Integrating, Fostering and Encouraging the Development of Literacy Skills in the Irish Primary Science Classroom

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Master's Degree by Research and Thesis

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December 2016

ABSTRACT

The National strategy to improve literacy and numeracy among children and young people 2011-2020 in Ireland states that we need to prioritise literacy and numeracy through positive interventions and integrating these skills across the curriculum. Irish Primary Schools are currently introducing best practice methodologies in literacy and numeracy teaching and Continuous Professional Development (CPD) courses are being rolled out all over the country. However there have been no specific models and CPD courses designed and implemented guiding teachers on how literacy and numeracy skills can be effectively developed in the Primary Science Classroom. The practice and development of key scientific process skills contribute significantly to developing the child's oral language, reading and writing skills. There is the fear that other curricular areas could be left behind with such a strong focus on developing skills only in English and Mathematics lessons. The overall research question was as follows: *What are teachers opinions on and attitudes towards the use of science lessons in, fostering the development of literacy skills in the Irish primary science classroom?*

This research employed an exploratory sequential mixed methods design of data collection, investigating, identifying and examining the literacy strategies and approaches used by teachers during science lessons, the teachers background and experience and provision of continuous professional development in this area by gathering both quantitative and qualitative data using questionnaires (N=42) and semi-structured interviews (N=3).

It was found that teachers incorporate oral language skills as much as possible in science lessons. However employing higher-order inquiry based oral language skills that encourage argumentation, collaborative discussions, pupil questioning, open ended-questioning, reading and writing strategies did not feature as prominently in science lessons. Difficulties impeding the use of such strategies were identified as follows: class sizes, overloaded curriculum, classroom management issues, teachers' poor scientific knowledge, lack of familiarity with and confidence with pupil lead activities and argumentation strategies.

It is clear from the results that high-quality science CPD and supports are needed focusing firstly on developing the teachers Inquiry Based Learning skills, Science Knowledge, Critical Thinking and Argumentation Skills and secondly on school planning of science and integrated approaches to teaching.

Overall the integration of Literacy skills across the curriculum needs to be addressed. Science offers a wonderful opportunity for children to develop literacy skills. If science can be envisioned as a subject matter that welcomes the inclusion of literacy practices, it is more likely that primary teachers will find ways to integrate science into their curriculum.

DECLARATION

Declaration of Authorship

This thesis is presented in the fulfilment of the requirements for the degree of Research Masters in Education. I hereby certify that this dissertation 'Integrating, Fostering and Encouraging the Development of Literacy and Numeracy Skills in the Irish Primary Science Classroom', is entirely my own work and that it has not been submitted for any other academic award or part thereof, at this or any other educational institution. All quotations from other sources are acknowledged and referenced.

Signature: _____ Date: _____

Rachel Galvin

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude and heartfelt thanks and appreciation to my mentor Maeve Liston who has been a huge inspiration to me and who has been so patient and helpful throughout this process. I would also like to thank the many teachers who took the time to complete the survey questionnaires and to those who participated in the interviews, all of which formed a substantial part of this study. I would like to thank the principals who kindly allowed me to send out the surveys to their teaching staff and for their encouragement. I would also like to thank my parents and my children who have always supported me. I most truly could not have completed this without your love and support and I am blessed to have each of you. Thank You!

Rachel Galvin, June 2016

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 2

CHAPTER 3

CHAPTER 4

LIST OF APPENDICES

GLOSSARY OF TERMS AND ABBREVIATIONS

ASD – Autistic Spectrum Disorder

Cedefop - European Centre for the Development of Vocational Training

CEFR - Common European Framework of Reference for Languages

CoE – Council of Europe

CPD – Continuing Professional Development

DES – Department of Education and Science

ECEC – Early Childhood Education and Care

EPV - Extra Personal Vacation

ESRI - Economic Social Research Institute

EU – European Union

IBL – Inquiry Based Learning

IBS – Inquiry Based Science

ICT - Information and Communication Technologies

IDEAS – In-Depth Expanded Applications of *Science*

INTO – Irish National Teachers Organisation

MIC – Mary Immaculate College

MIREC - Mary Immaculate Research Ethics Committee

NCCA – National Council for Curriculum and Assessment

NIPT - National Induction Programme for Teachers

NQT –Newly Qualified Teacher

PCK – Pedagogical Content Knowledge

PCSP – Professional Development Service for Teachers

PDST - Professional Development Service for Teachers

PISA - Programme for International Student Assessment

PIRLS - Progress in International Reading Literacy Study

PPDS – Primary Professional Development Centre

PSC – Primary School Curriculum

PD – Professional Development

OECD – Organisation for Economic Co-operation and Development

RDS – Royal Dublin Society

SESS - Special Education Support Service

SPHE – Social Personal and Health Education

SPSS - Statistical Package for Social Sciences

VIPS – Valle Imperial Project in Science

WEE - Wondering, Exploring, and Explaining

Improving Primary School Children's Literacy Skills through Primary School Science

Chapter 1: Introduction

1.0 Introduction

Literacy skills are crucial for every person to develop as an individual, to live a rewarding and satisfying life and to actively participate in society (EU High Level Group, 2012). Internationally challenges in literacy have been the main focus of many recent policy documents and developments highlighting the need for reforms within our education systems all of which are influenced by economic development and the future requirements of our work forces (Department of Education and Skills (DES), 2015).

In the UK a review titled: 'Our Literacy Changes Lives' outlined the importance of literacy skills, which underpin education, to five areas of a person's life i.e. economic wellbeing, aspirations, family life, health and civic/cultural engagement (Dugdale and Clark, 2008). It presents overwhelming evidence showing that literacy has a significant relationship with a person's happiness and success. It also shows that people with poor literacy are least likely to be in full-time employment and more likely to be in manual jobs compared with those who are competent in both.

Employers' perceptions of the skills needed of employees either already employed in or entering the job market have been well-documented. These studies show that employers require people with a wide range of transversal skills who are literate, numerate, creative, innovative and who can communicate well, possess critical and analytical thinking and possess team working skills (Department for Business, Innovation and Skills, 2012; DJEI, 2015; EGFSN 2016). The jobs market for low-skilled workers is rapidly shrinking with the percentage of low skilled jobs in the EU expected to decrease by up to 30% between 2010 and 2020 as reported by the European Centre for the Development of Vocational Training (Cedefop, 2013). The Cedefop Annual Report (2013) stated that 'emerging industries increasingly require knowledge and innovation from most workers, even in positions traditionally considered 'low-skilled'. Today's jobs require better skills and more education, and literacy is the gateway to both' (p.24).

One in five adults in Europe lack sufficient literacy skills with the majority being in current employment (EU High Level Group, 2012). Similarly one in five European 15-year-olds lack the literacy skills required to successfully function in a modern society (OECD, 2010). It is also important to note in an age of increasing migration and increasing diversity, the vast majority of children and adults with poor literacy skills were born and raised in the country they live in, and speak its language of instruction as their mother tongue (EU High Level Group, 2012).

It is also important to mention that mobility across Europe is increasing, with significant implications for education. In 2009, 10% of 15-year-old school children in the EU were born in another country or had both parents born abroad, compared to 7% in 2000. In some countries, such as Italy or Spain, the percentage of migrant children has risen five-fold over the decade from 2000 to 2010 (European Commission, 2011a). It is estimated that by 2060, a third of the EU population will have at least one parent born outside the country they live in (European Commission, 2011b). While low literacy is not primarily a migration issue as previously mentioned, some migrants do face difficulties in acquiring the language skills in the country they live in (EU High Level Group, 2012).

1.1 'Literacy' in Today's World

Literacy is one of five key areas of communicative competence described in the Common European Framework of Reference for Languages (CEFR).

'If success in the twenty-first century depends increasingly on advanced literacy skills and the education and training they make possible, it is important for educators, policy makers, and the public to understand what advanced literacy is. In short, a new definition of literacy is required—one that highlights the skills that children need to deal with the new demands.'

(Murnane *et al*., 2012, p. 6)

Block (1997) states that literacy skills today are ever evolving and changing from the traditional notion of 'literacy.' Up until the 19th century, literacy meant to be familiar with literature. Post 19th century literacy meant the ability to read and write texts. Literacy today focuses not only on recognising and saying basic words but on comprehension of the world around us. Knowing the core knowledge of basic literacy is just the starting point of survival in the society of today.

The ability to communicate with others and also the ability to comprehend and solve problems and learn from these problems are also becoming more and more important.

'The ability to use languages for the purposes of communication and to take part in intercultural interactions, where a person, viewed as a social agent has proficiency, of varying degrees, in several languages, and experience of several cultures. This is not seen as the superposition or juxtaposition of distinct competences, but rather as the existence of a complex or even composite competence on which the user may draw.'

(Council of Europe (CoE), 2001, p.168).

There is also a strong argument for a further move towards critical literacy in our education system in developing analytic habits of thinking, reading and writing, speaking or discussing which go beneath surface impression and mere opinions to discovering the deep meaning of any event, text, technique, process, object, statement, image or situation (Shor, 1992). Critical literacy in education should be used to acknowledge the complexity of learning about the world we live in by not simply decoding and understanding texts, but by encouraging a way of thinking that challenges the inherent meaning of information and life situations allowing children to develop a wide range of literacy skills through this process (reading, oral language, etc.). The Melbourne Declaration of Education Goals for Young Australians (2008) when children and young people are able to think critically and creatively, readily adapt to change, apply what they know to complex real-life situations and plan and manage their own learning, they are on the road to becoming powerful life-long learners and active and informed citizens. Critical literacy empowers the individual to develop capacities of reflection, critique and empathy, leading to a sense of self-efficacy, identity and full participation in society (EU High Level Group, 2012).

'Literacy, therefore, may be thought of as a moving target, continually changing its meaning depending on what society expects literate individuals to do. As societal expectations for literacy change, and as the demands on literate functions in a society change, so too must definitions of literacy change to reflect this moving target.'

(Leu and Kinzer 2000a, p.108).

Science curricula share the same vision and objectives in developing children's higher level thinking and inquiry skills. The use of oral language, talk and dialogue strategies in Science

plays a central role in developing critical reasoning skills in children (Cavagnetto, 2010). Critical thinking and elements of critical literacy can begin to be developed in Science lessons through inquiry based learning and argumentation. Critical thinking is an essential component of effective learning, especially in Science. It involves conceptualising, applying knowledge and ideas, synthesising, analysing and evaluating so as to better guide the children's thoughts, beliefs and actions. It incorporates the three highest levels of Bloom's taxonomy i.e. analysis, synthesis, and evaluation (Kennedy *et al.,* 1991; Paul and Elder, 2006).

Incorporating effective higher level oral language strategies in Science lessons can significantly contribute to the development of critical thinking through:

- analysing arguments, claims, or evidence (Ennis, 1985; Facione, 1990; Halpern, 1998; Paul, 1992);
- making inferences using inductive or deductive reasoning (Ennis, 1985; Paul, 1992; Willingham, 2007);
- judging or evaluating (Ennis, 1985; Lipman, 1988);
- making decisions or solving problems (Ennis, 1985; Willingham, 2007).

We must ensure that skills strategies and educational policy are always evolving to address and include the development of such ideas as critical literacy, technology, addressing socio-cultural issues and the overall needs of society. It is essential that schools and parents provide every child the opportunity to develop their confidence and skills in literacy to successfully enable the child to strive in our rapidly changing world to solve problems and to be successful in life (Council of Europe (CoE), 2001; EU High Level Group, 2012; OECD, 2010). Our rapidly changing world with its information-rich environment and sophisticated technology have an influence on how children and young people communicate in being able to read, communicate orally, in writing and through digital media. As new technologies for information, communication and collaboration are developed, new literacies also emerge (Bruce, 1997; Leu, 2000b). The digital world requires more higher-order problem-solving skills, with a greater ability to evaluate information critically by extracting and using knowledge from an extensive variety of digital sources (European Commission, 2010; Leu, 2000; Leu *et al.,* 2007; Andrews and Smith 2011).

1.2 Primary Literacy and Science Education

Primary Science is a way of thinking and doing, asking questions and finding ways of answering them through practical activities. The purposes of Primary Science Education is to provide opportunities for the children to develop knowledge of scientific concepts; to develop positive attitudes towards Science realising the relevance of Science in their everyday lives and most importantly to develop their scientific process skills. The main scientific process skills are: observation (looking at the evidence), predicting, recording data, higher order thinking, analysing the information (sorting and classifying, recognising and interpreting patterns), student and teacher questioning, collaboration (dialogue), arriving at conclusions, measuring and estimating and experimentation. The practice and development of the above process skills contribute significantly to developing the child's language, communication and literacy skills . The Primary Science Curriculum states that:

'*Much of the child's learning in Science takes place in the interaction between language, whether Irish or English, and experience. Through discussing their ideas and the results of their scientific investigations children will develop their scientific understandings.'*

DES (1999, p10).

Dialogue, exploratory talk, getting children to attempt to explain and provide their own explanations, prompting and probing questions, speech as reflection and communication, are fundamental teaching strategies employed in the primary Science classroom. Dialogue is a key principal in the Primary Science Curriculum. Answering questions, suggesting explanations are essential features of Science because Science is an attempt to provide rational explanations of events and phenomena. Children naturally want to explain and communicate their observations.

Ireland's National Skill's Strategy published in 2011 aims to develop Ireland as a place where the talent of our people thrives through the quality and relevance of our education and training base, which is responsive to the changing and diverse needs of our people, society and the economy (DES, 2011). The strategy set out to do this through a number of different means, many of which centred around the child and therefore placing education as the main vehicle in the development of literacy skills among our younger generations in the following ways:

1. Improving Teachers' and Early Childhood Care and Education Practitioners' Professional Practice;

2. Building the Capacity of School Leadership;
3. Helping Students with Additional Learning Needs to Achieve their Potential;
4. Improving Assessment and Evaluation to Support Better Learning in Literacy and Numeracy;
5. Improving Teachers' and Early Childhood Care and Education Practitioners' Professional Practice.

With an increasing emphasis on developing children's literacy and numeracy skills and the increase in time allocated to numeracy and literacy instruction in schools, it is imperative that other curricular areas are not left behind and that teachers focus on developing literacy and numeracy skills beyond the primary English and Mathematics lessons. Strands in the English curriculum which include receptiveness to language, competence and confidence in using language, developing cognitive abilities through language and the emotional and imaginative development through language can be addressed effectively in the primary Science curriculum (DES, 1999b). Teaching specific English Strands can be carried out in Science lessons through hands on experience and practical group work. Talk, peer collaboration and exchanging ideas significantly contribute to a child's conceptual understanding in Science (Howe *et al*., 2005). Dialogue allows the pupils to talk about their ideas, helping children to clarify their thinking and to develop their capacity to reason (Mercer *et al.*, 2004; Naylor *et al*., 2007). There is also a very strong link between the scientific process skills that should be developed in primary children i.e. describe, discuss, predict, explain, hypothesise and analyse ideas and the use of language, exploratory talk and dialogue in the classroom.

The Draft National Plan to Improve Literacy and Numeracy in Schools states that *'One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a reduction in the amount of time devoted to the core areas of literacy and numeracy'* (DES, 2010, p.28). As a result of introducing the Primary Science Curriculum, it can be strongly argued that the amount of time devoted to the development of literacy has actually increased due to the practice of the scientific process skills previously mentioned above. The problem lies that while the curriculum emphasises the importance of an integrated approach, there is little evidence of a focus on literacy development outside of the teaching of English (DES, 2010).

Most recently research has been carried out in Ireland on how to increase the development of language and literacy skills in the primary Science classroom. For example, Liston (2015) carried out research on providing opportunities for dialogue and scientific inquiry through the use of puppets with pre-service primary schools teachers and qualified class teachers. The study outcomes were very positive. From the comments of the children and teachers, it was found that the puppets provided more opportunities for productive talk and investigating, developing the children's scientific process skills when trying to solve the problem for their friend, the puppet: 'It was a great way to get them to develop their language skills and vocabulary' and 'Using a puppet generates more discussion with younger children' (Liston, 2015, p.12). Minogue (2015) carried out research on the impact of using nursery rhymes in junior primary Science lessons. Data from this intervention study found that the pupil's use of oral language and scientific inquiry increased over the course of the programme and their use of targeted scientific process skills also improved.

The results of the above mentioned studies and from the researchers experience at continuous professional development (CPD) sessions found that the majority of participating teachers seldom think about introducing effective literacy strategies used in their English and other lessons into their Science lessons. These studies opened Irish teachers' eyes to new methodologies for the Science classroom with the aim of developing both the children's literacy skills. Therefore, it was decided the focus of this study was to take a step back and explore what are the current practices and strategies being implemented with the aim of promoting and developing literacy skills in Irish primary Science classrooms.

1.3 Research Focus

This research involves an inquiry into the current practices of integrating literacy skills and associated teaching methodologies into Science lessons in Irish Primary Schools. The research investigate teachers' experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy skills. The study also explores if literacy skills are effectively being catered for in the professional development courses in primary Science.

1.3.1 Research Question and Embedded Questions

The overall research question was as follows:

What are teachers' opinions on and attitudes towards the use of Science lessons in, fostering the development of Literacy Skills in the Irish Primary Science Classroom?

This was further broken down into specific embedded questions:

1. To what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons?
2. What are the most common oral language approaches employed by teachers in the teaching of primary Science?
3. What are teachers' opinions on using primary Science lessons to enhance children's oral language skills?
4. What are teachers' background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science?

1.4 Summary of Chapters

Chapter One: Introduction

Chapter One provides an overview and purpose of this research. It provides a background surrounding this study and the purpose for undertaking this research.

Chapter Two: Literature Review

Chapter Two examines the relevant literature, recent developments, policies and practices in literacy, nationally and internationally, both at a macro and micro level, with a specific focus on integration of literacy skills with primary level Science. The chapter also discusses and examines possibilities and strategies to ensure on-going achievements in literacy are met in the Irish education system, by exploring literature on integrated approaches to the curriculum. Challenges and implications to such opportunities will also be discussed.

Chapter Three: Methodology

This chapter provides an overview and a rationale for the research design and describes in detail the data collection methods employed in order to address the aims and research questions set out in this dissertation.

Chapter Four: Results

Chapter Four presents the findings of the study and how the research questions were answered through the collection of data. It reviews the analysed data from the questionnaires and the interviews and compiles and discusses the major findings of the study.

Chapter Five: Conclusion and Recommendations

Chapter Five will discuss the results and their implications in further detail. The main conclusions and recommendations arising from the analysed data are outlined in this chapter also.

Improving Primary School Children's Literacy Skills through Primary School Science

Chapter 2: Literature Review

2.0 Introduction

The National strategy to improve literacy among children and young people 2011-2020 states that we need to prioritise literacy through positive interventions and integrating these skills across the curriculum ((DES), 2011; Shiel, 2002).

The practice and development of key scientific process skills contribute significantly to developing the child's language, communication and literacy skills. Internationally published literature details how Science can be successfully integrated with literacy to teach Science concepts (Barber *et al*., 2006; Burton and Campbell 1996; Heisey and Kucan 2010; Jackson *et al*., 2010; Poon 1990; Rule *et al*., 2004; Watts, 2001). Under this framework Irish Primary Schools are currently introducing best practice methodologies in literacy teaching. CPD courses are being rolled out all over the country by the Professional Development Service for Teachers (PDST) to facilitate this new national strategy. However, there have been no specific models of CPD courses designed and implemented showing teachers how literacy skills can be effectively developed in the Primary Science Classroom, which is a wasted opportunity. No such framework has been published to date in relation to the curricular area of Science. This research therefore is needed to investigate teachers' experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy skills to inform the design and development of future frameworks, guidelines and CPD courses for the integration and effective development of literacy skills in Science lessons.

This chapter will examine international and national perspectives and policy at a macro and micro level on literacy, it will look at policies on literacy skills (in the United States, Europe and the UK), from policies to implementation and measuring this impact to date. Strengthening the impact of the National Literacy and Numeracy Strategy will be discussed under the following headings: Responding to the Evolution of 'literacy', Further embedding Integration in the Curriculum, Science and Literacy, Science and Oral Language, Science and Writing, Science and Reading and Continued Professional Development of Teachers.

2.1 International Perspectives and Policy at a Macro Level on Literacy

Internationally, there have been a number of policy documents published focusing on identifying and implementing means of improving literacy skills, for example '*No Child Left Behind*' (Public Law, 2002) or '*Race to the Top*' in the United States, the '*Europe 2020*' strategy; and a '*Vision for Literacy 2025'* policy in the UK. All such reactionary policies were published as a result of declining literacy levels among both adults and children worldwide. The following sections below will provide of an overview of such policies internationally and nationally.

2.1.1 Policy on Literacy Skills: United States

In 2001, the Bush Administration in the USA brought in measures to improve the education system under the '*No Child Left Behind (NCLB) Act*' (came into Public Law in 2002). This Act was a result of these perceived shortcomings in achievement and standards on assessments and proceeded the '*A Nation at Risk'* Policy in 1983.

This Act required all government run schools receiving federal funding to improve standards in literacy and assess students work within the scope of these standards through a state wide standardised test, administrated annually to all students. The students' scores are then monitored to ensure all students are achieving a certain academic level and that the school is reaching the set criteria. If students' academic scores remain continually low over the course of a six year period, the school will be taken over and run by a private company (Public Law, 2002). The education system in the USA was viewed as 'fragmented and student outcomes as mediocre'. In addition to this a 'lack of focus and accountability' were pinpointed as serious shortcomings (Lee and Park, 2014). Therefore, the introduction of high-stakes testing to ensure accountability and higher educational standards was introduced (Hamilton, 2003).

There have been concerns about the requirements of the Act and strategies implemented such as teaching towards the test and in turn narrowing skills fostered by standardised tests and it is in stark contrast to the notion of education for all. Evidence has shown that some improvements have occurred, reporting significant improvements in reading at primary level (Department of Education USA 2006; Alliance for Excellent Education 2007; Dee and Jacob, 2009). However, despite the widespread implementation of assessment policy and its influence on classroom practice there has yet to be a significant increase in the performance of the USA on international assessment leagues such as the Programme for International Student Assessment (PISA).

2.1.2 Policy on Literacy Skills: Europe

The European Union has set targets for improvements in increased levels of literacy for all EU citizens by 2020 with less than 15% of 15-year-olds to be classed as 'low-achieving' in those basic skills, as measured by PISA tests (Europe, 2020). The latest PISA results (2012) show that 17.8% of European students were low achievers in reading, 22.1% in maths, and 16.6% in Science. The *Europe 2020* strategic growth strategy published in 2010, seeks to promote smart, sustainable, and inclusive growth. A key factor in the achievement of this strategy concerns literacy, numeracy, Science, and technology, so called basic skills (European Commission, 2010).

The European Union launched a European Policy Network of National Literacy Organizations' in February 2014. This network aims to raise awareness, exchange good practices, policies, campaigns and initiatives promoting literacy (EU High Level Group, 2012). As a consequence of the Europe 2020 strategy a High-Level Group on Literacy has also been set up, bringing together European academics and policy-makers to map Europe's literacy landscape, identifying changing needs and requirements, and how we respond to such needs. Their report published in 2012 details the importance of literacy in the 21st century, outlining key issues and solutions to achieve literacy for all in Europeans. This expert group called for a coherent literacy curriculum that maximises literacy development fostering high-quality teaching, allowing the mix of adequate instructional strategies to address individual needs. Key recommendations included: Emphasising emergent literacy activities in the Early Childhood Education and Care (ECEC) curriculum; Fostering early literacy activities in a broad sense; including instruction in reading strategies. These are useful tools for any student in various reading and learning situations in suitably challenging tasks (Kennedy *et al.,* 2012). The report also called for investments to improve literacy among citizens of all ages make economic sense, producing tangible gains for individuals and for society which in turn will contribute to the EU's future economic growth and for the wellbeing of its citizens.

