come back tomorrow and they could say you mightn't think they have taken it in and tomorrow they could come back and say 'do you remember we done this?' and I am saying 'ok they were actually listening they were taking it in. so I think the children participating being the leaders and me just being the observer and participator and they doing it.

10. How would you describe your role in supporting early childhood science education?

My role is, I suppose, just to explain how it works. Show them how it works and then after that, then once it's explained they get a little bit of how it works then just let them explore it and let them come up with their own experiments then after that. See what other things that can happen while they are exploring themselves.

11. How confident, on a scale of 1-10, do you feel about teaching science in ECE? (1 = totally lacking in confidence and 10 = extremely confident)

I would say about 8 and I would say that because there is a lot of things I don't know that I would have to go and research first. If they came up to me now, there's a lot of things I would know because I have done experiments before, but there are some things they might ask me and I would be going – ok I need to check that one out. I would say about 8 but as I say it is a learning curve for me too and I love it.

12. Where do you get your ideas for science activities?

A lot of them I would Google online, a lot of them because there is so much information out there and I would go to a 100 different sites if I have to just to find the right one that I think will fit the children here – that they will like.

13. When planning your teacher-led science activity is there an end objective in mind when you embark on science-based learning with the children?

Well we would normally follow on, say like we were doing weather in the classroom there because of the storms (*Ophelia).* The children were interested in the storm, so the weather experiments, the rainbow .and the storm actually followed on from that. From the children's interests on. Now that would lead on to, they might show an interest in bubbly water, that could lead on to the dancing raisins. So, it's really from what they find interesting in what you are doing at that time and what science experiment I would go and research and say well they are interested in sand or mud and I will go online and I go 'what science experiments can I do with mud for pre-schoolers?' Of course, the age of the children and what they are interested in. so I would actually research and say 'well would they like that? Well, no, they mightn't like that one too much. Yeah, they'd like that, so I go and set that one up and then when they are doing what they were interested in I slowly maybe hint at it or bring a word and see what the interest is like and if there is good interest, well we could make that. We could do that in science and then they normally, 'yeah yeah, can we do that now?' So, we really basically, what activities we are doing at the time and interests and then if I can find a science activity to fit into their interests and then we will extend on that that way.

14. To what extent do you think that children learn about science during play?

I think if they are like working with the blocks and they are building they are learning about height, they are learning about gravity. Well if I build it this high and it wobbles then it is going to fall to the ground then they are learning about gravity because gravity pulls stuff down to the ground. Even reading the story yesterday we learnt about gravity and spaceships and different planets, and measuring the bricks. How long is this? Which if they are in the kitchen like umm which food is cooked hot, which food is hot which food is cold? (pause) I'm trying to think what other activities we have..

You are fine, I know that sometimes it can be hard to think of things

No, I think yes there is even when playing with toys, even with playdough there is loads of opportunities to introduce science. How things work and why. Why the bridge fell down, well we have to make it stronger. It wasn't strong enough gravity knocked it down. Then we can extend on that with gravity we could do light, heavy, fall, what falls quickest. So, there is always opportunities to extend in their play.

15. What would help you to further support children's science learning?

My training (laughs) if I can go on a science course and more Googling because |I do spend a lot of time Googling science, I do, I am very bad (laughs). I am really mad to that science course. I would really love if they did like one whole, even a course like, where you actually have a cert at the end of it in science, I'd love to do that. It would be a great advantage to me and for the children. I feel that if I done a course there is more I could show the children because I would be learning new stuff. There are experiments that they could show me, different things, different ways of introducing it to the children because I am only going by what I see online. So, I would like to go to these people that have run these courses for ages and are probably more qualified than I am to show me, well what way would you introduce it to the children and maybe new experiments along the way and well yeah maybe I could do that or change it a little bit and fit it into what the children like here and do it here. That's why really, because well they would have more experience and more knowledge than me. So, I would be like the child and they would be teaching me and I would be hands on doing it (laughs). So, I would be learning and I could bring it here to the children and show them what I have learned and what way we can change it to fit our needs here.

- **Finally, I would like to ask a few questions about policy**

16. How, if at all, does Aistear influence your implementation of science?

    I suppose it would yes because Aistear is all about the children having their own choice and learning for themselves. So, science would yeah because we are letting the children explore and learn themselves through science. So, it would have an influence on that.