2.1.3 Policy on Literacy Skills: UK

One in six people in the UK struggle with literacy, having literacy levels below the level expected of an 11-year-old. This figure has remained unchanged since 2003 (Harding, Romanou, Williams *et al.,* 2011). The UK is the only economically developed country where 16 to 24-year-olds have the lowest literacy skills of any age group in society. In England 14.9% of adults aged 16 to 65 lack functional literacy skills. This equates to 5.1 million people. In

2014 the National Literacy Forum in the UK released '*Vision for Literacy 2025'* (National Literacy Forum, 2014). This policy recommended four areas where sustained policy action is needed to achieve its ultimate aim for all children to have the literacy skills they need to succeed by the time they finish secondary school. The four key recommendations in achieving this goal included: Improving early language and literacy provision in homes and early years settings, Introducing more effective teaching of reading, writing and spoken language skills in schools, providing universal access to reading materials and programmes to ensure that children read for enjoyment and developing partnerships between education and business to ensure that all school leavers have literacy fit for employment. It called on the whole of society to play a part in raising literacy levels. Since its launch both the private and public sector have some on board providing a framework for such sectors to play a vital role and have a significant impact. As the policy is in it's early stage it is difficult to measure and evaluate the impact if any on literacy levels in schools.

2.2 National Perspective and Policy at a Macro Level on Literacy in Ireland

The literacy skills of students in Irish primary schools, measured by the National Assessments of English Reading in 1998, 2004, and 2009, had not shown any significant improvements over thirty years, despite the considerable reduction in pupil-teacher ratios, the introduction of learning support and extensive curricular reform and demographic changes (DES 2011; NCCA 2012 a; b; c). In 2006, Irish fifteen-year-old students performed at the 'above average' level in the Organisation for Economic Co-operation and Development (OECD's) PISA. However, in the 2009 round of the assessment, Irish students performed at the 'average' level, ranking 17th out of 34 OECD countries in the area of literacy. The PISA 2009 tests showed that 17 per cent of all Irish fifteen year olds and almost one in four teenage boys lack the literacy skills to function effectively in today's society. The PISA results from 2009 also reported that Irish pupils ranked 26th out of 34 in the area of Mathematics and 14th out of 34 OECD countries in the area of Science.

The Department of Education and Skills Chief Inspector's Report 2010-12 reported on inspections of primary and post-primary schools revealed that a significant proportion of lessons in English were not satisfactory (DES, 2013). These whole school evaluations highlighted the need for improvement in the teaching of English. Inspections conducted in the 2009-2010 school year from over 230 whole-schools show that many schools at almost 20% showed 'weak' practices in the teaching of English. One percent of schools fell into the lowest

functioning category of 'significant weaknesses'. An analysis of 800 English lessons in approximately four hundred schools between October 2009 and October 2010 showed that assessment practices were unsatisfactory in a third of cases, 14% of pupils learning were unsatisfactory and English lessons whose preparations were unsatisfactory (DES, 2013).

A draft National plan 'Better Literacy and Numeracy for Children and Young People' was then published in 2010 in response to such concerns. It stated that '*relentless focus on the progress of every child and on improving the core skills of language'* is needed in schools and that *'all teachers give priority to language skills, literacy and numeracy in the subjects and programmes that they teach and to integrate the teaching of literacy and numeracy across all aspects of the curriculum'* (DES, 2010, p.13). Stakeholders in education were asked to comment on the draft plan and in 2011 the National Literacy and Numeracy Strategy (2011-2020): Literacy and Numeracy for Learning and Life was published to address the significant concerns of how Irish young people develop numeracy and literacy skills so that they may participate in the education system and become informed members of society (DES, 2011a, p.7). This publication initiated and drove the implementation of a programme of reform focused on curriculum, assessment and teaching strategies and practices to deliver a high quality, relevant learner experience and to enhance learning outcomes in early year settings, at primary and post-primary schools. A prominence was placed on raising education standards and literacy and numeracy results comparable to high ranking OECD countries so that we could '*continue to grow our indigenous knowledge economy and continue to attract high-value jobs through inward investment'* (DES, 2011, p. 8). The strategy set about doing all of the above by:

1. Enabling Parents and Communities to Support Children's Literacy and Numeracy Development.
2. Improving Teachers' and Early Childhood Care and Education Practitioners' Professional Practice.
3. Building the Capacity of School Leadership.
4. Helping Students with Additional Learning Needs to Achieve their Potential.
5. Improving Assessment and Evaluation to Support Better Learning in Literacy and Numeracy.
6. Improving Teachers' and Early Childhood Care and Education Practitioners' Professional Practice.

2.2.1 From Policy to Implementation

Bronfenbrenner (1979) ecological systems theory should be taken into account when translating theory into practice. This system highlights the importance of producing consistencies between policies at a macro level and the micro level (Santrock, 2007) i.e. how the Literacy Strategy is translated into high quality practices in educational settings.

The following section will provide an overview of how the Literacy and Numeracy for Learning and Life strategy was implemented focusing in particular on teachers' practices and primary level education, through a variety of different actions, future work and recommendations.

2.2.2 Improving Teachers' and Early Childhood Care and Education Practitioners' Professional Practice

Initial Teacher Education: New Extended Initial Teacher Education Programmes – Primary Teaching education course commenced in September 2012 and has been extended to include primary and post graduate courses. It has been in operation since September 2014.

Induction: The National Induction Programme for Teachers (NIPT) delivers a workshop programme for newly qualified teachers (NQTs). This involves participation in 10 of the 12 workshops offered is a Teaching Council requirement for registration. The primary literacy programme concentrates on teaching and managing a reading lesson.

Continuing Professional Development for Teachers: 781 summer courses were offered in 2014. All courses were required to include a focus on literacy (English and Irish), numeracy, school self-evaluation and school improvement.

Workshops were provided by the PDST in areas such as reading fluency, mental maths and writing through the education centre network. PDST in collaboration with the Special Education Support Service (SESS) co-designed, co-presented and co-evaluated new seminars for Principals and Link Teachers (Literacy and Numeracy) in relation to 'Improving Literacy and Numeracy through School Self-Evaluation'. SESS designed and delivered a new course: 'Communication and Language: Supporting Pupils with Special Educational Needs (Primary)'. The PDST also continues to provide in-school support with literacy in post-primary schools.

2.2.3 Improving the Curriculum and Learning Experience

Curricular change and innovation: The NCCA are currently developing a new integrated English and Irish specification at primary level. The NCCA's work is focussed on junior infant classes through to second class. The findings of this consultation process are informing the development of the curriculum. It is expected that the new curriculum will be available to schools from September 2015 and implemented from September 2016. The emphasis is not only on reading and writing but also on the listening and speaking aspects of the languages.

2.2.4 Measuring the Impact to Date

In 2011, Ireland participated in the Progress in International Reading Literacy Study (PIRLS) for the first time (PIRLS, 2011) which takes place every five years. These tests are carried out at primary school level and students in the equivalent of fourth class in reading. The Irish children that participated in the PIRLS were, on average, just over 10 years old. Irish pupils scored significantly above the international average in reading, ranking 10th out of 45 participating countries. Students in only five countries performed significantly better than Irish students.

Most recently the summary update on the implementation of actions in the Literacy and Numeracy Strategy were published in January 2015 (DES, 2015), which highlighted many positive points in Ireland's performance. Since this strategy was introduced Irish results in PISA (2012) have improved:

- Irish 15-year-old students' reading ability, both digital and print, were ahead of that of other countries: ranking 4th out of 34 OECD countries in print reading and 5th out of 23 participating OECD countries in digital reading.
- Students in Ireland performed at the OECD average on problem solving. Ireland is ranked 17th of 28 participating OECD countries and 22 of all 44 participating countries/economies. The proportion of students in Ireland performing below the baseline level of proficiency (i.e. below Level 2) is similar to the OECD country average.
- There is no significant difference between the performance of male and female students in Ireland. The performance on problem solving of both male and female students in Ireland is similar to the corresponding OECD averages.

- The mean score of students in Ireland with an immigrant background is significantly higher than the corresponding average for the OECD although significantly lower than that for native students in Ireland.

Results from the National Assessment of English Reading and Mathematics (2014) by the Educational Research Centre (ERC) also indicate an improvement in pupil performance, finding that the skills at both 2nd class and 6th class pupils are significantly higher than they were when previously assessed in 2009 i.e. improving by 14 and 13 points respectively. Thus representing the first major improvement in the assessment of reading and maths standards nationally in over 30 years (Kavanagh, 2015). Many of the targets set in the original strategy have already been met. An interim review of the strategy is currently underway, which will see new targets developed.

However, some challenges were also identified in the report by the DES (2015):

- The performance of Irish students on problem solving was good but there was considerable scope for development.
    - The problem solving performance of students in Ireland is over 18 points lower than expected given their performance in print mathematics, reading and Science and just under 10 points lower than expected when their performance on the computer based assessment of mathematics and reading are accounted for. This indicates that the effect of computer delivery on performance is about nine points in Ireland.
- Performance on the computer-based assessment of problem-solving is not as strong in Ireland.
    - The findings also suggest that a lack of familiarity with using computers (at home and at school) for school-related tasks may have contributed to lower performance on the computer-based assessments in Ireland and disadvantaged them relative to students in other countries.

2.3 Strengthening the Impact of the National Literacy Strategy

From the positive outcomes and challenges of the National Literacy mentioned above the following sections will now discuss and examine further possibilities and strategies to ensure such on-going achievements in literacy by developing a more integrated approach to the

curriculum specifically mentioning Science. Challenges and implications to such opportunities will also be discussed. The specific themes of the National Literacy directly related to this research were considered when approaching this section of the literature review which were as follows: *Improving Teachers' and Early Childhood Care and Education Practitioners' Professional Practice and; Improving the Curriculum and Learning Experience.* Strengthening the impact of the National Literacy part will be discussed under the following headings:

2.3.1 Responding to the Evolution of 'literacy'
2.3.2 Further embedding Integration in the Curriculum
2.3.3 Science and Literacy
2.3.4 Science and Oral Language
2.3.5 Science and Writing
2.3.6 Science and Reading
2.3.7 Continued Professional Development of Teachers

2.3.1 Responding to the Evolution of 'literacy'

Digital Literacy

From previously discussions in Chapter 1 regarding Literacy in the 21st Century and from the findings above (DES, 2015), literacy skills are continuously evolving and have changed from the traditional notion of literacy (Block, 1997; COE, 2001; Leu and Kinzer, 2000; Murnane *et al.*, 2012). We must ensure that we are catering for the literacy needs of an ever changing world which is becoming more and more dependent on technology in education and in everyday life.

Literacy is defined by the Oxford English Dictionary as the ability to read and write. The OECD (2009) provides a more comprehensive definition of literacy: *'Literacy is the ability to understand, use and reflect on written texts in order to achieve one's goals, to develop one's knowledge and potential, and to participate effectively in society'* (OECD, 2009, p.14). However, developments in technologies and changes in the demands in society, working life and in the education system have meant that literacy has taken on a wider meaning. Today, literacy encompasses the capacity to read, understand and critically appreciate various forms of communication including printed text, spoken language, digital media and broadcast media. Therefore new literacies exist through various forms of communication and in particular Information and Communication Technologies (ICT) (Leu, 2000).

Digitisation has added many more dimensions to literacy and thus changing the nature of literacy. Therefore the focus of the language education policy of Europe has changed from national languages to take in to account diverse linguistic, cultural identities and the development of web technologies such as the virtual communities, social networking sites, Twitter, YouTube, etc. (European Commission, 2010).

The National Literacy and Numeracy Strategy (2011-2020) states that:
'*Literacy includes the capacity to read, understand and critically appreciate various forms of communication including spoken language, printed text, broadcast media, and digital media. Throughout this document, when we refer to 'literacy' we mean this broader understanding of the skill, including speaking and listening, as well as communication using not only traditional writing and print but also digital media.*'

(DES, 2011, p.8)

While the definition of literacy in the strategy is extended to include new communications technologies, it fails to acknowledge the potential of using ICT to improve literacy skills (Moore, 1989, 1988, 1992). Its aims include to raise public awareness of the importance of oral and written language in all its forms (including print, writing and digital media) and to increase awareness of the importance of digital literacy and include assessments of primary students' ability to read digital material as part of the national assessments of English reading. The European Commission's research (Blamire, 2009) shows that a range of skills and competencies are acquired by using ICT, these include communication, language, digital, social and cognitive skills. The research, has found that the use of ICT had a positive impact on basic skill acquisition (reading, writing and arithmetic), promoting new pedagogical approaches, but for this to work it must be fully integrated into different subject areas (Labbo and Reinking, 1999; Leu, 2000).

The International Reading Association (2001) stated in their position statement on '*Integrating literacy and technology into the curriculum*' that in order to support students in developing new literacies that will be required in their future, we must have a literacy curriculum that integrates the new literacies of ICT into instructional programs; instruction that develops the critical literacies essential to effective information use; assessment practices in literacy that include technology and therefore needing teachers who are skilled in the effective use of ICT

for teaching and learning. The provision of supports, effective in-services and ongoing professional development programs are very important to ensure effective integration of literacy and technology (Margerum-Leys and Marx, 2002). Several studies have reported supports and support networks stimulate teacher use of technology and its integration within the curriculum (Leu, 2000; Moore-Hart, 2008; Vannatta and O'Bannon, 2002).

The digital world requires more higher-order problem-solving skills, with a greater ability to evaluate information critically. One of the aims of the Primary Science Curriculum in Ireland is *'to help the child to appreciate the contribution of Science and technology to the social, economic, cultural and other dimensions of society*' (DES, 1999a, p.11). There is a growing acknowledgement that one important aim of Science education should be to prepare students to engage with Science in the contexts they will encounter in later life (McClune and Jarman, 2010). There is also therefore a need for the ability to extract and use knowledge from an extensive variety of digital sources and resources (Leu *et al.,* 2007; Andrews and Smith 2011). Millar and Osborne (1998) in the UK have suggested that the capability to engage critically with Science-based news be promoted as a desirable outcome of a Science education. In the USA 'National Science Education Standards' also aims to promote an aptitude and ability to engage with Science issues which are reported in the press (National Research Council, 1996). Similar intentions are found in many curricular documents internationally. The capability and aptitude to engage critically with media-based Science can significantly contribute to children's scientific literacy and overall literacy skills. Therefore, the teaching of Science using a variety of media and digital sources can be two fold i.e. contributing both to the scientific literacy and to the digital literacy of children. When considering the development of literacy skills one must consider that initially higher order literacy skills need to be developed in children using both traditional and more modern forms of media (papers, magazines, printed materials and technology sources). Science lessons can contribute in this space over time, by laying the foundations for children to develop literacy skills as they progress through the different class levels of primary schools. They can the further develop critical literacy skills which then can be applied to digital sources.

2.3.2 Further Embedding Integration in the Curriculum

It is thought that pupils' affective and cognitive skills can be improved through thematic teaching approaches (Bruner, 1960). One of the underlying principles that inform the Irish

Primary School Curriculum states that *'learning is most effective when it is integrated'* (DES, 1999, p.16).

Integration of learning is an important element of the primary school curriculum where connections made in learning in different subjects are integrated into a broader and richer perspective emphasising '*the interconnectedness of knowledge and ideas and reinforces the learning process*' (DES, 1999, p.16). Since the implementation of the National Literacy and Numeracy Strategy an increasing emphasis has been placed on English and Mathematics in schools, with increasing teaching time being spent on writing, Mathematics and reading strategies such as 'Literacy Lift Off', 'Read Aloud', 'Drop Everything and Read', Paired Reading, 'Readers' Theatre', Choral Reading, Repeated Reading and Echo Reading etc. English and Irish teaching allocation times for the infant classes is now 6.5 hours and 8.5 hours per week for students with a full day, this is an increase of one hour overall for language (Irish and English) per week. The teaching allocation time for Mathematics was increased by 70 minutes per week to 3 hours and 25 minutes per week for the infant classes, and to 4 hours and 10 minutes per week for students with a full day (DES, 2011). We must question what does this mean for the other subject areas? Is there less time allocated to other subject areas to increase the number of 'English' lessons? However, literacy skills can be developed in any subject area across the curriculum.

The DES (2011) in it's **c**ircular to principals and teachers on the initial steps in the implementation of the national literacy and numeracy strategy suggested a combination of approaches that could be used to accommodate the increased allocation times by:

- using some or all of the discretionary curriculum time for literacy and numeracy,
- integrating numeracy and literacy skills with other curriculum areas,
- time spent on the other subjects in the curriculum could be re-allocated to the development of literacy and numeracy,
- prioritising curriculum objectives that are considered most valuable in supporting of some subjects such as the geography and history curriculum to the infant classes and first and second classes to later in the primary cycle.

(DES, 2011)

The implications for the classroom timetable will depend on how narrowly 'literacy' and 'numeracy' are interpreted within the broader often noted as the 'overcrowded' curriculum. It

depends on how principals and teachers implement the above recommendations. These implications will also impact very much on whether literacy skills are taught in a cross curricular way. What subjects will 'lose out' when time is constrained and will the ethos of the holistic approach to a child's learning be affected by this? Reducing time available for a range of other curricular areas which seems counterintuitive since research evidence supports the development of literacy skills across a range of curricular areas (Department of Language, Literacy, and Mathematics Education, 2011).

A report by McCoy, Smith and Banks (2012) commissioned by the ESRI 'The Primary Classroom: Insights from the Growing Up in Ireland Study' highlighted that the proportion of time spent on English is negatively associated with the amount of spent on all other subjects where the trade-off is greatest between English and Science, Geography and History except for Mathematics (see Figure 2). There also appears to be a trade-off between Mathematics and other subjects, except English and Irish, and again this is most evident for Science, Geography and History.

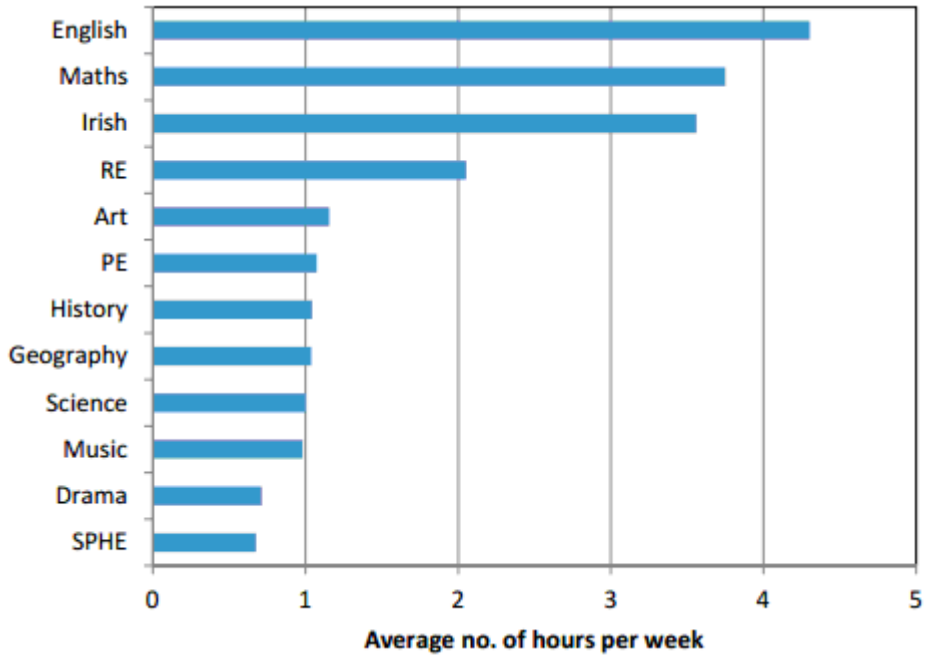

Figure 2. Average weekly time allocation to subject areas in Irish primary schools (Mc Coy, Smith and Banks, 2012).

Lavy (2010) found a significant relationship between the time spent on the language of instruction, Mathematics, Science, and test scores in those subjects across countries taking part in the PISA study (which covers 15-year-olds). These effects were stronger for Science and Mathematics than for language which reflects the more important role of school based learning

in these subjects (Mortimore *et al.*, 1988). However, the OECD (2010) noted that Irish students aged 9 to 11 years old spent comparatively more intended instruction time on religion and reading/writing and less time on Mathematics and PE than those in many other countries.

Not only should integration include interconnections of knowledge it should also include the use of teaching strategies and therefore the development of skills across the curriculum. The circular by the DES (2011) suggested to accommodate the increased allocation of literacy and numeracy time by integrating numeracy and literacy skills with other curriculum areas. However, the curriculum has a narrow enough vision of integration:

'*For the child, the distinctions between subjects are not relevant: what is important is that he or she experiences a coherent learning process that accommodates a variety of elements. It is important, therefore, to make connections between learning in different subjects. As they mature, integration gives children's learning a broader and richer perspective, emphasises the interconnectedness of knowledge and ideas and reinforces the learning process.'*

(DES, 1999 p.16)

Many definitions of integration traditionally include the following: A combination of subjects; An emphasis on project work; Sources that go beyond textbooks; Relationships among concepts; Thematic units; Flexible schedules and Flexible student groupings. However, they do not necessarily emphasise that educations should be developing integrated approaches in developing transferrable skills all needed for 21st century education and training rather than discrete, departmentalised subject matter (Humphreys, Post, and Ellis 1981; Palmer 1991).

Fogarty (1991) has described ten levels of curricula integration.

Table 2.1 Ten different levels of curricula integration (Fogarty, 1991)

Name	Description
Fragmented	Separate and distinct disciplines
Connected	Topics within a discipline are connected
Nested	Social skills and content skills are targeted within a subject area
Sequenced	Similar ideas are taught in concert, although subjects are separate
Shared	Team planning and/or teaching that involves two disciplines focuses on shared concept skills or attitudes
Webbed	Thematic teaching using a theme for a base instruction in many disciplines
Threaded	Thinking skills, social skills, multiple intelligences and study skills are 'threaded' throughout the disciplines

Integrated	Priorities that overlap multiple disciplines are examined for common skills, concepts and attitudes
Immersed	Learner integrates by viewing all learning through the perspective of one area of interest
Networked	Learner directs integration process through a network of experts and resources

These differentiations may move from two teachers teaching the same topic but in their own separate classes (e.g., both English and history teachers teaching about the same period of history), to team design of thematic units, to interdisciplinary courses or thematic units, to a fully integrated curriculum, which is also referred to as synergistic teaching. Synergistic teaching integrates what is learned and applied in one area of the curriculum is related and used to reinforce, provide repetition, and expand the knowledge and skills learned in other curriculum areas (Bonds, Cox, and Gantt-Bonds 1993). Synergistic teaching does more than integrate, it presents content and skills in such a manner that nearly all learning takes on new dimensions, meaning, and relevance because a connection is discerned between skills and content that transcends curriculum lines. Shoemaker (1991) highlights a key essential component of an integrated curriculum is core skills and processes. These include basic skills, such as reading and mathematics, as well as social skills and problem solving.

This research set out to explore the current practices of integrating literacy skills and associated teaching methodologies in primary Science lessons. The following sections will discuss and examine the rationale, possibilities and strategies in developing an integrated approach to the teaching of literacy and Science.

2.3.3 Science and Literacy

As previously mentioned, there is an authentic link between literacy and Science and they both go hand in hand. Science lessons can help in promoting literacy through oral language, reading and writing and the appropriate use of literacy in Science is needed to achieve a deeper understanding of Science and the ability to reason scientifically (Douglas *et al.*, 2006).

The key principles behind any primary Science curricula worldwide and Science in general are to provide children with opportunities to ask questions, manipulate materials, hypothesise, predict and test their predictions. These aims and principles are also central to the Irish Primary Science Curriculum (DES – Science and Teacher Guidelines, 1999a and 1999b).

The aims of Primary Science Education are as follows:

- to develop knowledge and understanding of scientific and technological concepts through the exploration of their environment,
- to develop a scientific approach to problem-solving placing emphasises on understanding and constructive thinking,
- to encourage the student to explore, develop and apply scientific ideas and concepts through designing and making activities,
- to foster the child's natural curiosity, so as to encourage independent enquiry and creative action,
- to help the student to appreciate the contribution of Science and technology to society,
- to cultivate an appreciation and respect for the diversity of living and non-living things, their interactions and interdependence,
- to encourage the student to behave responsibly to protect, improve the environment,
- to encourage discussion, resolution and avoidance of environmental problems so as to promote sustainable development,
- to enable the student to communicate ideas, present work and report findings using a variety of media.

(DES, 1999a, p.11)

The primary Science curriculum states that '*practical investigation is central to scientific activity and to the development of inquiry skills*' (DES, 1999b, p.51). Inquiry based Science lessons which incorporate the constructivist approach to teaching empowers pupils to think critically, make deep connections through questioning, exploring, thinking, experimentation and reflecting and applying this understanding in a productive way into actionable knowledge (Grabe and Grabe, 2000; Abrahms, Southerland and Evans, 2007). All of which are carried out through exploratory talk, dialogue, reading and writing.

The philosophy of inquiry based learning finds its roots in constructivist learning theories, such as the work of Piaget, Vygotsky, Dewey, and Freire. Pupils always work collaboratively and group work facilitates the acquisition of knowledge, developing team work, communication and problem solving skills through sharing thoughts and ideas and information (Johnson and Johnson, 1989; Webb, 1982).

Goswam (2008) also found that children usually learn more effectively with others than they do on their own. These conditions helps facilitate the children in becoming more autonomous learners, and small groups and pair work can make this an integral part of the lessons. The Primary Science Curriculum is based on the constructivist philosophy which regards education as a process - a child-centred education, in which the child is seen as an active agent in their own learning (DES, 1999). The child constructs this knowledge by interaction with others (Muijs and Reynolds, 2011).The revised curriculum (1999) emphasises explicitly in the guidelines for teachers the use of constructivist approaches in the different subject areas and the importance of using 'hands-on' activities and peer learning (child-child discussion).

A very important characteristic of integrated thematic teaching is that it helps children make sense of their world around them, also a key principle of primary Science curricula (Mitchell and David, 1992). A feature of integration is that children never learn concepts, knowledge and skills in isolation (Gibson-Quick, 1999). An integrated cross curricular approach can help to achieve progress in Science.

However, the integration of Science with other subjects can prove to be difficult for teachers due to curricular, time and policy constraints, when not carried out effectively (Harlen, 2000, p.238). A report by McCoy, Smith and Banks (2012) commissioned by the Economic Social Research Institute (ESRI) 'The Primary Classroom: Insights from the Growing Up in Ireland Study' found that whole-class teaching continues to be the dominant approach used in the primary school classrooms (Murphy, 2004; NCCA, 2005, 2008). Active collaborative learning methods which all contribute to a child's literacy and in particular oral language development are used less often than had been envisaged in the primary school curriculum and is much less prevalent in larger classes indicating the constraints of class size on the effective implementation of the primary curriculum. McCoy, Smith and Banks (2012) also noted that many teachers find covering the entire curriculum in the time available challenging along with having to provide differentiated learning opportunities within the context of larger classes and most notably, in the area of Mathematics. These findings show that there is a need to support and target teachers' professional development in utilising a range of pedagogies in active teaching methods not only in Science but across all subject areas to ensure an integrated approach to developing children's oral language skills (Murphy, 2004). Irish Studies found that teachers are mainly focused on Mathematics and English, stating that there is not enough time

to cover everything in the curriculum to the detriment to such subjects as Science (Murphy *et al.*, 2011; Varley *et al.*, 2008).

The following section will now discuss primary level Science and examine the interconnected links between it and the primary level English.

2.3.4. Science and Oral Language

The Primary School Curriculum's principles states that:

'*Language has a vital role to play in children's development. Much learning takes place through the interaction of language and experience. Language helps the child to clarify and interpret experiences, to acquire new concepts, and to add depth to concepts already grasped. In view of this crucial relationship between language and learning the curriculum incorporates the use of talk and discussion as a central learning strategy in every curriculum area. This facilities the exploration of ideas, emotions and reactions through increasingly complex language, thus deepening the child's understanding of the world.'*

(DES, 1999, p.15)

'*A great deal of education is to do with learning how to use language – to represent ideas, to interpret ideas, to formulate problems and to solve them*.'

(Mercer, 1995)

Language is essential when expressing and exchanging ideas, developing views and knowledge, and in communicating with others. Ellis (2005) found that the social domain of language interaction can be viewed as the primary source of learning. Lightbown and Spada (2006) also found that by engaging in meaningful communication from the beginning, the conditions are created to help with language development. Language helps us to understand the world around us. Therefore the use of language is a key characteristic in the effective teaching and learning of Science. Scientific knowledge depends *'inextricably on language and language is also central to our ability to think'* (Evagorou and Osborne 2010, p.136).

Fluency, grammar, vocabulary and pronunciation is developed through oral language activities. Oral language in Science can be developed through exploratory talk, argumentation dialogue in general which will be discussed in further detail in the proceeding sections. Grammar,

vocabulary and pronunciation can be addressed by the teacher as it arises incidentally in a Science lesson where the main focus is on communication and meaning (Long and Robinson, 1998).

2.3.4.1 Exploratory Talk

Exploratory talk can be described as effective talk in which everyone is invited to give their own ideas and to challenge each other respectfully, sharing information and reasoning out their ideas (Loxley *et al.,* 2014). Active listening and having interest in different points of view are also learned through this process. Jones (1988, p.72) states that:

'*pupil talk in a lesson has many functions. It increases the understanding of concepts, to learn how to communicate clearly with others, makes them active learners, gives them a diversity of viewpoints and a critical tolerance of others*.'

Children become aware of the importance of discussion and that it is ok to change one's point of view in response to a good reason.

Exploratory talk in the classroom should include the following rules:

- Include everyone in the discussion,
- Share all relevant information openly,
- Listen attentively,
- Ask questions,
- Challenge one another's ideas and opinions with respect,
- Ask for reasons for ideas,
- Seek to reach a group agreement before proceeding.

(Loxley *et al.*, 2014)

Such oral language skills are crucial in the Science classroom in order for effective learning to occur. Therefore the practice and development of key scientific process skills through exploratory talk contribute significantly to developing the child's oral language and communication skills.

2.3.4.2 Dialogic Teaching and Talk

'*Dialogic teaching harnesses the power of talk to engage children, stimulate and extend their thinking, and advance learning and understanding'.*

(Alexander, 2006, p.27)

Dialogic interaction allows students to work collaboratively in developing their knowledge. Alexander (2004) that states that this is carried out using:-

- discussion where students share information, exchange ideas and problem solve,
- dialogue where students are achieving common understanding through structured and cumulative questioning.

Alexander also found that these elements *'are the rarest yet most cognitively potent elements in the basic repertoire of classroom talk'* (2005, p.30). Collaborative classroom talk allows students to engage in a coordinated and continuing attempt to solve a problem or to construct common knowledge (Mercer and Littleton, 2007, p.25). At primary school level small group discussion in the Science classroom has proven to develop both student knowledge and reasoning (Mercer *et al.,* 2004). Internationally published literature details how Science can be successfully integrated with literacy to teach Science concepts (Barber *et al*., 2006; Burton and Campbell 1996; Heisey and Kucan, 2010; Jackson *et al*., 2010; Poon 1990; Rule *et al*., 2004; Watts 2001). Davies and Milne agree that as children talk to each other and to teachers they are enabled to *'rehearse their own scientific explanations, debate different ideas about phenomena and construct shared understandings'* (2010, p.89) Consequently they learn the language of Science through speech.

Dialogic teaching uses exploratory talk but in this instance the teacher is expected to organise and shape the talk, leading to effective classroom discussions so as to enable the students to gain deeper understanding. The role of the teacher is paramount in the development of children's' oral language in early year's Science as they provide dialogic teaching opportunities which have a cumulative effect and also raises pupils' awareness of the potential educational power of talk (Mercer *et al*., 2009). Teacher intervention finds out what the students think through dialogue, engages with their developing ideas and helps them clarify misunderstandings. Learners develop interactive skills such as asking questions, responding, listening, presenting and evaluating ideas (Alexander, 2004). Other studies by Azmitia and Montgomery (1993) found that children's dialogue is significant in their problem-solving

abilities. Mercer (2000) describes this spoken language between each other collectively making sense of experience and problem solving as 'interthinking'. Wegerif *et al.*, (2004) promotes dialogic talk where the group accept challenges, takes the responsibility for decision-making, where all relevant information is shared, alternatives are discussed and everyone in the group is encouraged to speak.

2.3.4.3 Argumentation and Critical Reasoning in Science

Wenger states that *'Learning to become a legitimate participant in a community involves learning how to talk'* (1998, p.105). Barnes (1976) distinguishes between speech as communication and speech as reflection. Barnes describes the reflective part as sorting out one's own ideas aloud 'thinking aloud'. Elements of Critical literacy can begin to be developed in Science lessons through Inquiry Based Learning (IBL) and argumentation. The knowledge gained through Science can be used to make informed decisions regarding ethical, societal, medical and environmental issues. The National Science Education Standards states that *'the knowledge and understanding of scientific Science and processes required for personal decision making, participation in civic affairs and economic productivity'* (NRC, 1996, p.2). According to the socio-constructivist learning theorists Duit and Treagust (1998) knowledge emerges by collaborative search of problem solutions in communities with distributed information among its members (Bell *et al.*, 2010, p.351).

Cavagnetto (2010) and Maloney and Simon (2006) argue that mere surface level engagement with inquiry Science using the Science process skills is inadequate. Instead pupils must talk about the process they are engaging with for meaningful internalisation of the scientific concepts. Argumentation involves making reasoned claims that are backed up with evidence or data. Argumentation is 'a social and linguistic process, where co-operating individuals try to adjust their intentions and interpretations by verbally presenting a rationale of their actions' (Patronis *et al.*, 1999, pp. 747-8). It is important to give students opportunities to reason for themselves and by examining their own misconceptions and to discuss scientific ideas (Evagorou and Osborne, 2010). From a cognitive aspect argumentation requires students to put forward evidence with a claim, this develops the ability to construct links and to evaluate the accuracy of a claim (Driver *et al.*, 2000; Kuhn, 1993). Simon *et al.*, (2007) outlines the following steps in order to facilitate argumentation in the primary Science class: facilitate talk and discussion through the use of small groups for pupils to work in, explicit teaching of pupils

how to position themselves in an argument through the use of role play, teaching pupils how to use evidence gathered from inquiries to support arguments, teaching pupils how to structure an argument through the use of talk frames and teaching pupils how to evaluate arguments made.

2.3.4.4 Challenges in Developing Oral Language Skills through Science

Bakhtin (1981) argues that to gain confidence in any language requires the use of talk. However, it has been found by many studies that the opportunities for students to talk within the Science classrooms are minimal. Only about 5% of talking is permitted in classroom time compared to 40% of the time that students spend listening to the teacher (Gallas, 1995; Newton *et al.*, 1999). Jones (1988) found that teacher talk dominated the talk in the Science classroom or was overshadowed by reading and writing. Lemke (1990) found that teachers tend to use closed questioning and to make low level cognitive demands on students. Lemke emphasised the need for open-ended questions which invite extended reasoning by students and engages them more in what's being discussed.

Research also shows that teachers don't wait long enough for a student to respond to a question (Rowe, 1974). Rowe also noted that training teachers to increase the 'wait-time' to an average of 3 seconds in which to wait for a response from students led to a significant improvement in the quality of answers. In the Science classroom talk includes speaking, listening and learning. This research set out to investigate Irish primary school teachers' experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy skills. It will seek to evaluate the value teachers place on utilising Science lessons as an approach in developing literacy skills in the classroom.

It is of critical importance that oral language development is promoted throughout the education process as it is the foundation on which the development of literacy skills stems from. However, reports consistently show that oral language development remains problematic in its implementation in classrooms and thereafter (e.g. DES, 2005; DES, 2010) and internationally (e.g. Alexander, 2003; Corden, 2007; Wasik *et al.*, 2006). Research highlights that once the important initial phases of learning to read of code-related skills such as phonological awareness is grasped by the child, therefore a broad range of oral language skills such as knowledge of vocabulary, discourse skills, oral comprehension, syntax, productive

narrative skills, fluency and comprehension need to become increasingly essential elements of literacy (Bowyer-Crane *et al.,* 2008; Muter *et al.,* 2004; Dickenson *et al.,* 2003; Locke *et al.,* 2002; Catts and Kamhi, 1999). These findings show the importance of oral language for the development of literacy skills at all levels of children's education. Other studies have also claimed that the separate approach to education has a deadening effect on pupils' experiences. Pupils therefore fail to see the links between subjects, instead they see them as isolated blocks of knowledge with little or no links to each other, and therefore the curriculum can only increase its relevance by linking the subjects (Beane, 2009; Jacobs, 1989).

The English curriculum at primary level in Ireland states that:
'*The acquisition of literacy is a principal concern of the English curriculum and this reflects stated national policy. It is important that reading, comprehension and writing skills are acquired systematically and that children with particular learning needs are identified at an early stage and provided with adequate remedial support.'*

(DES, 1999, p.2)

Research by Guthrie *et al.,* (2001, 2001, 2004), Romance and Vitale (1992, 2001), Magnusson and Palinscar (2004) and Klentschy and Molina-De La Torre (2004) have provided compelling evidence that demonstrates the impact of integrating reading and writing in Science on both Science, writing and reading comprehension achievements. The following sections will discuss this in greater detail.

2.3.5 Science and Writing

'*writing in Science is not only for communicating with others; it is also a tool for learning that supports scientists and students alike in clarifying thinking, synthesizing ideas, and coming to conclusions.*'

Worth *et al*., (2009)

Science writing helps students analyse and clarify their thinking, synthesising their ideas and communicating them with others. Science notebooks are becoming more prevalent in inquiry based Science instruction. Science utilises the essential components of proficient expository writing including organised thinking, conceptual understanding and writing structures. With expository writing, the students state information or ideas clearly and develop relevant evidence, explanations and details. There is a logical sequence with use of local transition

words to show logical connections. Scientific vocabulary is used accurately and non-scientific vocabulary is used effectively to clarify and explain ideas, concepts and inferences drawings (Douglas *et al.,* 2006, p.88). With students Science notebooks drawings are also an important part of the learning process. The students' ideas of the specific subject area can be expressed in practical (doing the experiment(s)), visual and linguistic form. The relationships between the experiment(s), words and pictures can be identified and analysed and provides more insight into the students Science understanding. Student drawings show the sophisticated ways in which the students think about ideas including labelling/captioning pictures and maybe even dialogue bubbles (Kress and Van Leeuwen, 1996; Unsworth, 2001).

Texts are written in different formats. For example text can be narratives (tell stories) or can be expository (explain information). Texts can be written in different styles and in the why that ideas are phrased to suit a particular audience. Science texts relies heavily on stating information in a certain format (e.g. cause and effect relationships, problems and solutions) and with technical language also being used (e.g. property or solutions of chemicals). As children develop their conceptual understanding they can use word banks structured like mind maps or graphic organisers to help organise their thinking, help students remember what they have learned and this in turn leads to deeper levels of understanding as students construct and explain their own organisers (e.g. tables, graphs, models and drawings (Douglas *et al.,* 2006, p.80).

'*in the classroom [Science writing and Science talk] are inextricably linked. Small- and whole-group discussions are often rehearsals for writing conclusions and reports, and quick-writes before a discussion can start ideas flowing. Discussion pushes students to clarify their ideas before they write their conclusions or write a more formal piece about their Science experiences.*'

(Worth *et al*., 2009)

There is a strong relationship between Science writing and Science talk. Talking can be a precursor to writing, and writing can be a precursor to talking. Children talk about Science with their teacher and peers recording this through writing activities so they can listen to others and rehearse their own language and ideas before printing them. On the other hand, writing can help students collect their thoughts without inhibitions before speaking. And a piece of Science writing, such as an entry in a Science notebook or on a posted word bank, can be a resource for

students to refer to during a Science talk. The combination of Science talk and Science writing supports the learning of Science ideas and, in the process, helps students develop the language to express these ideas.

2.3.6. Science and Reading

Reading comprehension is classified in two ways: the purpose of the text and the processes the reader must use in order to interpret the text**.** For young children, the main aims of reading are to acquire and use information or for literary experience (Mullis, Kennedy, Martin and Sainsbury, 2006). Literary experience requires the reader to engage with the text and to picture in their mind these imagined events, and to enjoy the language itself. Reading for informational purposes requires the reader to engage with aspects of the real universe and learn how the world is, how and why things work as they do. Reading comprehension is also classified by the process (Retrieve, Infer, Interpret and Integrate, Examine and Evaluate) in which the reader uses to comprehend text. These processes are very similar to scientific process skills developed in the primary Science curriculum, which can be seen in Table 2.2 below.

Table 2.2 Comparison of Literacy Skills and Science Process Skills (The National Centre of Education and the Economy and the Learning Research and Development Centre, 2000).

Literacy Skills	Science Process Skills
Note details	Observe and retain small details
Compare and contrast	Compare and contrast
Predict	_____ will happen because _____ If _____ then _____
Sequence of events	Process of logic and analysis
Link cause and effect	What causes things to react in a particular way
Distinguish fact from opinion	The use of evidence to support claims
Link words with precise meanings through experiences	Develop operational definitions of a concept
Make inferences	Make inferences based on observation and evidence
Draw conclusions	Draw conclusions by combining data from various sources

Reading comprehension is an essential part to both English and Science. Reading strategies used in Science teaching involve asking self-questions before, during after reading to act as a guide and when making predictions about the material to be read, discerning word meaning from the context and checking comprehension (Duke and Pearson, 2002). Good readers employ these strategies automatically. However, these strategies are consciously used when

comprehension is challenged (Wade, Trathen and Shaw, 1990). When a reader reads new text, this process involves word recognition knowledge, background knowledge, vocabulary knowledge, linguistic and textual knowledge, to consciously use strategies to make sense when comprehension is challenged and the ability to infer meaning and to have interest and motivation to engage in reading text. Classroom teaching strategies can help to scaffold students' comprehension of target texts by supporting students by prompting them to use the modelled independent reading strategies. A preview guide strategy in Science can be used to help support students to set up a purpose for reading in the guise of preview questions focusing on what students need to learn from the reading passage. These questions would be examined before reading begins to illicit predictions from the students and again after reading the text to illicit answers after reading the text. The reading is more purposeful as a result (Douglas *et al.*, 2006).

2.3.6.1 Challenges in Developing Reading and Writing Skills through Science

The Irish primary curriculum, views the English language learning as an integrated process in which oral language, reading, and writing are inseparable (NCCA, 2012). In relation to writing sometimes seen as *'the ignored stepchild of reading'* (Bradley, 2001, p.118) or the silent 'R' (NWP and Nagin, 2003, p.2). However, in the Response to the Draft National Plan to Improve Literacy and Numeracy in schools, it does not state clearly the *'equal contribution'* that both reading and writing make *'to the child's language development'* (Department of Language, Literacy and Mathematics Education, 2011, p.11). The document uses the term 'literacy' generally in the context of discussing reading, and almost exclusively in terms of the elements of reading which can be evaluated and assessed easily. The draft plan has a limited view of writing *'as perfect spelling and grammar and/or neat penmanship'* (Bradley, 2001). To attain competence in writing, writers must also be proficient in generating ideas, planning, organising, drafting and redrafting writing. Resnick and Hampton (2009, p.17) noted that that:

'Students…must understand that getting ideas down on paper is only a first step. They must be willing to rethink how these ideas are organised and expressed and to examine a draft in light of how well it communicates. They must make needed changes willingly…They must assume responsibility for various rounds of changes until, finally, the document communicates and is as good as they can make it…'

Lerner and Kline (2006), highlight many related abilities that writing requires, for example good verbal skills, the ability to read, and cognitive strategies for problem solving. Teachers must ensure to always adopt effective approaches to help children to become competent writers and to engage in the type of writing across the curriculum in many subject areas. Science provides a very suitable opportunity for this to be carried out. Process Writing is an effective approach which is advocated in the English Language Curriculum. However, there are other approaches such as Strategic writing, Genre writing, Writing across the curriculum and on demand writing. Some schools use writing Portfolios (using samples of children's writing) which is a very 'effective way of encouraging children to invest in the literacy process' (Pahl and Rowsell, 2005, p.126).

2.3.7 Continued Professional Development of Teachers

'*A curriculum only really comes to life in the hands of teachers in classrooms*.'

(DES, English Primary School Curriculum, 1999)

One of the key challenges identified internationally and in Ireland is the provision of a once-off workshop model which is mainly short-term in nature (Conway *et al.,* 2009). Recent CPD and in-service teacher course evaluation studies have found that CPD provision is fragmented and there is a lack of learner centred structures (Loxely *et al.,* 2007; Granville, 2005; Coolahan, 2003; Sugrue, 2002). Research by Loxely *et al.,* (2007) found that teacher effectiveness in the classroom is not improved by doing a once off CPD course. Burke (2004) highlights the lack of teacher involvement in CPD design and the fragmentation of these programmes and notes the difficulty of getting cover for teachers who wish to do a course during school time (2004, p.16). Coolahan (2003) found that there needs to be greater coherence and integration with regard to teacher educational development.

Many CPD courses run over the summer months and it is difficult for some teachers to find the time to do these courses. Teachers generally pay for these courses with teachers giving up several days of their holiday time freely to attend these courses face-to-face or online. The benefit of these summer courses to teachers' professional development is questionable. These courses are generally taken at the beginning of the summer holidays and there is no form of follow-up after the holidays to support implementation. Teachers who do one CPD course over the summer months are entitled to three extra personal vacation (EPV) days over the school

academic year. However, schools are not provided with substitute cover for EPV days and teacher's colleagues have to absorb the extra children into their classes which are already quite large. This represents a poor model of professional development.

There are some incentives for teachers to progress with studies in some areas of CPD where refunds will be given for specific courses undertaken and successfully completed and time to do these courses is also given to the teacher. However, these courses are mainly linked with special education. There had been an incentive to improve with regard to achieving a Masters or a Post doctorate qualification (an extra allowance was given in the teacher's wages) but this was removed in 2012 as part of the cutbacks. It would be advantageous if the Department of Education and Skills and the Teaching Council developed a model of teacher career development that would encourage and reward ambition and achievement.

The Department of Education have set up the PDST in 2010 to help restructure the support service system. Continual development courses are managed at regional and local levels. There are twenty one full time and nine part time Education Centres nationwide. These centres try to meet the needs of the local schools and teachers' needs and they also deliver national programmes (Egan, 2004). Under this framework Irish Primary Schools are currently introducing best practice methodologies in literacy and numeracy teaching. CPD courses are being rolled out all over the country by the PDST to facilitate this new national strategy. However, there have been no formal specific models and CPD courses designed and implemented by the PDST showing teachers how literacy skills can be effectively developed in the Primary Science Classroom. Facilitators of summer courses must fill in an application to the DES for approval of their course every year. As part of this process they are required in their application to ensure literacy is addressed in their courses. This is a welcomed move but one has to question the extent and quality of the integration in some courses.

No framework or formal strategy has been published to date in relation to the curricular area of Science.

2.4 Science Inquiry Programmes

The following Science inquiry programmes are have been trialled and implemented effectively in primary schools in other countries. Three of these programmes will be examined in the literature review and the methods used within these studies will be explored in detail.

2.4.1 Vallé Imperial Project in Science (VIPS)

VIPS is a systemic programme in Science and teacher professional development. VIPS was developed in partnership with 5 third level institutions and 16 school districts of Imperial County and is based on a need identified by The National Science Resources Centre (1994). This model of learning is of benefit to English language learners (Klentchy and Molina-De La Torre (2004); Amaral, Garrison and KLentchy (2002); Saul *et al.*, (2002); Jorgenson and Vanosdall (2002)) in that it includes a strand that focuses an ELD strategies for teaching Science. There are many English language learners theoretical models that can be used to help improve students' English language. However, students' level of language fluency will not prevent the student from learning language acquisition strategies in other domains (Douglas et al., 2006). ELD strategies integrated into Science instruction is an excellent way for students to make connections between process skills and Science content (Douglas et al., 2006). Vocabulary building is the main focus where teachers can help students build on their vocabulary by keeping a record of these using a *"working word chart*" when discussing Science materials before the lesson begins. Strips of paper with the new word or reviewed word can be added to the word wall chart by the teacher. The teacher models how to read the information from the chart to the students. The "*working word chart*" helps the English language students with their writing (see Appendix A).