17. Have you heard about the STEM in Irish Education Policy Statement 2017-2026? STEM refers to science, technology, engineering and maths

    No, I know about STEM, but I have never heard of that policy

18. *A final question - is there anything else that you would like to add, anything that you think we haven't covered?*

    No, I think now we got it all. I think we've covered it all.

- Thank-you so much for participating in this interview.

APPENDIX 3: Video transcript sample

Activity title: Coke and Mentos

Educator: T5

Assistant educator

18 Children

(Description in brackets), 'Speech'

(T5 had just finished reading a story to the children)

T5: Would you like to see something special?

Children: Yes (shout)

T5: Ok, everybody outside

(T5, her assistant and the children go outside)

T5: Ok, stand at the edge of the grass.

(The assistant educator hands a large bottle of coke and a packet of Mentos mints to T5)

T5: (Holds up the bottle) What is this?

Emma: Coke

T5: How many of you drink coke?

(Most of the children raise their hands)

T5: Oh no. Coke is so bad for you and do you know what the dentist told me? It's one of the worst things you could have for your teeth.

T5: (Unscrews the bottle cap and places it on the ground).
Ok, that's a bottle of coke and these are Mentos sweets, mints
(Holds up mints).
Are we ready?

(Some children have turned away from T5 and are looking at some wood blocks that are on the ground)

T5: Everyone should be looking here
(Points to coke bottle Takes a sweet out of the pack).

Everybody watching

(places the sweets into the bottle).

(Everyone watches the coke fizzing up and out of the bottle. The fizz extends about 5 cm above the bottle)

T5 & assistant: Wow

Children: Woooaah

T5: It usually goes up more. I'll try it again with more Mentos

T5: (Opens a second bottle of coke, and adds in this several Mentos)

T5: Watch everyone

(The coke fizzes up a little higher this time)

Children: Woooaaah

T5: That was better. Did you enjoy that?

Children: Yes (shouted)

T5: Ok, everyone back inside. It is nearly home time

(Everyone returns to the classroom)

APPENDIX 4: Ethical Approval

The University Of Sheffield.

Downloaded: 16/08/2018
Approved: 03/01/2018

Nuala Finucane
Registration number: 150208574

School of Education
Programme: Doctorate of Education

Dear Nuala
PROJECT TITLE: Science in Irish early childhood education: perceptions and practices of early childhood teachers
APPLICATION: Reference Number 016946

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 03/01/2018 the above-named project was approved on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

University research ethics application form 016946 (dated 06/12/2017).
Participant information sheet 1037849 version 2 (06/12/2017).
Participant information sheet 1037850 version 2 (06/12/2017).
Participant consent form 1037853 version 1 (03/12/2017).
Participant consent form 1037852 version 2 (06/12/2017).
Participant consent form 1037851 version 2 (06/12/2017).

The following optional amendments were suggested:
Nuala, please reflect on the reviewers' comments and in particular consider to what extent you need to i) use identifiable images of children in reporting the data, ii) how long you need to retain the whole data set, iii) how you will achieve ongoing voluntary informed consent from all parties and iv) how you will manage expectations if you have more settings wishing

to participate than you have capacity to study. Please reflect on all comments made by the reviewers above especially with regard to the information and consent sheets.

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Yours sincerely

David Hyatt

Ethics Administrator

School of Education

APPENDIX 5: Participant Information Sheet and Consent Form

Science in early childhood education: perspectives and practices of early childhood teachers

Introduction

You are being invited to participate in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Purpose of the research

We know that young children are naturally curious and eager to learn about the world; they are often referred to as natural scientists, who effortlessly engage in questioning, predicting, experimenting, creating and evaluating. The preschool environment provides a rich space in which to develop such knowledge and skills. In recent years there has been substantial research on literacy and numeracy development in the early years, yet there has been far less attention paid to children's scientific development. The aim of this project is therefore to expand the scope and depth of knowledge regarding how the concept of science is understood in Irish early childhood education settings.

Participants

You have been chosen to participate as you are an early childhood teacher who acts in a room leader capacity in a preschool room which caters for children aged from three to five years. It is intended that the total number of participants for this study will be between eight.

Voluntary participation

Your participation in this research is entirely voluntary. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. You can still withdraw from the research at any time, and you do not have to give a reason.