2.4.2 IDEAS

IDEAS was setup initially to help students master the core concepts of Science within The Science curriculum in the USA. IDEAS provides an overlap between reading and Science process skills (Crocker et al, 1986). The IDEAS model of integrated Science and language arts instruction was developed by Romance and Vitale (1992, 2001). The time allocated for traditional literacy instruction was replaced with a 2-hour block of Science (IDEAS) instruction that included attention to reading and language arts skills. The Science instruction involved first hand experiences, being concept-focused, giving attention to Science process skills, reading, concept mapping, having discussions and journal writing.

In implementing IDEAS, teachers usually engaged the students with hands-on activities first and then reading activities in order to ensure *'that students had the learning experiences needed to make critical reading more purposeful'* (Romance & Vitale, 1992, p. 547).

Romance and Vitale (1992a) argue that schools are unlikely to increase the amount of time needed for teaching Science and therefore by embedding reading/language into the 2 hour block for Science, this could remedy the problem within the Primary School Curriculum framework. (see Appendix B).

2.4.3 Wondering, Exploring, and Explaining (WEE)

WEE Science is a reading/Science programme designed for students in the middle classes of Primary school to promote Science through reading and Science activities. The programme is structured to result in improved Science instruction (Rutherford and Ahlgren, 1990) as well as to make the instruction of Science meaningful for the classroom teacher. This programme also strives to promote fun in "wondering". This research noted the fact that reading to learn or content-area reading is sorely absent from most primary school classrooms. With these insights in mind the WEE programme (an integrated Science and reading programme for the middle to upper primary school classes) was designed by Anderson, West, Beck, Macdonell, and Frisbie (1997).

Co-operative learning is used in the WEE programme where learning Science is carried out in groups. Slavin (1980) defines cooperative learning in the classroom as *'classroom techniques in which students work on learning activities in small groups and receive rewards or recognition based on their group's performance'* (p. 315). Co-operative learning in the WEE Science programme proved very beneficial in the positive influences on student learning (i.e., for high-level cognitive learning outcomes). Slavin (1980) found that for high-level cognitive learning outcomes, such as those attained in the WEE Science, *'structured cooperative techniques that involve high student autonomy and participation in decision-making may be more effective than traditional individualistic techniques'* (p. 337). Each group were asked to assign roles/responsibilities to its members (see Appendix C).

2.5 Conclusion

This chapter examined international and national perspectives and policy at a macro and micro level on literacy, it examined policies on literacy skills (in the United States, Europe and the UK), from policies to implementation and measuring this impact to date. However, reports on current practices and the implementation of the National Strategy in Literacy and Numeracy in

Ireland questions the extent to which there is a focus on developing literacy skills across the curriculum. Reports by McCoy, Smith and Banks (2012), Murphy *et al., (*2011) and Varley *et al.,* (2008) show that in Ireland the proportion of time spent on English is negatively associated with the amount of time spent on all other subjects where the trade-off is greatest between English and Science, Geography and History except for Mathematics.

The literature review then went onto focus on how we could look at strengthening the National Strategy on Literacy looking at firstly how literacy has evolved as more of an integrated skill and discussing the idea of further embedding literacy skills across the curriculum and then focusing in on the subject of science. Strengthening the impact of the National Literacy and Numeracy Strategy was discussed under the following headings: Responding to the Evolution of 'literacy', Further embedding Integration in the Curriculum, Science and Literacy, Science and Oral Language, Science and Writing, Science and Reading and Continued Professional Development of Teachers.

Much of the research that was mentioned in the internationally published literature above details how literacy skills can be successfully integrated into science lessons to teach science concepts and the development of scientific skills i.e. looking at integrating specific oral language, reading and writing activities into science lessons. However, very few studies have taken a step back and explored teachers' opinions on and attitudes towards the use of Science lessons in, fostering the development of Literacy Skills. Very little research has been carried out in this area to date in Ireland also. The literature in this study therefore looked at the challenges that teachers find internationally in integrating literacy skills in science lessons in an attempt to understand what is happening on the ground in classrooms.

It was then decided the focus of this study was to take a step back and explore what are the current practices and strategies being implemented with the aim of promoting and developing literacy skills in Irish primary Science classrooms and investigating to what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons.

The literature reviews mentions Continuous Professional Development (CPD) courses for teachers and how courses are being rolled out all over the country by the PDST to facilitate this new national strategy. However, there have been no specific models and CPD courses designed and implemented showing teachers how literacy can be effectively developed in the Primary

Science Classroom. Therefore, this study not only looked at to what extent literacy strategies were being incorporated into science lessons which are linked to challenges to the integrating of literacy skills in a more cohesive manner in science lessons but it also investigated the teachers' background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science.

The literature review has highlighted the need for such an important piece of exploratory research, investigating teachers' experiences of, opinions on and attitudes towards the use of science lessons to enhance children's literacy skills to inform the design and development of future frameworks, guidelines and CPD courses for the integration and effective development of literacy skills in science lessons.

Integrating and Encouraging the Development of Literacy Skills in the Irish Primary Science Classroom

Chapter 3: Methodology

3.0 Introduction

This chapter has provided an overview and a rationale for the research design and describes in detail the data collection methods employed in order to address the aims and research questions set out in this dissertation. The methodology documented *'the overall approach to the research process, from the theoretical underpinning to the collection and analysis of data'* (Hussey and Hussey, 1997, p.54). It sought to justify the adopted approach and outline the steps taken to collect, analyse and interpret the data. Ethical considerations, along with the validity and reliability of the research were also taken into consideration.

3.1 Research focus

This research was an inquiry into the current practices of integrating literacy skills and associated teaching methodologies into Science lessons in Irish Primary Schools. It involved an exploratory mixed methods design of data collection, investigating, identifying and examining the literacy strategies and approaches used by teachers during Science lessons by gathering both quantitative and qualitative data through the means of teacher questionnaires and semi-structured interviews.

The project also investigated teachers' experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy skills. This study has unveiled meaningful insights into the development and support of early literacy competencies in a more integrated manner across the Irish Primary School Curriculum.

3.1.1 Research Question and Embedded Questions

This research involved an exploration into how the development of literacy skills are being integrated and encouraged in the primary Science classroom in order to the answer the research questions set out below which in turn influenced the selection of data collection methods. Bryman (2012) states that:

> ‘*One of the chief manifestations of the pragmatic approach to the matter of mixing quantitative and qualitative research is the significance that is frequently given to the research question… This position with regard to the debate about quantitative and qualitative research prioritizes the research question and relegates epistemological and ontological debates to the sidelines. In doing so, it clears the path for research that combines qualitative and quantitative research.’*
>
> (Bryam, 2012, p.118)

The research questions were divided into an overarching research question addressing both quantitative and qualitative aspects of the research study which was further broken into separate quantitative and qualitative questions addressing such aspects of the study separately.

The overall research question was as follows:
What are teachers’ opinions on and attitudes towards the use of Science lessons in, fostering the development of Literacy Skills in the Irish Primary Science Classroom?

This was further broken down into specific embedded questions:

1. *To what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons?*
2. *What are the most common oral language approaches employed by teachers in the teaching of primary Science?*
3. *What are teachers’ opinions on using primary Science lessons to enhance children’s oral language skills?*
4. *What are teachers’ background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science?*

3.2 Paradigm

A phenomenological perspective was adopted throughout the study as the research is concerned with the lived experience of the participants involved. *‘Phenomenology aims to study the natural attitude as a reality based on experience’* (Hart, 2005, p.211). The aim was to translate the opinions and practices of teachers in supporting children’s oral language development in Science lessons into viable, collectable data. The research followed a pragmatic approach using an explanatory, sequential mixed methods design (Creswell, 2015).

3.3 Overview of the Research Process: Mixed Methods

A **sequential mixed methods approach** was used in this study gathering both quantitative (closed-ended) and qualitative (open-ended) data, integrating the two, and then drawing interpretations based on the combined strengths of both sets of data to gain an understanding in order to address the research aims and questions (Creswell, 2015). Therefore, quantitative data from Phase One of the study informed the qualitative methods used in Phase Two (Tashakkori and Teddlie, 1998). An **Explanatory Sequential Design** was employed by firstly gathering quantitative data and then conducting a second qualitative strand to further explore and explain the quantitative results (Creswell, 2014). Mixed methods research combined elements of qualitative and quantitative research approaches for the broad purposes of breadth and depth of understanding and corroboration (Bryman, 2012; Johnson; Onwuegbuzie and Turner, 2007; Creswell, 2009). This will be further discussed in section 3.4 below.

The Explanatory Sequential Design (See Figure 3) involved collecting and analysing quantitative data gathered in questionnaires to primary schools teachers in the first phase.

1. Examining the results of the quantitative analysis to determine:

(a) what results needed further exploration in the second, qualitative phase,

(b) what questions were required to ask participants in this qualitative phase.

2. Conducting qualitative data collection and analysis in the second phase to explore the topic further helped to explain the quantitative results.
3. Drawing inferences about how the qualitative results helped to explain the quantitative results.
4. The results from the separate data collections and analysis were then reported by merging the results.

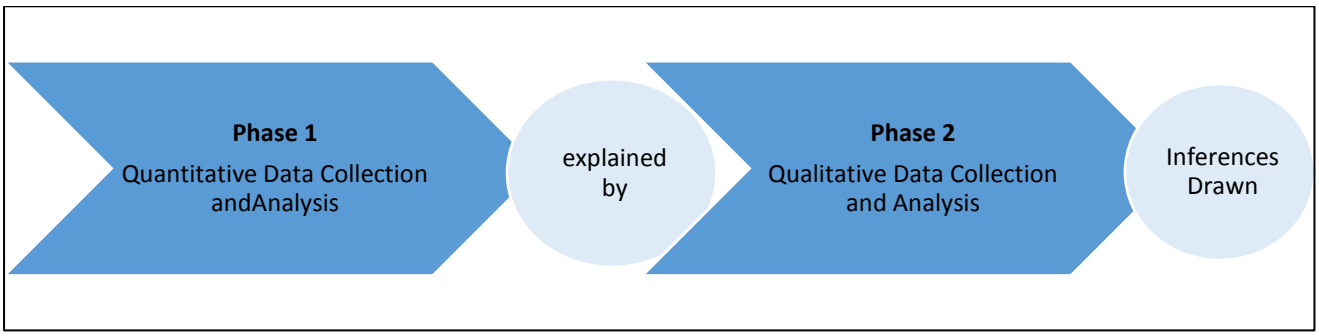

Figure 3.2 Explanatory Sequential Design used in this Research Study.

3.3.1 Research Design

Phase 1:

A nationwide questionnaire was carried out to gather both quantitative and qualitative data, investigating *to what extent teachers incorporate literacy teaching strategies and approaches in their primary Science lessons to enhance children's literacy skills.* In order to make the implementation of a nationwide questionnaire feasible, it was distributed through an online survey tool. However, the researcher also considered the possible lack of internet access and for this reason, questionnaires were also distributed to teachers by post or in person. The findings of the questionnaires in Phase 1 were examined and analysed and then were used to further inform the design of semi-structured interviews (Figure 3.1).

Phase 2:

Semi-structured interviews were conducted to explore in further detail *teachers' opinions on and attitudes towards the use of Science lessons to enhance children's literacy* skills and the teachers' background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science (Figure 3.1).

Phase 1 and 2:

Figure 3.1 shows a flow diagram of phases 1 and 2 in detail, showing each step in the process. The research question and embedded questions were the focus of the questionnaires and the interviews. Consent forms were sent to all potential participants. The questionnaires were set out to gather a comprehensive view of teachers' experiences and attitudes with regard to improving oral language through inquiry based learning in Science. Background information gathered will also help with creating themes and with regard to contrasting and comparing information that may come to the fore. The results from the questionnaires will help to inform what further information may be required through the interviews. The results from the interviews and the questionnaires will be examined, themes formed and analysed in detail.

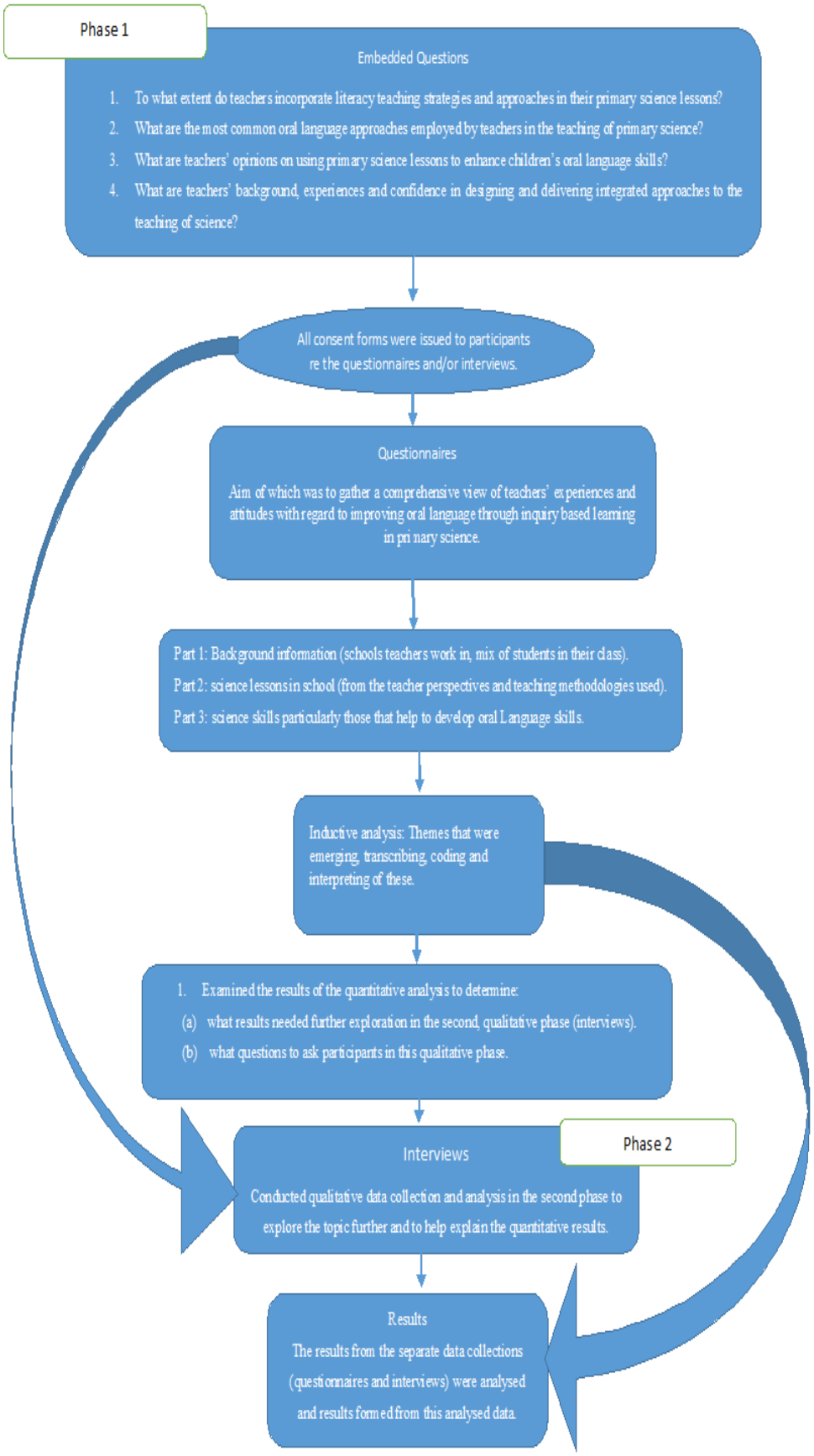

Figure 3.1 Research Design: Flow diagram providing details on the aims of Phase One and Phase Two of the research project and the methodology used in each phase.

3.4 Data Collection: Mixed Methods Approach

Winter (1989) suggests the most effective means of gathering information to reveal more about a situation is achieved through a combination of methods. Mixed methods approach '*allows researchers to mix and match design components that offer the best chance of answering their specific research questions*' (Johnson and Onwuebuzie, 2004, p.15). This method was applied after the researcher had considered and taken into account what the research was setting out to achieve and how this could be carried out with the resources available (Silverman, 2005). As the research was concerned with the practices of teachers in the classroom, teacher questionnaires and teacher interviews were used as *'both qualitative and quantitative researchers are concerned with the individual point of view'* (Denzin and Lincoln, 2000, p.10), placing the reader in the situation of that person. This collective strength provided a better understandings of the research exploration rather than drawing from either form of data alone (Creswell, 2015).

Qualitative and quantitative research are quite often viewed as polar opposites but it is argued that the methodologies should be viewed more as representing different ends on a continuum (Newman and Benz, 1998; Hammersley 1999). Many researchers view themselves as either belonging to either qualitative or quantitative paradigms (i.e. positivistic, confirmatory) or qualitative (interpretivist, discovery)). When deciding on mixed methods as a methodology it is important to recognise that quantitative and qualitative are based on very different principles (Brannen, 1992; Bryman, 2012) (See Section 3.4.1). Faults are seen to be present in both quantitative and qualitative methods as separate entities, but many researchers advocate a mixed-method approach (Creswell, 2015; Brannen, 1992; Bell, 2010; Slavin, 2008).

It also should be noted many researchers do not employ a mixed method approach as there is a concern that both sets of data may arrive as contrasting conclusions (Teddlie and Tashakkari, 2009). However, it can also be argued that divergent findings are valuable in that they lead to a re-examination of the conceptual frameworks and the assumptions underlying each of the two components (Teddlie and Tashakkari, 2009). By using the explanatory mixed method design, the quantitative data collected can be used to for further exploration using qualitative collection methods. Moving away from a preoccupation with irreconcilable paradigms, and a willingness to embrace multiple paradigms. Pragmatism the underlying philosophy in Mixed Methods stress the methods used in research should be determined by the question asked (Punch, 2009).

In this research the two phases build upon each other so that there are distinct, easily recognised stages for conducting the design. The researcher chose this type of research methodology as it can assist in exploring certain results in more detail if needed and can assist in explaining and interpreting unexpected results (Creswell 2003, 2009). The very nature of this study was an exploration of what is happening in schools therefore an explanatory approach was the most desirable approach to ensure the necessary data was collected.

3.4.1 Qualitative and Quantitative Framework

A quantitative paradigm is more scientific and usually involves large scale sets of data, for example surveys. It is objective, ungrounded and verification orientated. It is outcome based and statistical. It is based on a stable world (Bell, 2010). Quantitative research is empirical research where the data are in the form of numbers. Quantitative researchers collect facts and study the relationship of one set of facts to another and use numerical data as opposed to qualitative researchers who are more concerned with understanding individuals' perceptions of the world (Bell, 2010). Bryman (2012) states that quantitative research can be constructed as a research strategy that emphasises quantification in the collection and analysis of data.

The quantitative aspect of this study looked very much at the 'What', what was being implemented in classrooms and 'How' i.e. in an attempt to answer the research questions: '*To what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons?'* And '*What are the most common oral language approaches employed by teachers in the teaching of primary Science?'*

In researching the social world, knowledge can be divided into a framework of qualitative and quantitative approaches. By using both qualitative and quantitative approaches allows for both inductive (making generalizations from specific observations) and deductive thinking (starting with a specific observation and making a conclusion of a more generalisation) (Table 3.1). The qualitative paradigm involves collecting and analysing data usually in word form and non-numeric, for example interviews. It is concerned with describing meaning, rather than drawing statistical inferences (Creswell, 1994). It is processed based and contains rich information. It incorporates the positivistic research paradigm giving rise to an account of reality (Bassey, 1999). The key to understanding how qualitative research works in this particular research is the idea that meaning is socially constructed by individuals in interaction with their world (Creswell, 2009). For the most part, qualitative researchers aim to understand the '*how*' and

the '*why*' of people's behaviour and attitudes as they interact with the world around them (Yin, 2003). It is empirical research where the data are not in the form of numbers (Punch, 2005, p.3). The qualitative aspect of this study looked the 'Why', after collecting the quantitative data investigating '*What are teachers' opinions on using primary Science lessons to enhance children's oral language skills*?' and '*What are teachers' background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science*?'

Table 3.1 The Paradigm Wars: Differences between Quantitative and Qualitative Methods

Positivist/ Quantitative	Interpretive/ Qualitative
The researcher should be an objective outsider who brings a theory to the research	The researcher should be an rigorous and careful insider who understands people's worldview
The researcher should begin with a **hypothesis**	The researcher should let **the theory emerge from their interaction** with the research context
The person researched is a **research subject**	The person researched is a **research participant**
Typically use surveys or **large data sets**	Typically use **interviews, observations, maps, images, or texts**
Usually involves **many research subjects**	May use many or **few research participants**
Often looks to **measure** extent of an issue within a population	Typically looks to **describe processes** that are happening within groups
Variables can be named and relationships between them identified	Reality is a complicated mix of different contributing factors which should be understood in all its complexity
Statistical data should be used to see patterns	Text and words should be used to see meanings
The researcher should portray the research as objective ('This research has identified that…')	The researcher should identify their presence in the research ('I found that…')

The questionnaire in this study was made up of a mix of mainly closed and also some open-ended questions gathering qualitative and quantitative data (See Appendix H) this allows for more detailed information and post work reflections, the results of which can be translated into statistical information where appropriate. The questionnaire incorporated questions that allowed the participants to expand on their answers which allowed for more in-depth findings. The semi-structured interviews comprised of open-ended questions. The semi-structured interviews allowed for direct personal investigations. These questions were based on what themes emerged from the questionnaire analysis. Interviews were time consuming but were one of the most effective ways of collecting qualitative data. The summary of the aims of the data collection methods used in each phase of the research project are detailed in Table 3.2 below.

Table 3.2 Summary of the aims and data collection methods used in each phase of the research project.

Aims	Data Collection Methods
Phase 1: Quantitative Data Collection and Analysis	
To investigate to what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons?	Questionnaire distributed to schools and teachers around Ireland. (The details of each school will be looked at so as to ensure that a cross broad section of gender schools in as many counties as possible will be selected).
To investigate what are the most common oral language approaches employed by teachers in the teaching of primary Science?	Questionnaire distributed to schools and teachers around Ireland. (The details of each school will be looked at so as to ensure that a cross broad section of gender schools in as many counties as possible will be selected).
To gain an insight into what are teachers' opinions on using primary Science lessons to enhance children's oral language skills?	Questionnaire distributed to schools and teachers around Ireland. (The details of each school will be looked at so as to ensure that a cross broad section of gender schools in as many counties as possible will be selected).
To gain an overview of teachers' background and experiences in designing and delivering integrated approaches to the teaching of Science?	Questionnaire distributed to schools and teachers around Ireland. (The details of each school will be looked at so as to ensure that a cross broad section of gender schools in as many counties as possible will be selected).
Phase 2 : Qualitative Data Collection and Analysis	
To investigate further what results will need further exploration from the quantitative analysis (from phase 1) and to conduct qualitative data collection and analysis to explore the topic further and help explain the quantitative results and to help answer the research question.	Interviews – Interviewees recruited from the questionnaire respondents when it was completed. The questionnaire respondents were provided with a link to a plain language statement regarding the interviews and invited to contact a given e-mail address with their contact details if they were interested in participating further. If they completed a hard copy they indicated their interest by emailing the researcher.

3.5 Recruitment of Participants

An advertisement was placed on social media pages and mailing lists of national educational institutions, organisations and associations to assist the recruitment of research subjects (See Appendix D). Teachers were invited to participate in the study investigating literacy strategies and approaches used by primary level teachers during Science lessons. They were invited to indicate their willingness to participate by e-mailing a given address. They were also asked to include contact details (mobile phone number and/or school postal address) for verification.

Interviewees were recruited from the questionnaire respondents. At the end of the questionnaire, respondents were provided with a link to a plain language statement regarding the interviews and invited to contact a given e-mail address with their contact details if they

were interested in participating further. If they completed a hard copy they indicated their interest by emailing the researcher.

Participants contacted the researcher when they were willing to get involved in the study. The researcher then sent them an information sheet and consent form to the participant via email with a link to the SurveyMonkey© (See Appendix E and F). If the participants filled in the survey electronically there was a consent form on the SurveyMonkey© along with a consent button to press if they agreed to the terms of the research (Appendix G). The participants that preferred a postal questionnaire were sent a SAE to return the consent form and completed questionnaire to the researcher (Appendix H).

3.6 Data Collection Instruments Generic

3.6.1. Data Collection Instrument: Questionnaire

Survey research refers to a type of non-experimental empirical research design which is used extensively in social Sciences research. A survey is a system for collecting information to describe, compare, or explain knowledge, attitudes, and behaviour (Fink 1995 p.1). Bell (2010) notes that a survey works positively if it is designed specifically to suit the aims of research and the nature of the respondents. Related surveys in the area of action research were examined (Zambo and Zambo, 2006; Wideman and Aquino, 2006; Graves, 2006). Survey research is typically used for explanation, description and exploration purposes or a combination of these (Babbie 1973). The purpose of carrying out an explanation survey research is to make assertions about the specific population (Babbie, 1973). This type of survey research tests and explains relationships between certain variables. Exploration surveys are usually carried out when little is known about a phenomenon and so the findings are typically used to gain an insight into a general phenomenon in order to develop concepts for further expansive research (LoBiondo-Wood and Haber 2006; Babbie, 1973). Descriptive surveys are designed to quantify opinions, behaviours and attitudes for example in a given population (Gerrish and Lacey 2006; LoBiondo-Wood and Haber 2006; Babbie, 1973). Descriptive surveys are also undertaken to establish trends and associations between different variables (Gerrish and Lacey, 2006). Therefore, this survey research method was considered as a valid rationale for choosing a research design, so that findings emanating from this study could be compared to these similar international research studies. The researcher is obtaining a baseline as opposed to any changes in the level of knowledge and attitudes of participating primary school teachers to inquiry based

teaching and learning for students. It was therefore decided that a cross-sectional survey research design was the most appropriate for this study.

Survey data can be obtained in a variety of ways including observations, interviews and questionnaires (Parahoo, 2006). Data was collected in this study by a self-administered questionnaire. Self-administered questionnaires are widely used in data collection methods in research (Bourque and Fielder 1995). Parahoo (2006) points out that the use of questionnaires in descriptive research allows for the generation of data from which hypotheses can be formulated. This also facilitates an insight into an understanding of the phenomena. Questionnaires can be administered via personal interviews, the telephone, via the internet, or by post (postal questionnaire).

Hoinville and Jowell (1987) point out that a questionnaire should be designed to be clear and unambiguous so that the respondents can understand exactly the questions being asked. Therefore, the wording used in this survey was deliberately made clear and unambiguous, and the survey will be thoroughly evaluated for these traits through an extensive pilot study. The teachers' questionnaire was designed so as to be easily readable and quick to complete (see Appendix E). The questionnaire elicited responses by way of a smiley face Likert scale format. The questionnaire was designed to look interesting and easy rather than complicated and boring (Cohen *et al.*, 2000). The length of the questionnaire was kept as short as possible so as to encourage a high response rate (Leslie, 1970; Brown, 1965). The questions were also kept as short as possible. Oppenheim (1992) recommends a maximum of twenty words per line.

The advantages of using a questionnaire as a means of obtaining data includes that confidentiality can be maintained, its low cost, ensures large geographic coverage, anonymity can be assured, and avoidance of interviewer bias (Parahoo, 2006; Bourque and Fielder, 1995; Oppenheim, 1992). However, one of the most highlighted disadvantages of self-administered questionnaires is a low response rate (Parahoo, 2006; Bourque and Fielder, 1995). The higher the response rate, therefore the more comprehensive the results of the survey will be. However, the smaller the rate of responses, the less reliability can be placed on the findings generated (Buckingham and Saunders, 2004; Parahoo, 2006). A low response rates may also introduce bias (Curtis and Redmond 2009).

3.6.1.1 Questionnaire Design

The aims of the questionnaire was to gather a comprehensive view of teachers' experiences and attitudes with regard to improving oral language through inquiry based learning in primary Science. Careful consideration was given to the design of the questionnaire. A self-completion questionnaire was chosen as an appropriate method as a research instrument in this study. This type of self–completion questionnaire allows for large numbers of individuals and for information to be gathered quickly. It is anonymous, economical and has preceded standardised answers (Denscombe, 1998). Every effort was made to ensure that the wording was concise, clear and unambiguous to minimise errors (Cohen and Manion, 1997; Davidson 1970). Questionnaires can be administered quickly and easily without requiring the presence of the researcher. This is advantageous as it avoids interviewer bias where the respondent's answers could be influenced by the presence of the interviewer (Oppenheim, 1992).

The questionnaire starts with easily answerable questions so as not to discourage respondents from completing them (Levine and Gordon, 1958). However, response rate may be low, there may be incomplete responses, incomplete questionnaires and any misunderstandings that may occur cannot be rectified by the researcher (Oppenheim, 1992). The results can be subsequently analysed, patterns can be extracted and comparisons made (Bell, 2010). This questionnaire investigated how Science and English are currently being taught in the primary Science classroom (teaching, learning methodologies) and was also based on the literature review. The questionnaire was subdivided to help answer the research questions as follows:

Section 1: Background information.
Section 2: Continuous Professional Development (CPD)
Section 3: Literacy Skills in the Science Classroom

3.6.1.2 Types of Questions

Dichotomous Questions: were used at the start of the questionnaire which requires the respondent to give a very specific answer and to answer in a truthful manner (Parahoo, 1997) examples include yes/no type answers, are you male or female, please tick the appropriate box with regard to the type of school you teach in.

Open-ended Questions: were used to allow the teachers to give their own personal response including comments, suggestions, criticisms and opinions, which may not be transparent in the closed questions (Cohen and Manion, 1997). It allows the participants to expand on the closed

questions and gives a more qualitative aspect to the study. This allows for a greater insight and understanding of a topic being investigated (Bell, 2010).

Multiple Choice Questions: were used to gain into the respondents opinions on a topic. These questions/statements were very clear on how to accurately complete them so as to avoid any confusion. The results aimed at getting specific responses to specific statements.

Rating Scale Questions: for example the Likert Scale were used throughout the questionnaire. The respondents are asked to rate a series of statements using a five point scale from 'strongly-agree' to 'strongly-disagree' (Parahoo, 1997). This type of questioning obtains solid statistical information. However, there are some limitations that need to be taken into account during data collection and analysis. Participants may interpret the questions/statements differently. So to try and avoid this, careful consideration was given to wording the questions/statements in the questionnaire survey.

3.7 Questionnaire Design

LoBiondo-Wood *et al.,* (2010) notes that questionnaires are advantageous in studies as they provide complete confidentiality and there is also no interviewer bias as there is no interviewer while teachers are completing the questionnaires. In this research project the questionnaires were broken into three sections. Appendix H contains the questionnaire in full used in this research project. The sections helped the researcher to focus on the data that was needed in order to answer the research questions.

Table 3.3 Summary of Questionnaire Design

Section of Questionnaire	Style of Question	Aim of the Research being Addressed
Section 1: Background information	Closed questions and multiple choice questions	Investigates the background information (schools teachers work in, years of experience, mix of students in their class).

Section 2: Continuous Professional Development (CPD)	Closed questions, open-ended questions and multiple choice questions.	Gain an insight into how often teachers attend Science CPD courses, if they have attended Science courses with an emphasis on literacy development and how effective Science CPD courses undertaken by teachers have been in relation to developing literacy skills in primary Science.
Section 3: Literacy skills in the Science Classroom	Likert scale questions, closed questions and multiple choice.	To investigate the use of teaching strategies in teaching Science lessons in developing literacy skills. and the teachers' opinions on using primary Science lessons to enhance children's oral language skills.

3.7.1 Closed Questions

Closed ended questions provide responses that enable the researcher to collate responses and code results with ease. However, spontaneous responses of the respondents are not catered for in closed questions. (Meadows, 2003). Section one used closed question responses in providing background information of the participants in the study.

1. What type of primary school do you teach in? (tick as many boxes as required)

Rural Deis	Urban 1 Deis	Urban 2 Deis	Mixed	Girls school	Boys school	Gaelscoil

Figure 3.2 Example of closed-ended questions in the questionnaire

Please tick the appropriate boxes in the following questions below

7. How many courses or CPD courses in *Science* have you undertaken in the past 5 years?

0	1	2	3	4	5	>5

Figure 3.3. Example of closed-ended questions from section 2 in the questionnaire

3.7.2 Likert Scale Questions

A Likert scale allows the respondent to rate their response in order of feeling which therefore allows the response to be more meaningful (Clason and Dormady, 1994). In this research project, Likert scales were used in section 3 to ascertain the teachers' use of teaching strategies and methodologies in primary Science.

6b. Please rank your opinion on the level of literacy in the Science Courses

V. Satisfactory	Satisfactory	Neutral	Unsatisfactory	V. Unsatisfactory

Figure 3.4 Example of a likert scale question from the questionnaire

3.7.3 Open-ended questions

Open-ended questions enables the respondent to answer the questions using his or her own words without providing predetermined answers (Meadows, 2003). Open-ended questions were also used to investigate teachers' personal beliefs, and their attitudes on a specific topic in the questionnaire. For example, the last part of question 10 of the questionnaire aimed to investigate teachers' personal beliefs, and their attitudes towards how they felt that oral language could be improved through primary Science.

"One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a reduction in the amount of time devoted to the core areas of literacy and numeracy" (from: Better Literacy and Numeracy for Children and Young People p.28).

Please tick the appropriate box That reflects your feeling on the above statement	Strongly agree	Agree	Neutral	Strongly disagree	Disagree

Figure 3.5 Example of an open-ended question from questionnaire

3.7.4 Pilot Questionnaire Survey

A pilot questionnaire was given to a similar group of primary school teachers in a local school. The pilot study audience was similar in gender groupings of males and females (2 males, 2 females for the pilot) with teaching experience of five years and ten years. Each teacher was given a letter explaining the purpose of the study and instructions for completing the survey online. Teachers were not obliged to take part in this study or to complete the online survey. The pilot questionnaire was therefore representative of a group similar to the actual study group. The purpose of a pilot is to ensure that questionnaire is effective for the chosen population and that it yields the data that is required (Oppenheim, 1997).

To maintain confidentiality, a numbering system was used to correlate each name with a numbered questionnaire. Only the researcher had access to the list of names and numbers. Piloting was necessary to ensure that wording of the questions are clear and understood and that the sequence of questions is correct so as reduce the rate of non-responses and helped in ensuring the required data is gathered from the chosen population (Oppenheim, 1992; Bell, 2010). A questionnaire can be modified slightly in light of the pilot study (Kothari, 2008) i.e. wording and terminology used were made clearer to the reader. Carrying out this preliminary analysis also ensured ease of coding and analysing for the main study (Fink, 1995). As part of the research ethics confidentially and anonymity was ensured to all participants.

3.8 Data Collection Instrument: Interviews and Interview Design.

Semi-structured interviews (see Appendix I) were administered to help answer the research question**.** Interviews have the potential to provide rich and highly illuminative material (Robson, 2004). Bell (2010) also supports this view, adding that interviewing can flesh out and add rich material to the bones of questionnaire responses. The responses in an interview can be developed and clarified in contrast to a questionnaire where the responses have to be taken at face value. This process allows the interviewer to branch off at times and explore their responses in more depth. *'The way in which a response is made (the tone of voice, facial expressions, hesitation, etc.) can provide information that a written response would conceal'* Bell, 2010, p.157). The interview questions allowed the interviewees to express their views in their own terms which resulted in gathering rich data. This benefit has been heighted in Cohen and Crabtree (2006) research.

Creswell (2005) recommends that interviews are best conducted towards the end of one's study as interviews can shape the responses to the researcher's perceptions. The interviews took place when the questionnaire responses were gathered and analysed to clarify if any gaps appeared in the questionnaire that could be answered in the interviews. Participants were told in advance that the interviews would be audio recorded for transcription purposes. The questions were pre-determined and were asked in a logical sequence. Open-ended questions were included 'to secure vivid, accurate, inclusive accounts that are based on personal experience' (Burgess, 1982, p.107). Kothari (2008) noted that with a semi-structured interview, the interviewer has greater freedom to ask or omit questions if required.

3.8.1 The Interview Pilot

Piloting the interview was carried out to evaluate and improve the interview procedure. This process also helped to increase reliability and validity of this project. The questions were formulated to answer the research question. Wording of the questions and sequencing of the questions were evaluated in this piloting process to adequately reflect the research questions (Bell, 2010). The pilot interview questions were piloted with two primary school teachers who has taught in a mixed school in County Cork.

3.8.2 Interview Process

At the start of each interview, the interviewer engaged the interviewee in an informal chat to help relax and put the interviewee at ease. Bias can be an issue in interviews. The Oxford dictionary (1995) defines bias as someone having a 'predisposition or prejudice' on a subject. The interview questions were designed to try and avoid bias. 'Interviewers are human beings and not machines, and their manner may have an effect on respondents' (Selltiz *et al.*, 1962, p.583). Therefore, it was essential that the interviewer has developed good interpersonal skills (e.g. tone of voice, politeness, non-judgemental manner, being a good listener, giving time for interviewee to respond). Evidence from the literature review and the questionnaire were also compared with to help avoid bias.

3.9 Ethical Considerations

'Protection of participants' rights is a fundamental aspect of conducting research, and the issues of informed consent and anonymity and confidentiality are of paramount importance' (Ryan *et al*., 2009, p 312). Flick and Kvale (2007) caution that there are many ethical issues involved in research, ethical clearance was sought and approved from Mary Immaculate Research Ethics Committee (MIREC) (Appendix J). This research was carried out according to the MIREC and in according to social Science ethics. Ethical approval was sought prior to the distribution of the questionnaires. An information sheet was designed and distributed to schools and teachers providing details on this study including the purpose of this study, the requirements of the participants and how the information gathered would be used. The participants were promised confidentiality and anonymity (Morgan and Symon, 2004). Participation of teachers in this research was on a voluntary basis and participants were informed that they were under no obligation to follow through in this study and could withdraw at any time. Participants were informed that this research would be assessed by MIREC only for examination purposes.

Written permission to proceed with the interviews was obtained from all participating teachers. Teachers were promised confidentiality and anonymity of the material gathered through the questionnaires and interviews consent forms. All interview participants were given pseudonyms to protect their anonymity. The data itself did not contain any sensitive information and all questions related to participants' professional views. In summary, the researcher made every effort to treat the participants of this study with the utmost respect, dignity and anonymity.

Hard copies of the questionnaires is stored in a locked filing cabinet in the home of the researcher and electronic data is stored on an encrypted USB key. The data will be kept for the duration of the study plus 3 years after its completion in adherence to the MIC Research Storage Retention Policy.

3.10 Sampling

The nationwide questionnaire of the schools was not randomly selected but was chosen based on a broad cross-section of school type in as many counties as possible. The schools were not randomly selected and this is regarded as a non-probability sample. A sample of 100 qualified teachers nationwide were used. The sampling methods used were purposive sampling and convenience sampling. Purposive sampling demands us to think critically about the parameters of the population we are interested in and to choose our sample carefully on this basis (Silverman, 2000). Sampling obtains information about an entire population by examining only part of it (Kothari, 2008). The advantage of purposive sampling allows the researcher to 'hand-pick' the participants for the research and this is critical for this study (Dane, 1990). Convenience sampling was included, involving the selection of the most accessible subjects. Convenience sampling was selected due to time constraints, effort and cost to the researcher. Convenience sampling may result in poor data and can lack intellectual credibility. However, every effort was made to avoid this pitfall.

3.11 Triangulation

Triangulation refers to the use of multiple methods of data collection so as to secure an in-depth understanding of the phenomenon being researched (Denzin and Lincoln, 2000; Robson, 2004). Relying on just one method may distort the researcher's picture of reality (Cohen and Manion, 1997). Bell (2010, p. 116) also recommends using more than one method of data collecting. This resolves the issue of 'method boundedness' (Parahoo, 1997, p.67, Miles and

Huberman, 1984, p.231-243). Triangulation can be further subdivided e.g. the methodological triangulation, where the researcher uses more than one method examine the phenomenon under investigation (Mitchell, 1986). In order to add depth and to help increase reliability, objectivity and validity this research project used both qualitative and quantitative data using a variety of different data collection methods (Robson, 2004). This helped to accomplish triangulation. The primary data collection method will be quantitative with some qualitative elements.

By using more than one method for data collecting this will help to cross-check any findings. This form of multi-method collecting is known as triangulation. Data from the questionnaires, interviews and reflective logs were triangulated to ensure validity and reliability (Creswell, 2014). The researcher used various data sources in the study, including questionnaires (closed and open-ended responses) and semi-structured teacher interviews. All of these methods helped to cross check any findings. A filing system was used for collecting and transcribing the data. The transcribed data was then examined and themes were identified and colour coded accordingly. This was then analysed with the literature review. This study included an in-depth examination on how oral language skills in primary Science can be improved by using several different types of data sources.

3.12 Data Analysis

Data analysis is an attempt to organise, provide and account explanations of data making some kind of sense of them (Hitchcock and Hughes, 1999). Bell (2010) notes that the data analysis is an important stage in the research process and the results should be valid and reliable. The quantitative data was analysed using SPSS and is presented throughout the results chapter in numerical format, graphs and tables. In contrast the qualitative data was analysed more through the use of coding, organising response into specific categories. This method of analysis ensured triangulation was implemented in the study, looking at the topic by collecting data through a variety of different meas.

A. The responses from the questionnaires, and interviews were read and the data was categorised.

B. All the questions from the questionnaires were entered into an SPSS programme, version 18 and the responses were coded. The data was recorded and analysed using this programme, Visual representations were generated with this programme. This data analysis allowed for

thematic, deductive analysis of data where connections and themes were seen to emerge. The findings from the questionnaire analysis directly informed the questions for Phase Two. The interview was designed in such a way to verify information and gather further information on teachers' opinions and attitudes. Deductive coding in phase 1 of data analysis organised themes by extracting information and developing interview questions for further analytical consideration. Specific categories were made from the analysed data such as inadequate continuous development. The coding was driven by the research questions. Once the data had been coded it was examined in order to elicit findings and draw some conclusions.

3.13 Reliability and Validity

Reliability is 'the extent to which research produces similar results under constant conditions on all occasions' (Bell, 2010, p.117). In mixed methods research, validity is determined by the researcher's ability to 'draw accurate and meaningful conclusions from all the data in the study' (Creswell and Plano Clarke, 2007, p.146). Validity can also be described as the degree to which the instrument measures what it seeks to measure (Oppenheim, 1992). In this mixed method study, reliability and validity can be determined and should produce relevant and reliable data by using more than one data collection method. Reliability may also be accomplished by generalisations that may be formed from this research. Using multiple methods of data collection provides consistency and are not dependent on one position which Denscombe (2007) argues, enhances validity. The structure of a piece of research determines the conclusions that can be drawn from it and most importantly, the conclusions that should be drawn from it (Sapsford and Jupp, 1996, p.1).

Every effort was made to eliminate bias and to render the questions unambiguous and it was hoped that the reliability and validity would be borne out by reference to the data gathered from the survey questionnaires and the interviews. The questions in the questionnaire were carefully worded. The design and layout was made simplistic and inviting to the reader. The piloting of the questionnaire ensured any ambiguities were highlighted and ensured reliability and validity of the questionnaire. Unfortunately the response rate was low. This may have been to time constraints and due to the time of the year the questionnaires were distributed when teachers were preparing for the nationwide commemoration of the 1916 Rising and some had little time for anything else including the questionnaire. The semi-structured interviews were developed from the results from the questionnaires and with regard to the literature review and contained

non-biased questions. The interviewer made every effort to ensure not to influence the interviewees responses. The results from the collected data were verified through triangulation.

3.14 Limitations of the Study

Time Constraints and the number of participants influenced the length of time that was needed to collect the data and to analyse it in detail. The time constraint affected the size of the sample cohort that could be analysed. Every effort was made to incorporate a diverse range of participants in the study. As the sample size was small, the results cannot be generalizable beyond the specific sample. The interviews may not accurately reflect the opinions of all teachers.

3.15 Conclusion

This research project employed a mixed method approach, using both qualitative and quantitative methods in the context of the research methodology to help answer the research question. The quantitative method used questionnaires of teachers. The quantitative questionnaires were conducted with a sample size of teachers participating in the study (n=24) to provide quantifiable reliable data that could be generalizable to a larger population. The qualitative method used included semi-structured interviews with teachers with open-ended questions. These were used to obtain a more in-depth analysis and investigate the new research themes that may come to light as the project progressed. This chapter has also provided an in-depth explanation of the data collection strategies. Ethical issues were adhered to, providing all participants in the research with anonymity and confidentiality. As with all research, there will be limitations due to time constraints. SPSS was utilised in analysing the questionnaire data and the interview analysis. The methods used were conducted in accordance with the objectives of the research and with the themes identified in the literature review. Measures were taken throughout this research project to uphold the reliability and validity of this study. All of these actions helped with the exploration of how the development of literacy skills are being integrated and encouraged in the primary Science classroom. This also helped to clarify the research objectives and highlighted if inquiry based learning and the practice of scientific process skills affect the development of children's expressive verbal skills and writing skill and into how students' effective thinking skills could be improved to help students become more articulate in the investigative learning process.

Integrating and Encouraging the Development of Literacy Skills in particular Oral Language skills in the Irish Primary Science Classroom

Chapter 4: Results & Discussion

4.0 Introduction

The findings of the study and how the research questions were answered through the collection of data will be presented in this chapter. It reviews the analysed data from the survey questionnaires and the interviews and compiles and discusses the major findings of the study.

4.1 Findings from the Questionnaire of Primary School Teachers

A nationwide questionnaire was carried out to gather both quantitative and qualitative data, investigating the incorporation of literacy teaching strategies and approaches in primary Science lessons, the different strategies and approaches used by teachers and their experiences of the use of Science lessons to enhance children's literacy skills (N= 42). A total of 42 questionnaires were completed and returned by teachers. The response rate was low despite every effort to advertise the study in as many different media as was possible. The findings of the questionnaires in Phase 1 will be examined and analysed in the following sections. This information was then used to inform the design of more qualitative aspect of the study i.e. the semi-structured interviews of Primary School Teachers (N=3).

4.1.1 Background Information of Participants

Section 1of the questionnaire investigated the background information of the teachers (schools teachers work in, years of experience, mix of students in their class).

Type of School

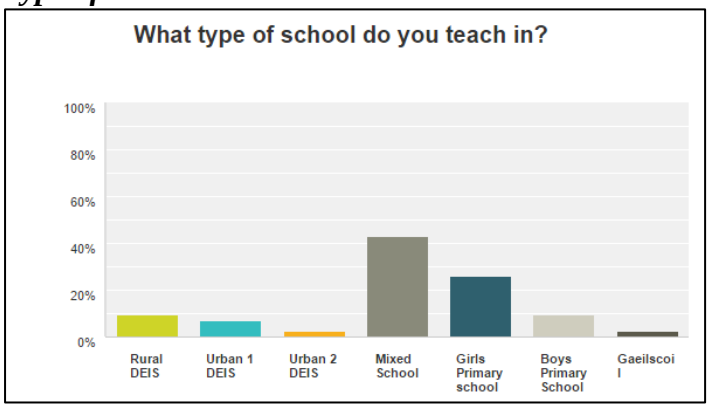

Figure 4.1 Type of school of the participating teachers (N=42)

The profile of the teachers who returned questionnaires were as follows:

- 45% were teachers in urban schools with 55% teaching in rural schools.
- 36% of the teachers taught in single-sex schools with 64% in mixed gender schools.

Table 4.1 below provides a breakdown of this information in more detail.

Table 4.1 Breakdown of schools represented in the sample (N=42)

Type of School	% of Participating Teachers
Rural DEIS	10
Urban 1 DEIS	7
Urban 2 DEIS	2
Mixed School	43
Girls Primary School	26
Boys Primary School	10
Gaelscoil	2

Gender and Teaching Experience

The majority of teachers were female (79%). The majority surveyed (54%) had 11 years teaching experience or more (43% female and 11% male teachers). 24% had 6-10 years teaching experience with 22% having 0 to 5 years of experience (Table 4.2).

Table 4.2 Teaching experience and gender of participating teachers (N=42)

No. of Years Teaching Experience	% of Participating Teachers
0-5 (Male)	5
6-10 (Male)	5
11 or more (Male)	11
0-5 (Female)	17
6-10 (Female)	19
11 or more (Female)	43

24% were junior/senior infant class teachers, 55% were middle (1st to 4th) class teachers and 33% were senior (5th and 6th) class teachers. A further breakdown can be seen in Figure 4.2 below. One teacher taught an Autism Spectrum Disorder (ASD) class with a range of different class levels within the class.