What your participation will involve

Your participation in this research will involve permitting me, the researcher, to be in your preschool room for about 3-5 days during which time I will use a camcorder to record the children's engagement in science activities. These activities may be child initiated and occur during play or Montessori activities, or they may be teacher-directed. It is very likely therefore that you will appear in the video. Also, your participation will involve an interview of approximately 45 minutes in length to take place at a mutually agreed upon time and location. You may decline to answer any of the interview questions if you so wish. With your permission the interview will be audio-recorded to facilitate the collection of information; it will later be transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the transcripts of both the interview and video, this will give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish.

Possible disadvantages of taking part

Participation in the research will involve the presence of an additional adult (myself) in your classroom which initially may be a little distracting for you and the children. It is my intention to be as unobtrusive as possible during my time in the room. Additionally, participation in the interview will take up some of your time.

Possible benefits of taking part

While there are no immediate benefits for those people taking part in the project, it is hoped that this work will inform policymakers, teacher training providers and teachers who want to make science education an integral part of early childhood education in Ireland.

What happens if the research stops earlier than expected

If the research project stops unexpectedly the reason(s) will be explained to you.

Complaints Procedure

If for any reason you wish to raise a complaint, please contact my research supervisor Dr Rachael Levy. If you feel that your complaint has not been handled to your satisfaction, you can contact the Chair of Ethics Review Panel, Dr David Hyatt. Dr Levy and Dr Hyatt’s contact details can are at the end of this information sheet.

Confidentiality, Anonymity and Data Storage

All the information that I collect about you during the research will be kept strictly confidential. To achieve this confidentiality, all information will be stored electronically on my personal computer which is password protected. To ensure that information collected cannot be linked to the individual each participant will be assigned a reference code and all data associated with them will be stored under that code. In the case of email communication, all emails will be permanently deleted from my account at the end of the project.

The video recordings made in the classroom will be uploaded to my personal computer for data analysis. This computer is password protected and is only accessible by me. Information taken from the video recordings such as anonymised quotations from you and the children, and still images may be used in the final thesis publication. Also, anonymised quotes, video footage and pictures taken from the video recordings may be used in future academic paper publications, conference presentations, and research projects. The video recordings will, therefore, remain in storage for the next five years and will then be destroyed. Your consent to participate in this research will, therefore, include consent to the future use of your data.

Results of the research project

The research project is likely to be completed by September 2019, and you will be furnished with a copy of the final thesis. Please be assured that you will not be identified in any reports or publications.

Ethical Approval

This project has received ethical approval from the School of Education's Ethics Review Panel.

Obtaining Your Consent

If you feel you understand the study well enough to make a decision about it, please indicate your agreement by signing the attached consent form.

Once again thank you for reading this information sheet and considering to be part of my research project.

Kind regards,

____

Nuala Finucane

Contact details

Researcher
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Chair of Ethics Review Panel
Dr David Hyatt
University of Sheffield
Sheffield S10 2TN
Tel: 00 44 114 222 2000
Email: d.hyatt@sheffield.ac.uk

Participant Consent Form

I have read the information presented in the information letter about a study being conducted by Nuala Finucane, doctoral student, at the University of Sheffield. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. It is in full knowledge of the above study, that I agree to the following:

	YES	NO
I agree to participate in this study	☐	☐
I agree to participate in video recordings of science activities in the classroom	☐	☐
I agree to have my interview tape recorded	☐	☐
I agree to the use of anonymous quotations in any thesis, publication or presentation that comes from this research.	☐	☐
I agree that the video or still images taken from the video recording may be used in any thesis, publication or presentation that comes from this research.	☐	☐

If you answered NO to the previous question, please consider the following:

I agree that images taken from the video recording in which my face will not visible may be used in any thesis, publication or presentation that comes from this research.	☐	☐

Printed Name of Participant: ______________________________

Date of Consent: ______________________________

Participant's signature: ______________________________

Researcher's signature: ______________________________

Appendix 6: Parent/Guardian Information Sheet and Consent Form

Science in early childhood education: perspectives and practices of early childhood teachers

Your child is invited to take part in a research study which will explore through observation, current practices surrounding science education in early childhood settings. The researcher is inviting all children in ____________________ preschool class to be in the study. This information sheet provides information to allow you to understand this study before deciding whether you give consent for your child to take part.