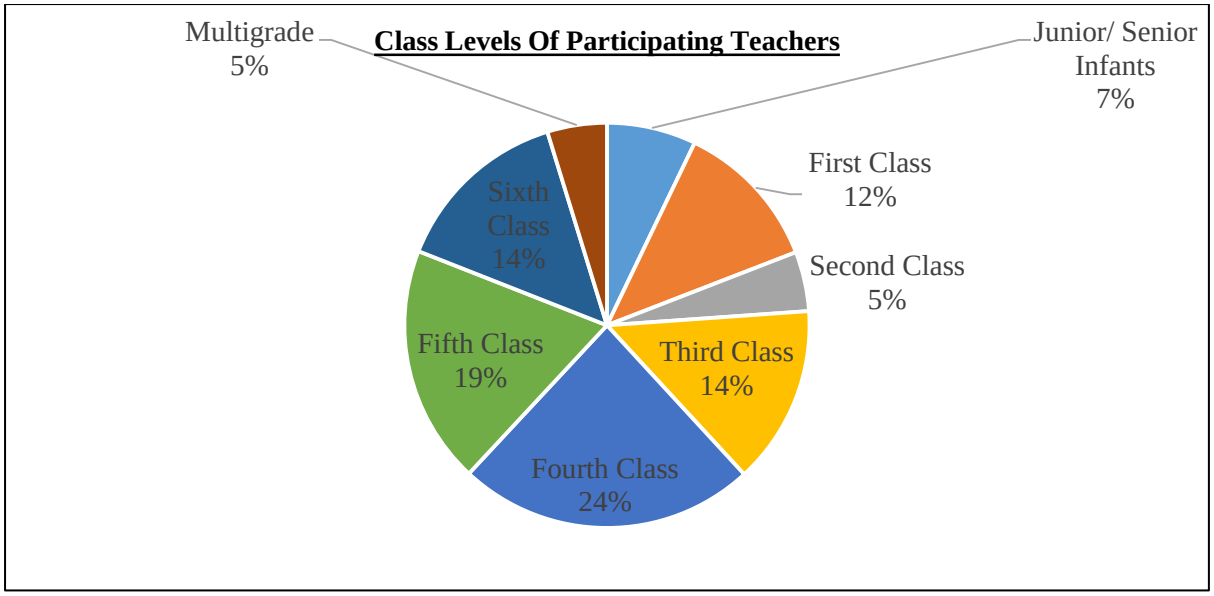

Figure 4.2 Class levels being taught by participating teachers (N-=42)

4.2 Continuous Professional Development of Teachers

Section 2 of the questionnaire set out to gain an insight into how often teachers attend Science CPD courses, if they have attended Science courses with an emphasis on literacy development and how effective Science CPD courses undertaken by teachers have been in relation to developing literacy skills in primary Science.

The teachers were asked how many CPD courses in Science they had attended in the last 5 years. Table 4.3 shows the breakdown of these results in percentages. The findings surprisingly show that a large amount of teachers **(48%) have not taken any CPD course in Science in the past 5 years** and only 33% took one CPD Science course in the same time period, while 5% had taken 2 courses, 10% have taken 3 courses and with 5% that have taken 5 or more courses in the past 5 years. Table 4.3 below shows the breakdown in detail.

Table 4.3 CPD Courses in Science attended by the participating teachers in the past 5 years (2011- 2016) (N=42)

No. of CPD Courses in Science Attended in the Past 5 Years					
0	**1**	**2**	**3**	**4**	**≥5**
48%	33%	5%	9%	0%	5%

Table 4.4. CPD Courses in Science attended in the past 5 years (2011- 2016) by the participating teachers of varying teaching experience

Teaching Experience Years	No CPD Course	1 CPD Course	2 CPD Courses	3 CPD Courses	4 CPD Courses	5 or more CPD courses

0 – 5	6	2	1	0	0	0
6 – 10	4	5	0	2	0	0
11 or more years	10	7	1	2	0	2
Total/42	**20**	**14**	**2**	**4**	**0**	**2**

The results from the Table 4.4 above show that **20 out of the 42 participants did not attend any CPD course in Science in the past 5 years** with half of these teachers having 11 or more years. Ten teachers out of the group surveyed have 11 or more years of teaching experience. Table 4.4 also shows that 14 teachers across the range of teaching experiences have only taken one CPD Science course. It seems in general the **more experience of the teacher the fewer CPD courses in Science they attend**. However, there was an exception with 2 teachers with 11 or more years teaching experience attending 5 or more CPD sessions in Science. It is also surprising that teachers with **0-5 years teaching experience have not attended very many CPD courses in Science overall in the past 5 years**. This may be due to the fact that many of the more recent CPD sessions have focused specifically on literacy and numeracy. **The participation rates of Science CPD courses across the spectrum of teachers with varying teaching experiences were overall low.**

4.2.1 Literacy Skills in the Science CPD Courses

80% of the teachers' stated that there was not an emphasis placed on Literacy skills in the Science CPD courses

- '*no emphasis at all on Literacy in any course I have attended*.'

Some of the teachers' commented that they had attend courses provided my MIC and the RDS focusing an emphasis on Literacy and Science.

- '*Science and Fairy Tales in primary school Science* ***MIC [Mary Immaculate College],*** *this had literacy element in them as well as practical hands on Science activities.*'
- '*I completed the* ***RDS Science Creativity and Science Education*** *(with emphasis placed on literacy skills).*'

When they were asked further about their experience of Science CPD sessions focusing on literacy skills, the results were disappointing:

- **Only 1 out of the 42** had attended a CPD session on developing **oral language skills** specifically in Science lesson and it was an online course.

- **No teacher out of the 42** had attended CPD session on developing **writing skills** specifically in Science lessons.
- **No teacher** had attended a Science CPD session on developing **reading skills** specifically in a Science lesson.

The teachers were then asked to rate their opinions on the level of literacy in the Science Courses they had attended ranking them from very satisfactory to very unsatisfactory. Not surprisingly 75% of the responded stated that the levels were either **unsatisfactory or very unsatisfactory i.e. 66% and 9%** respectively. With 15% being satisfied i.e. **13%** stating that is was **satisfactory** and **2% stating** they were **very satisfactory**. 10% stayed neutral on their opinions.

No teacher stated that the level of literacy in the Science Courses they attended was very sufficient, **12% stated it was sufficient**, 7% remained neutral with the remaining **81% stating it was insufficient.**

The teachers were asked "how many Courses or CPD in *Literacy* have you undertaken in the past 5 years?" 100% of the teachers had attended a course on Literacy over the past 5 years. **90% of the teachers had attended up to 3 courses with 10% attending 4 and 5 courses** (7% and 3% respectively). Many stated they had attended courses in local education centres, national conferences and summer courses, some specifically mentioning "Building Bridges of Understanding" programme by Martin Gleeson, PDST teacher courses i.e. Reading Recovery; spelling, oral language, poetry, comprehension, writing genres, storytelling and poetry in literacy. **It is evident from the results there have been a significant number of supports on offer to teachers over the past 5 years in Literacy skills.**

4.2.2 Levels of satisfaction with CPD Provision in Science

The teachers were asked to rate their levels of satisfaction with CPD courses in Science they had attended in the past within the past 5 years under the headings: Very Satisfied/Satisfied/Neutral/Unsatisfied/Very Unsatisfied. They were asked to rate their opinions under the following areas: pedagogical skills, subject matter in Science, provision of resources, increase in confidence levels in teaching Science and the cost of the CPD courses/courses were the main focus here. See Table 4.5 for the results.

Table 4.5 Levels of satisfaction with CPD provision in Science (N=42)

	Levels of Satisfaction with CPD Provision in Science (% of Participants)				
	Very satisfied	**Satisfied**	**Neutral**	**Unsatisfied**	**Very Unsatisfied**
Content	33	48	19	0	0
Update pedagogical skills	20	60	16	4	0
Update subject matter knowledge	16	60	16	8	0
Increase confidence in teaching Science	16	52	24	8	0
The provision of teaching resources	12	40	36	12	0
Cost of the CPD course	13	25	38	17	8

The '**satisfied' option was the most popular option** ticked by teachers for all categories above, followed by neutral, Very satisfied, neutral, unsatisfied and very unsatisfied.

a. Content: 33% were very satisfied and 48% were satisfied with the content supplied in the Science CPD courses. 19% choose to remain neutral in choosing an option here. None of the teachers were dissatisfied with the content. The overall level of satisfaction was 81%. One teacher commented that they felt that '*content has not changed to my knowledge over the past 20 years.*'

b. Update pedagogical skills: 20% were very satisfied and another 60% were satisfied with the teaching methodologies giving a total of 80% level of satisfaction. 4% were dissatisfied and 17% remained neutral. On further investigation on the dissatisfied response, this person had over 11 years of experience and had taken 3 CPD courses over the past 5 years. This teacher also commented that '*neither content nor teaching practice has changed to my knowledge*.'

c. Increase their confidence in teaching Science: 16% were very satisfied with the CPD courses they had taken and how it increased their confidence levels in teaching Science. A further **52% were satisfied** with 8% feeling dissatisfied and 24% remaining neutral.

d. The provision of teaching resources: Overall less than half were satisfied with the teaching resources (e.g. worksheets/booklets). Breaking this down further **12% felt that very satisfied** with the teaching resources offered on the Science CPD courses. Another **40% were also satisfied**. 12% were dissatisfied and 36% did not express an opinion either way.

e. Cost of the CPD courses: there was strong opinion on both sides regarding the cost of CPD courses. 13% were very satisfied with the cost and 25% expressed satisfaction totalling **38 % altogether who were largely satisfied** with the cost of CPD courses. 17% were dissatisfied

and 8% were very dissatisfied totalling 25% who were largely dissatisfied with the cost. The 38% remained neutral. Satisfaction rate was just 13% higher than those who were dissatisfied. In the sections of c, d and e above a high percentage of teachers' chose neutral responses to these statements. These areas will be further looked at in the interview to see if any further details can be highlighted and addressed.

Comments from the teachers regarding Science CPD courses they had attended included the following:

- '*CPD courses taken by them were free with Mary Immaculate College in partnership with the Mallow STEM* ***Community Schools Project*****'**.

- '*CPD courses in Science should be carried out under a* ***whole school approach*** *as not every teacher is familiar with Science.*'

- '*School of Excellence in Science and Innovation in Science Teaching. A 6 week course in conjunction with WIT for the* ***whole staff.***' *This individual also took a course in M.I.C* '*in creating innovative Science lessons using nursery rhymes and Science.*'

- '*I would like to understand how to teach* ***electricity*** *better to the senior classes..*

- *'We require the skill to understand* ***electricity*** *better so as to be able to teach it adequately especially to 5th and 6th class pupils.*'

Some of their comments included their experience with a **variety of different models of CPD.** Others commented on the **models of CPD they would like to see** i.e. whole school, some teachers' commented on the **content** (Strand and Strand Unit or Content) they would like to see covered in the courses, highlighting their need for further support in particular concepts in Science (i.e. electricity).

4.2.3 Future CPD and Integration of Oral Language Development within CPD courses on primary school Science

The teachers were asked to comment on statements/questions to build a picture on the teachers' interest in attending CPD courses in Science that place a focus on the integration of oral language development. They were asked to tick either: Yes, No or I don't know (Table 4.6).

Table 4.6 Teachers' interest in future CPD and integration of oral language development within CPD courses on primary school Science

Interest in future CPD integrating oral language in primary school Science (% of Participants)			
	Yes	**No**	**Don't Know**
I would like more opportunities to undertake CPD courses in Science	92	3	5
Would you like to attend a Science CPD session on developing oral language skills specifically in the Science lesson?	70	14	16
Did your undergraduate/ postgraduate primary teacher education course incorporate the development of oral language skills specifically in Science education?	18	76	6

An overwhelmingly large amount **of 92% were in favour of having more opportunities in undertaking CPD courses in Science** showing there is a need for CPD in this subject area**.** 3% of participants replied negatively and just 5% selected 'I don't know' option.

A large amount of teachers surveyed (**70%) expressed an interest in attending Science CPD courses on developing oral language skills in Science.** There were 14% of negative responses and 16% were 'I don't know' responses.

Only **18%** reported that their **undergraduate/postgraduate primary teaching education course incorporated the development of oral language skills specifically in Science education.** With a significant amount **76% stating that their undergraduate/postgraduate teacher education course did not include the development of oral language skills specifically in the Science lesson.** 6% responded with 'I don't know.'

Comments from teachers included how literacy was incorporated undergraduate/postgraduate primary teaching education:

- '*oral language in relation to Science directly with specific* ***Science terminology*** *such as translucent versus opaque and by describing and reporting your investigation method and results were also promoted as key parts in Science lessons.*'

- *Using '****comparative adjectives*** *e.g. hot/hotter/hottest' and 'introduce* ***new vocabulary*** *for example in the investigation, experiment part of the Science lesson.'*

Comments from teachers included how they could be supported in integrating literacy in Science teaching:

- '*it would be great to have easy access to **resources** on each class level regarding Science experiments and in particular I find it challenging to make magnets lesson more interesting for the senior rend of the school.*'

- '*it would be great to see specific **resources** for encouraging the development of oral language such as a list of appropriate **vocabulary, oral language games** such as those played in English and Irish*.'

The teachers' comments highlighted that the teachers **can see the relevance of Science lessons in the development of vocabulary, adjectives and scientific terminology**. They also highlighted they would like to be introduced to **teaching strategies and resources** showing how this can be carried out in Science lessons.

4.3 Literacy skills in the Science Classroom

Section 3 of the questionnaire investigated the use of teaching strategies in teaching Science lessons in developing literacy skills and the teachers' opinions on using primary Science lessons to enhance children's oral language skills.

4.3.1 Incorporating literacy teaching strategies and approaches in their primary Science lessons

Teachers were asked to rank the amount of time spent during a Science lesson on oral language, reading and writing. The results are shown in Table 4.7.

Table 4.7. Time spent on dialogue, reading and writing in primary Science lessons (N=42)

	% of Class Time in Science Lessons							
	≤10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**≥80%**
Teacher Talk	6	8	22	22	17	19	6	0
Pupil Talk	6	14	17	29	23	11	0	0
Teacher Writing	34	14	19	16	17	0	0	0
Pupil Writing	21	39	16	13	11	0	0	0
Teacher Reading	85	7	9	0	0	0	0	0
Pupil Reading	91	6	2	0	0	0	0	0

An individual child discussing their ideas with the class	33	30	3	15	6	7	0	6
An individual child arguing/debating their ideas	44	38	9	3	3	3	0	0
Whole class discussions	11	23	11	20	6	9	9	11
Argumentation Strategies	57	20	3	7	13	0	0	0

Teacher talk contributed to the highest proportion of time spent in Science lessons. 42% of teachers use teacher talk ≥50 in their lessons. This was followed closely by whole classroom discussion and pupil talk with 35% and 34% of teachers using these methodologies respectively ≥50 of the time in their Science lessons. The least frequently used teaching methodologies were argumentation strategies, individual pupils discussing their views and teacher writing.

A more limited amount of time was given to pupil reading in the lessons (80% of teachers felt 10% of class time in Science was spent on reading) than pupil writing. Overall **a greater percentage of time was spent on teacher reading and writing** when compared to pupil reading and writing**. It is difficult to draw any clear conclusions from this table of data without carrying out observations in classrooms or delving further into this topic through discussions with teachers.** Argumentation strategies, children debating and discussing their ideas were ticked in the lower percentage levels.

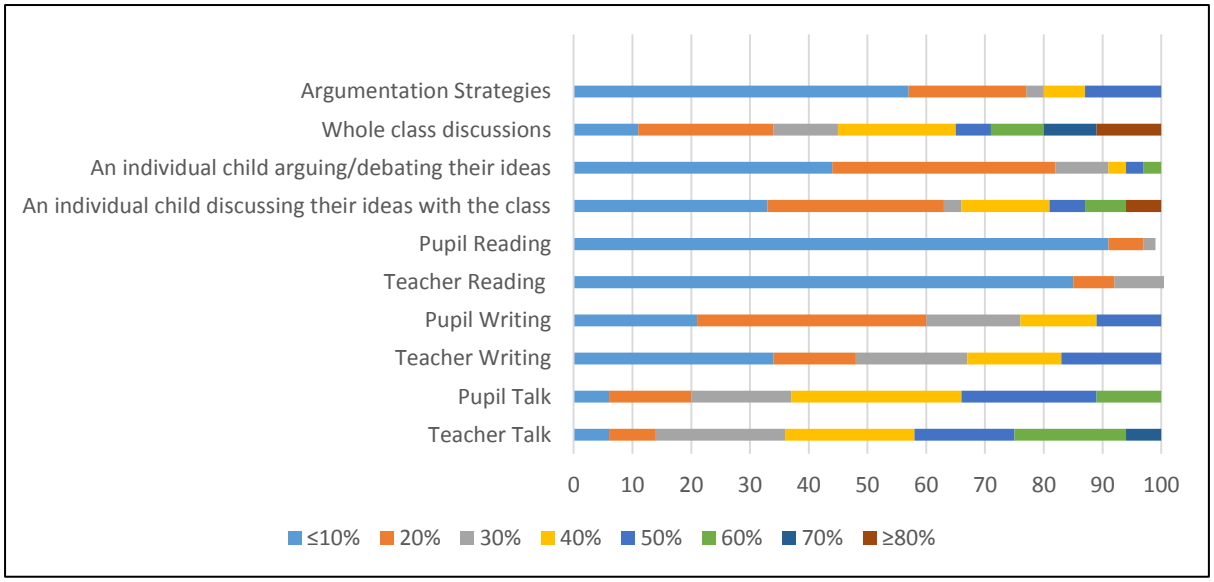

Figure 4.3 Teachers' estimates on the proportion of time they spend on literacy skills in Science lessons (Results represented as a % of the total participants N=42)

Comments from teachers included:

- '***Class size*** *is a problem for trying to implement individual pupil discussing their ideas fairly in the classroom which also impacts on the time allocated to a Science lesson and other subject to get through on the curriculum.*'

- '*I find time and getting the* ***content covered*** *an issue and therefor I just stick to a few teaching methodologies.*'

- '*I am teaching only a short while and I am not familiar with* ***argumentation strategies***.'

Comments from the teachers highlighted the logistics of carrying out dialogue activities with large class sizes and allowing time for such strategies. Also one teacher highlighted their lack of familiarity with argumentation strategies.

4.3.2 Higher Order Oral Language Approaches Employed by Teachers in the Teaching of Primary Science

The teachers were asked to provide opinions on their practices in employing higher order oral language skills that encourage argumentation, problem solving, pupil questioning, and open ended-questioning. They were asked to rank their opinions as either Strongly Agree/ Agree/Neutral/Strongly Disagree/Disagree.

Table 4.8 Teachers' opinions on higher order oral language approaches in the teaching of primary Science (Results represented as a % of the total participants N=42)

Incorporating higher order oral language skills into Science lessons (% of Participants)					
	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Think-pair-share used a lot in my Science lessons	27	35	30	5	3
Group work to 'build' answers and solutions between students discussing problems and pooling knowledge and experiences	19	54	19	3	5
Children are encouraged to ask (the teacher and others) questions	41	54	5	0	0
Children are encouraged to make connections	38	57	5	0	0
I sometimes respond to student questions with further questions to prompt them to think for themselves.	33	56	8	0	3

I always supply starting-points for investigations, and guide the students through open-ended questioning	30	51	16	0	3
Children are encouraged to think aloud	33	48	11	1	8
Productive argumentation is used	8	19	35	19	19

From the above Table 4.8 above **it is evident that teachers are incorporating quite a significant amount of oral language skill development in Science lessons.** However it was interesting the number of teachers that disagreed about the occurrence of some opportunities for productive talk in their lessons. **Over 90% of teachers either strongly agreed or agreed that in their lessons children are encouraged to ask questions** and to make connections. Questioning featured often in the teachers' lesson with **81% stating they use starting-points** for investigations, and guide the students through open-ended questioning however **3% strongly disagreed** with this and while most teachers encourage **children to think aloud, 9% disagreed with this.** This was also reflected in the answers regarding children talking among themselves, **while many teachers incorporate Think-Pair-Share and group work involving discussions among children, 8% of teachers' disagreed that this is encouraged in their lessons.**

89% agreed that they **sometimes respond to student questions with further questions to prompt them to think for themselves, however 3% disagree that this a feature in their lessons.**

Similar to the findings of Table 4.7 above argumentation does not appear as often as the other oral language strategies in Science lessons. The use productive argumentation such as concept cartoons, the use of puppets, competing theories, cards sorts (students work collaboratively to match, arrange or sort information on cards), and evidence statements was the least common methodologies with only 27% of teachers using these techniques to teach a Science lesson. **38% do not use these argumentation strategies in their lessons.**

Table 4.9. Occurrence of teaching strategies/activities in the primary Science lesson incorporating literacy skills (N=42)

Occurrence of teaching strategies/activities in the primary Science lesson incorporating literacy skills				
		Always (%)	Sometimes (%)	Never (%)
Reading & Writing	Science Books	43	43	14
	Children's English Literature	0	2	98
	English Poems	0	0	100
	Writing Process Skills	8	92	0
	Worksheets	6	11	83
	Use of Science Notebooks/Diaries	19	46	35
	Use of Word Walls/Word Banks	16	59	24
	Card Sorting/Matching	0	0	100
	Sentence Stems	17	64	19
Dialogue & Argumentation	Exploratory Talk	43	46	11
	Dialogic Teaching and Talk	29	56	15
	Collaborative Group Work	46	51	3
	Talking Points	25	47	28
	Concept Cartoons	0	11	89
	Concept Mapping	14	58	28
	Debating	0	43	57
	Student KWL Charts	31	44	25
IBS	Science Process Skills	47	47	6
	Inquiry based learning	40	57	3

In Table 4.7 teachers were asked for an indication of the proportion of a Science lesson allocated to oral language, reading and writing. It was found a more a more limited amount of time was given to pupil reading in the lessons than pupil writing. The next section of the questionnaire investigated some of the specific teaching strategies teachers' incorporated into their Science lessons (Table 4.9).

4.3.2.1 Reading and Writing

As can be seen from Table 4.9 Science books are used either 'Always' or 'Sometimes' by 43% of the teachers. However, a high proportion of the teachers 'Never' incorporated Children's English Literature (98%) or Poems (100%) into their Science lessons.

8% admitted that they focused on 'Always' focused on writing skills in the Science class, with the majority 92% stating they sometimes focus on this. 83% never used worksheets. 19% 'Always' and 46% 'Sometimes' use Science notebooks and diaries. However, 35% 'Never' use a Science notebook.

The majority of the teachers (59%) only ‘Sometimes’ use Word Walls and 64% only ‘Sometimes’ use sentence stems. Card sorting or matching is never used by the responding teachers.

4.3.2.2 Dialogue and Argumentation

Table 4.7 indicated that Teacher talk contributed to the highest proportion of time spent in Science lessons. Results in Table 4.9 indicate that out of the three talking strategies in the questionnaire: Exploratory Talk, Talking Points and Dialogic teaching and talk, exploratory talk was indicated by the teachers to be used the most often. 43% of teachers’ stated they ‘Always’ incorporated exploratory talk, with 46% only ‘Sometimes;’ and surprisingly 11% ‘Never’ doing so. They were then asked about dialogue in the classroom and a lower percentage (29%) stated they ‘Always’ incorporate this and with 56% only ‘Sometimes’ and again surprisingly 15% stating they ‘Never’ incorporate dialogic teaching. These findings are surprising as you would presume Science lessons are all based around children talking about their ideas, their experiences of Science etc. Collaborative group work which would allows the children to develop their communication skills was ‘Always’ carried out by nearly half of the teachers surveyed (46%) and by 51% some of the time.

When asked about their specific use of strategies that promote argumentation, debating and higher order critical thinking skills and analysis skills it was found 89% ‘Never’ use Concept Cartoons, with 28% and 58% either ‘Never’ or ‘Sometimes’ using concept mapping. 57% ‘Never’ use debates in their Science lessons with 43% ‘Sometimes’ using this teaching methodology. KWL charts were used by some teachers i.e. 44% ‘Sometimes, and 31% ‘Always’ with a quarter of teachers ‘Never’ using KWL charts in Science lessons.

4.3.2.3 Inquiry Based Science (IBS)

Science Process skills are used only by 47% of the teachers all the time compared to the same amount of teachers who use it ‘sometimes’. The same was found with IBL being used by 41% of the teachers ‘always’ and used ‘sometimes’ by 57% of teachers surveyed.

4.3.2.4 Teachers’ Opinions on Time Devoted to Literacy and Numeracy in the Curriculum.

Teachers were asked to comment on the following statement:

'*One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a reduction in the amount of time devoted to the core areas of literacy and numeracy.*' (Better Literacy and Numeracy for Children and Young People p28).

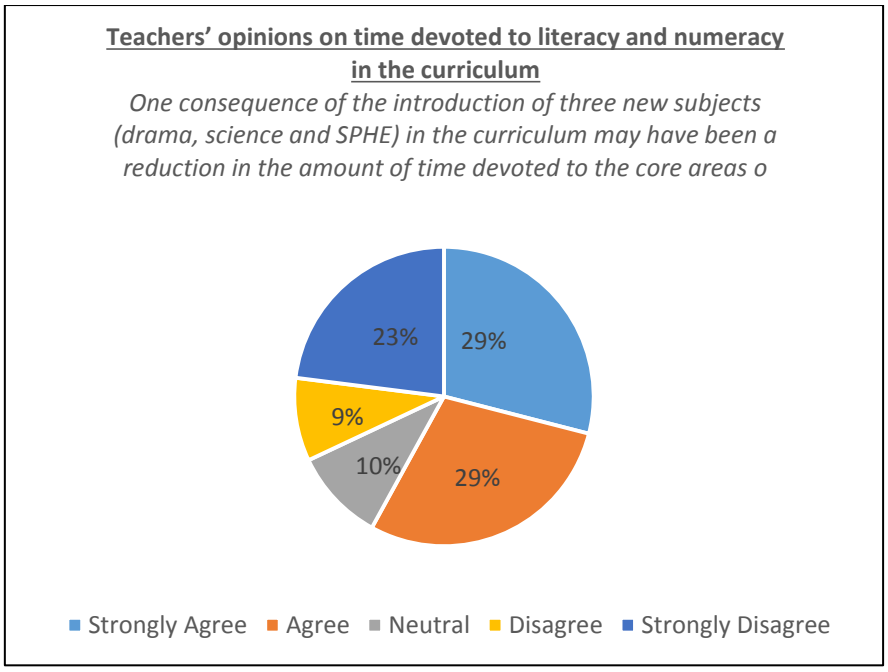

Figure 4.4 Teachers' opinions on time devoted to literacy and numeracy in the curriculum (N=42)

The teachers' opinions on this statement are interesting. **Over half (58%) were in agreement with the above statement,** while 31% disagreed with the statement, with 10% remaining neutral.

- '*I agree with the above statement in that some topics are rushed through and we do not have adequate time to explore different topics/ideas that crop up during the lesson. I would love the opportunity to explore further but I don't have time.* ***Time pressure*** *is the biggest disadvantage we are working under. Bright pupils will achieve but because we are in a DEIS Band 1 school, many pupils are educationally disadvantaged and need more time at certain subjects.*'
- *'I definitely agree. Teaching two classes with children in these classes with S.E.N. and* ***separate programmes in English and Maths*** *leaves very little time for other subjects.'*
- '*I do feel that this is* ***a valid point*** *if we do not teach in an integrated manner. However, it is vital that* ***teachers seek and use methodologies that promote the integration*** *of*

literacy and numeracy into Science, drama and SPHE in order to teach concepts and themes in context and in a meaningful manner.'

- '*An overloaded curriculum has forced teachers to integrate subjects in order to achieve objectives.* ***This integration is not always appropriate or suitable***. *Integration of literacy into Science lessons is off putting for children with literacy difficulties – especially reading and writing.*'

Teachers in some of their comments were in agreement that literacy skills can be integrated into Science lessons. However, concerns over the time it takes to do this in such an overcrowded curriculum was difficult and the strong focus on literacy lessons allows less time for the teaching of Science, SPHE and Drama. Some teachers' commented that CPD and the provision of methodologies and resources for teachers on effective integration was needed:

- '*Well this doesn't make sense!* ***Surely oral language can be developed at some stage during this time.'***
- '*Certain aspects of literacy and numeracy* ***can be integrated*** *and developed through drama, Science and SPHE but I would agree that the* ***time devoted*** *to the main core subjects has been reduced.*'
- '***Drama/SPHE/Science can be used very effectively in development of oral language***. *Drama as a standalone subject is rare in my class.*'
- '*I agree with this opinion in that teachers have less time to concentrate on a subject and we feel we are rushing through subjects in order to complete the curriculum. I try through my planning to integrate topics as much as possible but still feel under* ***time pressure to get the curriculum covered***.'
- '*I agree with this opinion in that teachers have less time to concentrate on a subject and we feel we are rushing through subjects in order to complete the curriculum. I try through my planning to integrate topics as much as possible but still feel under* ***time pressure to get the curriculum covered***.'
- '*because there is such a strong focus on Literacy and Numeracy now in schools,* ***time spent on subjects like drama, SPHE and Science has reduced*** *and sometimes I just have to leave these subjects out in the timetable during the week.*'
- '*Literacy and numeracy can easily be integrated into all subject areas but teachers* ***need more creative CPD courses*** *in how to plan these strategies.*'

4.3.2.4 Teachers' Opinions on the Implementation of Inquiry Based Learning

Teachers were asked to comment on the following statement:

'*It can be challenging to implement IBL effectively in your Class*.'

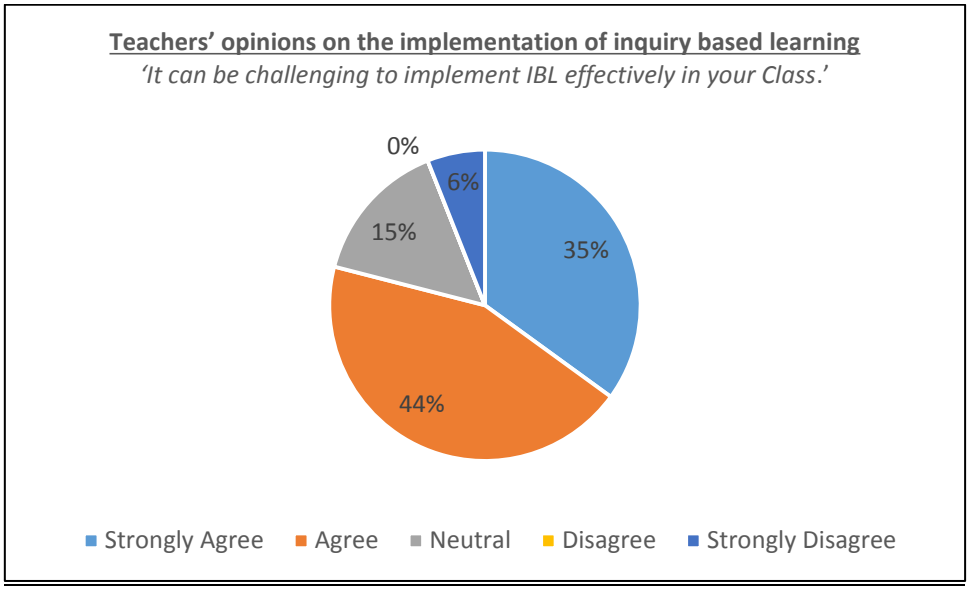

Figure 4.5 Teachers' opinions on the implementation of inquiry based learning (N=42)

Less participants commented on the above statement than the statement from the 'Better Literacy' report. **79% of the teachers' felt that it was challenging to implement IBL effectively in their class.** 6% disagreed with this statement. Two teachers' noted experiencing difficulties with **classroom management** and that **class size** as issues in implementing IBL effectively.

One participant noted that '*when children are working in groups, it is difficult to **manage** all the groups as class size is very big. I have 33 pupils in my class*.' Two other participants commented that they felt that they **didn't have enough knowledgeable skills on some of the content in the Science curriculum to make IBL more effective**.

One participant wrote that '*when using scientific skills such as analysing magnets in 5th and 6th class it is too simple and what is being learnt about magnets is not much different to what is being learnt about them in the lower classes in the school.*'

4.4 Summary of key findings from the questionnaire of primary school teachers.

Summary of findings from the questionnaire that were used to guide the structure and discussions during the semi-structured interviews, highlighting possible areas to probe with the teachers:

Continuous Professional Development of Teachers.

1. Attendance at Science CPD Sessions.
2. Science CPD Sessions incorporating literacy skills.
3. Models of CPD that teachers feel would work.

Incorporating literacy teaching strategies and approaches in their primary Science lessons.

4. Their opinions on incorporating reading and writing teaching strategies and approaches in their primary Science lessons.

Inquiry Based Science Lessons.

5. Incorporating higher order oral language skills that encourage argumentation, debating, problem solving, pupil questioning, and open ended-questioning did not feature as prominently in Science lessons.
6. Incorporating opportunities for collaborative discussions.

Continuous Professional Development of Teachers

- A large amount of teachers (48%) have not taken any CPD course in Science in the past 5 years and the more experience of the teacher the fewer CPD courses in Science they attend.
- However the teachers had received a significant amount of supports over the past 5 years in the development of Literacy skills.
- 80% of the teachers that had attended Science Sessions stated that **there was not an emphasis placed on Literacy skills in these courses**. With only 1 out of the 42 attended a CPD session on developing oral language skills specifically in Science lesson and no teacher out of the 42 had attended CPD session on developing writing skills and reading skills in Science lessons.
- **Overall the level of satisfaction with CPD provision in Science was high** with no teachers being 'very unsatisfied' with content, pedagogical skills, subject matter in Science, provision of resources and increase in confidence levels in teaching Science. **A small proportion were 'unsatisfied' with the CPD sessions in updating their**

pedagogical skills, subject matter knowledge, increasing their confidence levels in teaching Science, the provision of resources and the cost of such courses.

- A large number of teachers **would be in favour of having more opportunities in undertaking CPD courses in Science** showing there is a need for CPD in this subject area (92%) with a large amount of teachers (70%) expressing an interest in attending Science CPD courses on developing oral language skills in Science.
- From looking at the collected data it seems to be the case that **the teachers' teaching the senior classes seem to be less satisfied with CPD** and the knowledgeable skills they need to enable them to teach effectively on a certain topics in Science.
- A significant proportion also mentioned that their **undergraduate/postgraduate primary teaching education course did not incorporate the development of oral language skills specifically in Science education** (76%).
- The teachers' comments highlighted that the teachers **can see the relevance of Science lessons in the development of vocabulary, adjectives and scientific terminology**. They also highlighted they would like to be introduced to teaching strategies and resources showing how this can be carried out in Science lessons.
- Many teachers' mentioned **different models of CPD** they had been involved with or would like to see for example: Community School Projects and Whole Schools CPD sessions.

Incorporating Literacy Teaching Strategies and Approaches in their Primary Science Lessons

- From the above it is evident that teachers are **incorporating quite a significant amount of oral language skills in Science lessons** i.e. through exploratory talk, dialogue and developing communication skills. **However, employing higher order oral language skills that encourage argumentation, problem solving, pupil questioning, and open ended-questioning did not feature as prominently in Science lessons**. Argumentation strategies, children debating and discussing their ideas were ticked in the lower percentage given lower.
- Teachers' **highlighted the logistics of carrying out dialogue activities** with large class sizes and allowing time for such strategies. Also, one teacher highlighted their **lack of familiarity with argumentation strategies.**

- It was **surprising and worrying** to observe when investigating the occurrence of teaching strategies (Table 4.8) that some teachers stated they **'Never' incorporate exploratory talk (11%) and dialogue (15%).**
- Overall, a **greater percentage of time was spent on teacher reading and writing when compared to pupil reading and writing in Science lessons.**
- Incorporating children reading and writing resources and teaching strategies i.e. literature and poems, word walls etc. used in English lessons were more limited in Science lessons.
- **Writing and vocabulary teaching strategies were also more limited that oral language strategies.**
- Over half (58%) were in agreement that '*One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a reduction in the amount of time devoted to the core areas of literacy and numeracy'***.** However their comments did confirm that **they felt literacy skills can be integrated into Science lessons.** Concerns were raised over the time it takes to do this in such an overcrowded curriculum was difficult. Some teachers' commented that **CPD and the provision of methodologies and resources for teachers** on effective integration was needed.

Inquiry Based Learning

- **Teacher-directed teaching and teacher led investigations** seemed to be more common in Science lessons rather than more child-led/child centred investigations due to several factors. The time in which to get the Science lesson completed by due to an **overloaded curriculum, class size and manageability of groups, lack of resources and lack of teachers content knowledge in Science.** This may have an influence on the time spent on discussion and debates, and communication in groups in general.
- From looking at collected data with regard to the teachers number of years teaching experience and style of teaching, it appears that the teachers with the **longest teaching experience tend to be the biggest group that uses Teacher-directed teaching** and teacher led investigations.
- 79% of the teachers' felt that it was **challenging to implement IBL effectively** in their class**.** Teachers' noted experiencing difficulties with classroom management and that class size as issues in implementing IBL effectively.

- One teacher felt that they **didn't have enough knowledgeable skills** on some of the **content in the Science curriculum** to make IBL more effective.
- Some teachers especially those who teach the senior classes find the content of the Science curriculum challenging to implement effectively and **this raises questions about the challenges being afforded to older pupils in developing skills including higher order thinking skills, argumentation, effective discussions and interpretations, evaluations on pupils' opinions.**
- **Class size** seems to be an issue in carrying out a Science lesson effectively with regard to collaborative group work where classroom management can be challenging.

4.5 Findings from Interviewing Primary School Teachers (N= 3)

Having analysed the data from the questionnaire, the interview questions were designed to highlight any areas that the researcher felt needed to be explored further to help answer the research question. The interview questions were pre-determined and were asked in a logical sequence. Open-ended questions were included 'to secure vivid, accurate, inclusive accounts that are based on personal experience' (Burgess, 1982, p.107). The interview questions allowed the interviewees to express their views in their own terms which resulted in gathering rich data. Three teachers were interviewed who teach the middle and upper class levels. Two were from a mixed school and one from a boys' school. These teachers were currently teaching in the junior classes, middle and higher classes.

4.5.1 Continuous Professional Development of Teachers

All three teachers had attended Science CPD sessions in the past 5 years. They were asked ***would they consider doing CPD courses on Science outside of school time?***

The comments from teachers' highlighted elements of a CPD programme in Science they feel is most effective and suitable to their needs i.e. **offer the face to face, hands on session's during Croke Park hours* where teachers are provided with the opportunity to share practices and discuss their experiences together.**

***** *The provisions of the Public Service Agreement provides for an additional 36 hours per school year at primary level. The terms of the agreement became operative for primary schools in February 2011.*

All three teachers' interviewed found the face-to face courses better than on-line courses. They found the hands-on experience very satisfactory and interaction with other teachers and facilitator of the course. Teacher #1 added that *'it would be great if courses could be held during **Croke Park times** and this would be more productive I would think or in-service courses during the school day.'*

What model of CPD do you find most desirable for your needs?

All teachers' found the CPD courses useful and helpful to their teaching of scientific process skills and IBL. However, teachers also found that although the CPD courses taken during the summer months were beneficial, the teachers had to revise the material again in September and would have benefited from a help forum in some areas of the Science curriculum that they needed clarity on. There was mixed reactions to online Science CPD courses and the face-to-face CPD Science courses.

The teachers were then asked to elaborate on what CPD models do they feel are the best. Teacher #3 commented that *'the CPD courses are very good but I usually do these courses in July and by the time September comes I have **forgotten a lot of what was covered on the course**.'* Teacher #1 who had moved from being an infant teacher to the senior end of the school found that after having done a Science CPD course over the Summer, felt that she ***'was still unprepared for the Science curriculum.** I had to do a lot of research in it throughout the year.'* And added that *'it would be great to have a Science folder available on each class level. It has been a steep learning curve for me and not just in Science.'*

Teacher #1 commented with regard to Science courses where *'only 1 representative of staff could attend. This **should have been a whole staff approach** as it would have benefited the teachers' level of content knowledge and experiences will differ especially in the middle and the senior end of the school classes.'* Teacher #3 noted that with postgraduate programs there is *'**no incentive to do masters** as there is no promotional prospects or monetary gain in furthering ones education.'*

Teachers were asked to elaborate on the cost of CPD courses that they had undertaken.

Two of the teachers' interviewed found the on-line courses more expensive generally than the face-to-face courses. All teachers' interviewed found the face-to-face courses more beneficial as they were practical and you could ask the tutor and other teachers' questions if you wanted

to. Teacher #1 commented that *'the most recent Science courses that I have attended in the past 2 years have been **free** with the Mallow Science Partnership initiative that is in collaboration with Mary Immaculate College'* and added that *'I have found it **useful and very practical**.'*

4.5.2 How effective were the Science CPD courses and/or past Science courses that you have taken have helped you in teaching Science in the classroom and with regard to teaching oral language?

None of the teachers had specifically attended a Science CPD course focusing specifically on literacy skills. However, they did acknowledge that Science by its nature can develop children's literacy skills. The three teachers' mentioned oral language, writing and reading. Teacher #1 stated that '*we can develop children literacy skills in Science I think in line with **writing genres',*** and teacher #2 felt that '*Science can develop literacy skills by using for example **predicting, pre and post activity reviews, vocabulary building and reading Science texts** like for example how things work etc.'* Teacher #3 stated '*we can develop children oral language through **pre-experiment discussions** and writing skills by **recording materials, steps and outcomes** of an experiment.'*

4.5.3 Incorporating literacy teaching strategies and approaches in their primary Science lessons

They were then presented and asked to comment on the statement: One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a *reduction in the amount of time devoted to the core areas of literacy and numeracy*." (From: Better Literacy and Numeracy for Children and Young People p28).

Teachers in some of their comments were in agreement that literacy skills can be integrated into Science lessons. However, one teacher highlighted that time spent on other subject areas were being affected by increasing the emphasis literacy and numeracy presumably in Maths and English lessons. Teacher #2 did refer to a more integrated curriculum that is focusing on integrating methodologies across the board with the need to '***focus on methodologies across the subjects rather than discrete subject areas***.' Teacher #1 felt that *'drama and SPHE gives children lots of oral language time and Science has plenty of opportunity with report writing etc.'* Teacher #3 felt that *'if you **integrate literacy with Science and numeracy both areas are covered very effectively.'***

4.5.4 Incorporating literacy reading, writing and dialogue in primary Science lessons

The questionnaire data highlighted that teachers were incorporating quite a significant amount of oral language skills in Science lessons i.e. through exploratory talk, dialogue and developing communication skills. However, employing higher order oral language skills such as encouraging argumentation, problem solving, pupil questioning, and open ended-questioning did not feature as prominently in Science lessons. A stronger focus was placed on oral language than on reading and writing also in lessons. Therefore, they were asked: ***How do you currently incorporate literacy into your Science lessons with regard to reading, writing and through dialogue?***

It was found that the three teachers' interviewed apply teaching methodologies they use in English lessons to the Science lessons such as Writing Genres, Card Sorts, Sentence Stems and employ methodologies such as concept mapping also to encourage greater discussion in the classroom.

Dialogue

With regard to dialogue all three teachers use **think-pair and share for discussion** on a Science topic or an experiment. All agree that **collaborative group work and project work** helps with enhancing pupil oral language development and confidence levels and all use whole class discussion at the start of their Science lessons. Teachers #1 and #2 use collaborative group work but in small groups preferably as noise levels can be an issue and large numbers create chaos with some unruly students disrupting the purpose of the group work and teacher #2 noted that '**sometimes the discussions around the experiments can be rushed due to time constraints.**' *The teachers' interviewed use a mix of method to aid dialogue among students such as* ***project work*** *and working together independently in the computer room for example.*

Teacher #3 commented that *'using* ***card sorting and sequencing in a Science lesson*** *or when the children are doing a basic experiment, they have assigned roles and talk about what they are supposed to do, how they will do it and help each other to complete the task through discussion.'*

They were probed further to provide any further details of any other higher order oral language activities that promote debating, argumentation and pupil questioning etc. All teachers commented that they were not sure exactly was argumentation was.

Reading

With regard to reading all three teachers use the mandatory Science book prescribed for their class level. They also **provide reading materials** to children from different media sources to provide extra information to children. Two of the teachers' found the lack of having ICT resources (computers) a hindrance as pupils cannot look up information on the internet at school and pupils are asked to look up information on their family computers at home assuming all pupils have access to a computer at home. Teacher #1 commented that *'with regard to reading the **school Science book** is used and the pupils get turns to **read aloud** from it.'*

Writing

With regard to pupils writing in the Science lessons all the teachers' interviewed are familiar with and use the '**Writing Genre** – A structured Approach' which was distributed to all primary schools in Ireland from the PDST (2013) and is available on the PDST website. All three teachers' mentioned **procedural writing** is used when the pupils are writing up their experiments. Teacher #3 also noted *'I use **STEM sentence starters** with the younger pupils as they tend to find it difficult to get started and worksheets are great also for these junior classes.'* And added *'the pupils sometimes **draw their experiment**.'*

4.5.5 Future Training on Incorporating Literacy Skills into Primary Science Lessons

The teachers were then asked:

Would you be interested in attending CPD sessions in how to incorporate Literacy skills into Science in the future?

The teachers would all welcome the opportunity to learn about new strategies in reading and writing suitable for Science lessons, however they all commented they are mindful that they do not want reading and writing to take up a large proportion of the Science lessons also. Teacher #3 commented that *'I would love ideas on literacy skills and oral language in Science and also developing more thought provoking discussions and discussions in general.'*

4.5.6 Inquiry Based Learning and scientific process skills

Teachers were also asked to elaborate in the interview on ***how IBL and scientific process skills were being implemented in their Science lessons***? As it was implied in the questionnaires that

maybe more teacher-directed Science lessons and teacher led investigations were being used due to class sizes, time constraints and classroom management issues.

There is an authentic link between literacy and Science. Science lessons can help in promoting literacy through oral language, reading and writing and the appropriate use of literacy in Science is needed to achieve a deeper understanding of Science and the ability to reason scientifically (Douglas *et al.*, 2006). Inquiry based Science lessons which incorporate the constructivist approach to teaching empower pupils to think critically, make deep connections through questioning, exploring, thinking, experimentation and reflecting and applying this understanding in a productive way into actionable knowledge (Grabe and Grabe, 2000; Abrahms, Southerland and Evans, 2007). All of which are carried out through exploratory talk, dialogue, reading and writing. It was also implied in the questionnaire higher order language higher order oral language skills that encourage argumentation, problem solving, pupil questioning, children debating and open ended-questioning did not feature as prominently in Science lessons. Therefore instead of asking to the teachers directly I was decided to investigate this through exploring how IBL was implemented in the teachers' lessons.

All responses mentioned the challenges they were facing when trying to implement IBL i.e.

- **Time, class size, classroom management the teachers' scientific knowledge** were stated as challenges to focusing on the delivery of IBL and the development of scientific process skills.
- One teacher considered **Science books as a resource for IBL** Science Lessons. This implies that the teacher uses a very much prescriptive approach to IBL.

Teacher #1 commented that '*the scientific process skills that I use in IBL varies and depends on what I will be teaching the children. I use the* ***Science book*** *for 5th class and I try and use as many of them as I can over the year. I would say to be honest we would not have enough* ***time*** *to get through all the Science process skills in depth. I have a lot of children who would just mess also so I concentrate on the experiment with the children and what the outcomes should be.*' Teacher #2 responded that '*my* ***scientific knowledge*** *is not great but I do the best I can.'*

Teacher #3 added that '***class size*** *has an effect on how much inquiry can be done 'as keeping* ***control*** *of large class working in groups is challenging*.'

To expand on the above question in the interview the teachers were asked if they prefer to use closed or open ended experiments. Similar to the findings of the questionnaires the same issues arose: **time, overcrowded curriculum, planning, class sizes, resources and scientific knowledge**.