This study is being conducted by myself (Nuala Finucane); I am a doctoral student at the University of Sheffield.

Background Information:

The purpose of this study is to expand the scope and depth of knowledge regarding how the concept of science education is understood in Irish early childhood education settings. The focus of the study is on the early childhood teachers' perspectives and practices; however, the children will naturally feature as they engage on a daily basis in the various activities provided by the teacher.

Procedures:

I will attend your child's preschool for about 3-5 days to observe engagement in science-related activities. These activities may be child initiated and occur during play or Montessori activities, or they may be teacher-directed. In either case, I will video record the activity including the teacher and children's actions and communication.

Voluntary Nature of the Study:

This study is voluntary. You are free to accept or turn down the invitation and, of course, your child's decision is also an important factor. After obtaining parent consent, I will explain the study and let each child decide if they wish to volunteer. No one at the setting will treat you or your child differently if you or your child chooses to not be in the study. If you decide to consent now, you or your child can still change your mind later. Your child can stop at any time.

Risks and Benefits of Being in the Study:

Being in this type of study involves some risk of the minor discomforts that your child might encounter in daily life, such as uncertainty and distraction due to the presence of another adult in the room. However, being in this study would not pose a risk to your child's safety or well-being.

While there are no immediate benefits for those people taking part in the project, it is hoped that this work will inform policymakers, teacher training providers and teachers who want to make science education an integral part of early childhood education in Ireland.

Privacy:

The thesis publication coming out of this study will not share the identities of individual participants. Details that might identify participants, such as the location of the study, also will not be shared. I will not be gathering any personal information about any child involved in the study. Data will be kept secure by storing it on my password protected computer. Codes will be used to identify locations and names.

The video recordings made in the classroom will be uploaded to my personal computer for data analysis. This computer is password protected and is only accessible by me. Information taken from the video recordings such as anonymised quotations from the children and still photographs may be used in the final thesis publication. Also, anonymised quotations and photographs taken from the video recordings may be used in future academic paper publications, conference presentations, and research projects. The video recordings will, therefore, remain in storage for the next five years.

Questions:

Please feel free to ask questions now, or if you have questions later, please contact me via the mobile number or email address provided below.

Complaints Procedure

If for any reason you wish to raise a complaint, please contact my research supervisor Dr Rachael Levy. If you feel that your complaint has not been handled to your satisfaction, you can contact Dr David Hyatt, (Chair of Ethics Review Panel at the University of Sheffield). Dr Levy and Dr Hyatt's contact details can be found at the end of this information sheet.

Obtaining Your Informed Consent

If you feel you understand the study well enough to make an informed decision about it, please fill out the attached consent form.

Thank you for reading this information sheet.

Kind regards,

____

Nuala Finucane

Contact details

Researcher

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Parent/Guardian Consent Form

I have read the information presented in the information letter about a study being conducted by Nuala Finucane, doctoral student, at the University of Sheffield. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. It is in full knowledge of the above study that I agree to the following:

	YES	NO
I agree to my child's participation in the research study	☐	☐
I agree to the use of their anonymised quotes in any thesis, academic publication, or conference presentation that comes from this research.	☐	☐
I agree that images or video clips may be used in any thesis, publication or presentation that comes from this research.	☐	☐

If you answered <u>NO</u> to question 3, please consider the following:

I agree that still images or clips where my child's face will not be identifiable may be used in any thesis, presentation or publication that comes from this research.	☐	☐

Printed Name of Parent: ______________________________

Printed Name of Child: ______________________________

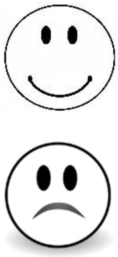
Date of Consent: ______________________________

Parent's signature: ______________________________

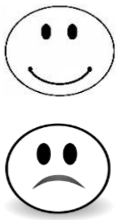
Researcher's signature: ______________________________

APPENDIX 7: Child's Assent Form

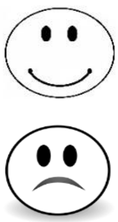
I am happy for a video recording to be made during my science activities



I am happy for some of my words to be written in a report and other people will read them.



I am happy that a video/photograph of me may be shown to other people.



Child's Name: ______________________________

Date: ___________________________________

Researcher's Signature: ______________________