Teacher #1 noted that *'…in trying to carry out open ended investigations, it just takes too long and I have a whole school curriculum to cover too.' This was also echoed by teacher #2* and added that it *'requires a bit **more planning**'* and resources too. While teacher #3 noted that '***class size** is not very conducive to open investigations …with regard to **classroom management** of these kids and the experiments …is very challenging*.'

Two participants from the questionnaires noted that that they felt they didn't have enough **knowledgeable skills** on some of the content in the Science curriculum to make IBL more effective. The three teachers' interviewed also agreed with this especially in the older classes where the pupils need to be challenged more. Teacher #2 commented that they found it challenging, '*with teaching 6th class I find it **difficult to find new material** on some topics from 6th class books.*' Teacher #3 commented that '*I don't have enough **resources** available to allow the pupils to work in smaller groups… with little resources and large class size is challenging.'* Teacher #1 noted that '*I would like to **know more interesting/challenging experiments** that 5th and 6th class pupils can do and that are relevant to them'*. All of the participants interviewed found **time as a constraint** and therefore the investigations are more teacher directed rather than pupil directed.

4.5.7 Collaborative Group Work in Your Science Lessons

Data from the questionnaires showed that 8% of teachers' disagreed that Think-Pair-Share and group work involving discussions among children, was encouraged in their lessons. Collaborative group work which allows the children to develop their communication skills was 'Always' carried out by nearly half of the teachers' surveyed (46%) and by 51% only some of the time in Science lessons. Therefore, it was decided to investigate the teachers' thoughts on collaborative group work further and to further investigate their thoughts on the development of children's literacy skills through group work. They were asked: ***How effective is collaborative group work in your Science lessons?***

Teacher #2 commented '*pair work in particular helps the **academically weaker** pupils to be **more confident and helps build up their self-esteem**. However, sometimes with the larger group work, the quieter more reserved pupils can be lost in the mix unless definite roles are assigned to the members in the group but still some of the more boisterous ones try to dominate the activity.'*

Teacher #1 who teaches in the senior classes found that with an SEN pupil in her class with *'Asperger's work better in **pair work than in a large group** and so the class has some pair work and group work being carried out simultaneously and the pupils are moved around from pair work to group work and this works well.'*

Teacher #2 also noted *'I find having small groups of 3 or 4 works best in my class. I am lucky though my class size is small' adding that 'its manageable and the groups are more focused. **Pupils can ask each other questions to clarify their understanding** in the small groups and I think it's less intimidating for the shyer/quieter pupils to get more involved also.*' This kind of group work is also conducive to helping pupils develop their scientific skills.

All three teachers' preferred a more teacher directed approach with some aspects of autonomy given to the pupils while they are carrying out experiments, as teacher #1 pointed out that as *'**classroom management** can be an issue in a large class.'* Teacher #2 relayed similar comments and added that *'closed activities were much **quicker to accomplish** [rather than open ended investigations] due to time constraints.'* Teacher #3 noted that *'**its very time consuming** for the teacher to go around to each group in a large classroom.'* Teacher #1and #3 noted that there are some '**negative experiences of working in groups'** resulting in arguments regarding tasks being carried out in the group.

All of the teachers' commented on class size being an issue when carrying out group work. Group work can be very noisy and with large class sizes getting around to all groups and give them the time they need and manage the class at the same time is challenging at times. This is unfortunate as group work and discussions among peers is an essential component to the learning of Science and in oral language development.

Teachers were asked to further elaborate on **how they felt group work could be improved in order to promote dialogue and discussions among the pupils?** They were all able to suggest

ideas they mentioned station teaching that they are using in Maths and English. Teacher #3 also added that the pupils *'enjoy **project work** and are great at **coming up with ideas on their own.'*** It is interesting to note in the previous question the teachers' decided to go for more teacher led lessons in Science but when asked about how they could improve their practice they mentioned strategies used in English and Maths to improve literacy skills that can be implemented also in the Science lessons which they are not currently doing.

4.5.8 ICT in Science Lessons

Do you think ICT can develop or hinder children literacy skills in Science?

Use of ICT encourages 'learning by doing' communication and collaboration. ICT helps pupils' to communicate effectively, able to work collaboratively, and to critically evaluate, manage and use information. Therefore it was decided to ask the teachers in the interviews if they used ICT in their Science lessons. All of the teachers' interviewed used ICT in Science to some degree. Only one of the teachers' interviewed had the facility of a computer room which pupils use to research their Science experiments, collaborate together and type up their experiments.

Teacher #1 commented that *'having a computer room is a great resource and it is great stimulation for the **children as they work together on projects**, there is a **lot of talk and discussion and this is great and the kids are very helpful to each other helping one another out with explaining things and with new ways of inputting information onto the computer**.'*

However, unfortunately the lack of resourcing does not allow the integration of ICT into Science lessons as often as the teachers would have liked. Two teachers only had minimum use of computers in their classrooms. These teachers sometimes asked the pupils to research Science projects on their home computers provided they have access to computers at home.

4.6 Conclusion

This research project used a mixed method approach as outlined in chapter 3. The questionnaires and the interviews set out to answer the research question and the embedded questions. The questionnaires centred on the information researched in the Literature Review in chapter 2 which have helped to answer the research question and the embedded questions. The study looked at qualitative and quantitative data. The findings from the questionnaire

were examined and analysed in detail. The findings from the questionnaires helped to inform the interview questions along with information gathered from the literature review.

The overall research question was as follows:
What are teachers' opinions on and attitudes towards the use of Science lessons in, fostering the development of Literacy Skills in the Irish Primary Science Classroom?

The embedded research questions included:

1. *To what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons?*
2. *What are the most common oral language approaches employed by teachers in the teaching of primary Science?*
3. *What are teachers' opinions on using primary Science lessons to enhance children's oral language skills?*
4. *What are teachers' background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science?*

In brief, the overall findings show that the incidence of specifically planning and making a conscious effort at integrating literacy skills in all areas of the curriculum and in particular in Science was not very evident in this study. Time constraints due to an overcrowded curriculum is putting pressure on the amount of time needed to carry out literacy skills within Science effectively. Discussions within Science experiments can be rushed as a result. The quantitative data from the questionnaires has shown that many teachers' stated they were incorporating exploratory talk, dialogue and developing communication skills in Science lessons. Collaborative group work is only carried out half of the time due to large class sizes. The logistics of carrying out dialogue in a large classes and classroom management seems to be very challenging. Closed ended experiments are favoured more than open ended experiments because of classroom size and time constraints. Data from the questionnaire and interviews highlighted that pupil reading was less prominent in lessons that teacher reading and over all reading was not prioritised in Science. However, when they were asked about their practices several times in the questionnaire inconsistencies and contradictions began to emerge. Teachers in this study also highlighted their lack of scientific knowledge as a key factor influencing how they incorporate inquiry based learning and literacy skills in Science. Teachers were in agreement and are all very aware that literacy skills can be integrated into

Science lessons and Science lessons can play a significant role in developing children's literacy skills. Teachers' responses to the survey and the interviews has raised concerns with regard to the delivery of inquiry based Science teaching in primary classrooms incorporating collaborative, dialogic and higher order literacy skills in oral language, reading and writing. Chapter 5 will examine these findings in detail and will give possible recommendations, conclusions and possible future research that could be carried out.

Discussion, Recommendations and Conclusions

Improving Primary School Children's Literacy Skills through Primary School Science

Chapter 5

5.0 Introduction

The National strategy to improve literacy and numeracy among children and young people 2011-2020 states that we need to prioritise literacy and numeracy through positive interventions and integrating these skills across the curriculum (DES, 2011; Shiel, 2002). One of the recommendations of the Strategy was also that '*we have to acknowledge that understanding and using literacy and numeracy are such core skills that time for their development must be safeguarded, sometimes by delaying the introduction of some curriculum areas*' (DES, 2011, p44). This was of major concern to the researcher and was one of the main reasons for carrying out this research with the focus on literacy through the Primary Science Curriculum. It was feared that if schools and teachers take this statement quite literally that other curricular areas could be left behind, with teachers only focusing on developing literacy skills in primary English lessons.

The overall research question was as follows:

What are teachers' opinions on and attitudes towards the use of Science lessons in, fostering the development of Literacy Skills in the Irish Primary Science Classroom?

This was further broken down into specific embedded questions:

1. *To what extent do teachers incorporate literacy teaching strategies and approaches in their primary Science lessons?*
2. *What are the most common oral language approaches employed by teachers in the teaching of primary Science?*
3. *What are teachers' opinions on using primary Science lessons to enhance children's oral language skills?*
4. *What are teachers' background, experiences and confidence in designing and delivering integrated approaches to the teaching of Science?*

This research set out to investigate how the development of literacy skills are being integrated, and encouraged in the primary Science classroom through inquiry based approaches to

teaching. The study also explored if literacy skills were catered for in professional development courses for teachers and the teachers' opinions on how effective they have been in promoting literacy skills in Science. This study has highlighted key factors that influence and affect teachers' delivery of a more integrated approach to the curriculum, inquiry based Science lessons and the teaching of literacy skills through primary Science for example the constraints of policy and the curriculum, the over-crowded curriculum leading to time constraints, class sizes, teachers' scientific knowledge and caginess in delivering pupil-led, collaborative inquiry based Science lessons due to classroom management issues, lack of resources and experience.

The teachers in this study welcome the provision of s*pecialised Science CPD courses with regard to integrating literacy skills in Science* which would help them deal with trying to have time to deliver a very over crowded curriculum in a more integrated manner: '*I would love ideas on literacy skills and oral language in Science and also developing more thought provoking discussions and discussions in general'* (teacher #3).

It is also recommended that a greater focus need to be placed on: best approaches and practices to school planning when developing integrated approaches to the curriculum and primary Science; support needs to be provided to teachers in planning, managing and incorporating more effective inquiry based learning and co-operative learning strategies in Science lessons and developing critical thinking and argumentation skills; the development of effective Science CPD based on the needs of teachers in Science i.e. specific scientific content, developing teachers' scientific knowledge and thus their confidence in teaching.

All of the above mentioned issues and recommendations arouse from the findings in the study which will now be discussed and examined in further detail in the sections to follow.

5.1 Incorporating Literacy Teaching Strategies across the Curriculum

From the interviews and questionnaires it is clear that schools are placing a strong emphasis and spending a significant amount of time on the development of children's literacy skills. They are doing this by increasing the number and length of English lessons in the schools, employing many different reading strategies and initiatives in classrooms and across the school. The teachers have also received much support through the provision of CPD sessions over the past 5 years. However, it is clear from their comments that other subject areas are receiving

less attention as they are focusing a significant proportion of time on English and Maths as discrete separate subjects.

Comments from the teachers involved in this study highlight that in their schools and classrooms they teach, a greater amount of time is allocated to English and Maths lessons. Similar to the findings of McCoy, Smith and Banks (2012), there appears to be a trade-off between English and other subjects, and this was evident for Science, Geography and History, and Drama. The results from this study show that teachers' feel the time constraints with pressures to deliver an over-crowded curriculum and the increasing pressure to focus on literacy skills has led to '*rushing through subjects in order to complete the curriculum'* (questionnaire response – teacher 'm') allowing less time for other subject areas: '*sometimes I just have to leave these subjects (Science, SPHE and Drama) out in the timetable during the week'* (teacher #2).

The researcher observed from speaking with teachers in the interview and it was alluded to by some teachers in their questionnaires that '*separate programmes in English and Maths'* are focused on rather than effective and quality integration of subjects, 'l*eaving very little time for other subjects*' (questionnaire response – teacher 'n'). Therefore, it seems that some schools and teachers maybe interpreting the statement by the DES (2011) regarding 'd*elaying the introduction of some curriculum areas to safeguard time for the development of literacy and numeracy skills'* to mean leaving out or reducing time spent on other subject areas if time does not allow. This has been found in previous Irish Studies showing that teachers are mainly focused on Mathematics and English. They feel that there is not enough time to cover everything in the curriculum to the detriment to such subjects as Science (Murphy *et al.,* 2011; Varley *et al.,* 2008). One teacher commented '*teachers have less time to concentrate on a subject. I try through my planning to integrate topics as much as possible but still feel under time pressure to get the curriculum covered*' (questionnaire response – teacher 'n').

It could be said that policy by the DES (2011) is self-contradictory as it also states that '*placing a strong focus in schools on the development and monitoring of students' literacy and numeracy skills is not incompatible with a broad and balanced curriculum, nor should it lead to a narrowly focussed curriculum. On the contrary, ensuring that each child masters the skills of literacy and numeracy in a wide range of contexts is essential if they are to be enabled to access learning in a whole range of areas. At the same time, learning in all areas of the*

curriculum can greatly enrich students' opportunities to acquire and apply their literacy and numeracy skills' (DES 2011).

The incidence of specifically planning and making a conscious effort at integrating literacy skills in all areas of the curriculum and in particular in Science was not very evident in this study and this needs to be explored in further detail with a greater sample of teachers and schools Nationwide to gain a more extensive picture of the '*broad and balanced curriculum'* being delivered in schools and therefore the overall education of the child currently in our primary schools.

5.2 Science and Literacy

Teachers were in agreement and are all very aware that literacy skills can be integrated into Science lessons and Science lessons can play a significant role in developing children's literacy skills. Teachers did feel an overall integrated approach to the curriculum is needed stating that there '*should be more of a focus on methodologies across the subjects rather than discrete subject areas'* (teacher #2) and '*if you integrate literacy with Science and numeracy both areas are covered very effectively*' (teacher #3).

Pearson, Moje, and Greenleaf (2010) state that Science and literacy are each in the service of the other, and that a curriculum based on the two will give synergy effects. Science learning benefits from embedded literacy activities and literacy learning benefits from being embedded within Science inquiry. Integrated instruction that incorporates both Science and literacy is critical for developing students' aptitudes for scientific attitudes, deeper understanding of the practices of Science, as well as the understanding/application of scientific knowledge (Cervetti *et al.,* (2012).

This study did find that teachers were incorporating quite a significant amount of oral language skills in Science lessons i.e. through exploratory talk, dialogue and developing communication skills. However, one teacher did state '*sometimes the discussions around the experiments can be rushed due to time constraints'* (teacher #2). It has been found that teachers struggle to find time to teach Science and teach it effectively in the crowded elementary curriculum, particularly when literacy and numeracy dominated priorities (Goldston, 2005). Tilgner (1990) suggests that many teachers already eliminate or reduce Science instruction when they need additional time during the school day and this was mentioned by teachers in their comments.

Comments from teachers also indicated that they want to be shown how they can teach a more integrated approach to the curriculum and be provided with resources: '*it would be great to see specific resources for encouraging the development of oral language such as a list of appropriate vocabulary, oral language games such as those played in English and Irish.*' Even though the teachers have received a large amount of support in English, they still require help and information on how an integrated approach to literacy across the curriculum can be implemented and in particular in Science. When the teachers were asked in the interview how they could integrate oral language, reading and writing into their Science classes they were able to identify many possible strategies and methodologies they could use. The researcher even noticed that the interviews themselves began to get the teachers to think about their practices and their planning of integrated approaches to literacy and Science: '*now that I am thinking about it I probably do not do enough reading and writing'* (teacher #1). Space and opportunities should be provided and facilitated where teachers and staff in schools have sufficient time to look at their planning and how they plan to integrate literacy across the curriculum. CPD sessions on planning could be provided to help begin initial discussions and ideas, asking teachers to think how they could implement a school based approach to literacy and integrating literacy and Science. From the interviews it is clear that teachers know what works best for them with their specific class groups with specific educational and learning needs and personalities. With support and initial guidance on how literacy can be integrated across the curriculum i.e. all subject areas, instead of the core subjects, addressing timing and the delivery of a very busy curriculum, teachers are and would be very competent to make this a reality in all schools. It is important to make them aware of this and focus their thoughts around planning.

The strands in the English curriculum that include strand units of receptiveness to language, competence and confidence in using language, developing cognitive abilities through language and the emotional and imaginative development through language can be dealt with just as effectively if not more so in the primary Science curriculum. Teaching specific English strands in the English curriculum can be catered for in primary Science and with hands on experience, practical group work, helping pupils overcome communication difficulties, raising their confidence and self-esteem. This would reduce the time allocation for parts of the English curriculum. The importance of oral language would become more acute and teachers' planning and target-setting would be easier to implement for pupils' oral language development.

5.2.1 Integration Oral language into Science lessons

The quantitative data from the questionnaires has shown that many teachers stated they were incorporating exploratory talk, dialogue and developing communication skills in Science lessons. Collaborative group work which allows the children to talk with one another and develop their communication skills was 'Always' carried out by nearly half of the teachers surveyed (46%) and by 51% only some of the time. Teachers' highlighted logistical issues in carrying out dialogue activities with large class sizes and allowing time for such strategies: '*it's very time consuming for the teacher to go around to each group in a large classroom of pupils to see how they are getting on and to have the lesson completed in the allocated timeframe'* (questionnaire response – teacher 'k').

However, when they were asked about their practices several times in the questionnaire inconsistencies and contradictions began to emerge. It was very worrying to observe when investigating the occurrence of teaching strategies in Table 4.8 that some teachers' stated that they 'Never' incorporate exploratory talk (11%) and dialogue (15%) in their lessons. When explored in further detail in their open-ended answers in the questionnaires and in their interviews, it was evident that teachers are overly focused on management issues and keeping control in Science lessons. Many just wanted to get through the lesson in the time allowed. Therefore, time is not been given to dialogue and exploratory talk a very important aspect of Science. Language is not only used to develop vocabulary and grammar but is also a means for communicating and learning Science (Lemke, 1990; Wellington and Osborne, 2001). To make meaning in Science and to learn Science, children need to be using language (spoken, written and reading) at all times in Science lessons (May, Hammer, and Roy, 2006).

A social-constructivist pedagogy, one of the key pedagogies underlying the principles of inquiry based learning, primary Science and literacy curricula worldwide which involves group and pair work focused around open-ended, interactive discourse, involving exploratory and reflective learning, pupils taking risks, and sharing thoughts and ideas is widely advocated (Bruner, 1986; Wells and Mejia-Arauz, 2006). Therefore, pedagogy English and Science lessons should be very much centred around group work and exploratory learning through talk, exemplified in discussion opportunities, exchange of ideas, sharing information and problem-solving (Abrahms, Southerland and Evans, 2007; Grabe and Grabe, 2000; Johnson and Johnson, 1989; Wells and Mejia-Arauz, 2006; Webb, 1982).

5.2.2 Inquiry Based Learning

This study also investigated inquiry based learning and active hands-on collaborative learning in Science which all contribute to a child's literacy and in particular oral language development as mentioned in the previous section above. This was investigated as it has been reported such methodologies are being used less often than had been envisaged in the primary school curriculum and is much less prevalent in larger classes indicating the constraints of class size on the effective implementation of the primary curriculum (McCoy, Smith and Banks 2012). This study found similarly to McCoy, Smith and Banks (2012) that many teachers find covering the entire curriculum in the time available challenging.

Science lessons can help in promoting literacy through oral language, reading and writing and the appropriate use of literacy in Science is needed to achieve a deeper understanding of Science and the ability to reason scientifically (Douglas *et al.*, 2006). However, teachers in this study highlighted the logistics of carrying out inquiry based learning through collaborative, dialogic teaching can be difficult to implement with large class sizes and allowing time for such strategies an issue with one teacher in the interviews commenting '*I would say to be honest we would not have enough time to get through all the Science process skills in depth*' and *'trying to develop critical thinking skills and problem solving skills among pupils with little resources and large class size is challenging'* (questionnaire response – teacher 'k').

All three teachers preferred a more teacher directed approach with some aspects of autonomy given to the pupils while they are carrying out experiments. Similar to studies by Murphy (2004) and the NCCA (2005, 2008) teachers that were interviewed found that whole-class teaching was preferable stating that *'closed activities were much quicker to accomplish [rather than open ended investigations] due to time constraints with trying to get all of the other subjects on the school curriculum done also'* (teacher #2). The main reason that more open ended investigations, collaborative work was not carried out were again mainly due to time constraints, class sizes, overcrowded curriculum, planning, class sizes, resources and classroom management issues. Also, a very important issue that was raised in the study was that teachers' scientific knowledge was a challenge for teachers as they felt their knowledge was not strong enough to carry out effective IBL lessons and encourage higher order oral language activities such as debating, argumentation and open questioning: '*my scientific knowledge is not great but I do the best I can'* (teacher #2) and *'my own understanding of some of the Science content is limited'* (teacher #1). Therefore, employing higher order oral language

skills that encourage argumentation, problem solving, pupil questioning, and open ended-questioning did not feature as prominently in Science lessons.

Another issue that arouse in the interviews was the fact that teachers did not want reading and writing to take over a lot of the time in their Science lessons where they wanted to focus on scientific process skills. However, the main aim of Science education is provide the opportunity for children to act, work and think like scientists. Scientists depend on literacy practices, both written and oral in order to develop understanding about the world around them (Norris and Phillips, 2003; Yore et al., 2004). One teacher commented '*I would like quick snappy activities that promote reading and writing skills in my Sciences class…..but do not or so that they do not take over from the overall process or time to carry out the experiment*' (teacher #2). This has been found in other studies where some teachers hesitate to include literacy in Science teaching because of their commitment to hands-on Science approach (Pappas, 2006).

5.2.3 Critical Literacy and Argumentation

When asked about their specific use of strategies that promote argumentation, debating and higher order critical thinking skills and analysis skills it was found 89% 'Never' use Concept Cartoons, with 28% and 58% either 'Never' or 'Sometimes' using concept mapping. 57% 'Never' use debates in their Science lessons with 43% 'Sometimes' using this teaching methodology. Some teachers highlighted their lack of familiarity with argumentation strategies: **'***I would like to know what exactly argumentation is'* (teacher #1). And *'I am teaching only a short while and I am not familiar with argumentation* strategies' (from a questionnaire response - teacher 'd').

Therefore, employing higher order oral language skills that encourage argumentation, problem solving, pupil questioning, and open ended-questioning did not feature as prominently in Science lessons. A greater emphasis is now being placed on the need for critical literacy in our education system (Shor, 1992; Council of Europe (CoE), 2001; OECD, 2010; EU High Level Group, 2012). The use of oral language, talk and dialogue strategies in Science plays a central role in developing critical reasoning skills in children (Cavagnetto, 2010). Critical thinking and thus elements of critical literacy can begin to be developed in Science lessons through Inquiry based learning and argumentation. It involves conceptualising, applying knowledge and ideas, synthesising, analysing and evaluating so as to better guide the children's thoughts, beliefs and actions (Kennedy *et al.,* 1991; Paul and Elder, 2006).

However, the study did highlight teachers' lack of scientific knowledge and thus their lack of confidence in using such methodologies as a key factor as to why they may not be employed in their lessons. In the interviews teachers were asked if they prefer to use closed or open ended experiments '*my own understanding of some of the Science content is limited'*(teacher #1). Teachers were not familiar with argumentation. One teacher felt that '*In order to promote debating and argumentation I would need to have a good knowledge of Science which I will be honest I do not have'* (teacher #3). 92% of the teachers in the questionnaires were in favour of having more opportunities in undertaking CPD courses in Science. Their participation rates in Science CPD over the past 5 years may be considered low. However, they had attended many literacy courses over this period of time. Over all their levels of satisfaction for Science CPD they had already attended was high. However, some teachers commented that these courses had not changed their level of scientific knowledge in any way. Teachers' scientific knowledge will be discussed in further detail in the next section 5.2.4 below.

5.2.4 Teachers' Scientific Background

Teachers in this study also highlighted their lack of scientific knowledge as a key factor influencing how they incorporate inquiry based learning and literacy skills in Science. Most primary teachers come from a non-science teaching background and many may not have undergone any specific professional training in Science and technology (OECD 2006). It has been reported in many countries that teachers' lack of knowledge, expertise, confidence and training in the teaching of Science needs to be addressed (European Commission 2004; 2007; Murphy, Neil and Beggs 2007).

It is argued that a teacher's ability to teach is directly linked to their level of knowledge of the topic and that poor Science teaching being carried out in schools is due to the teachers inadequate subject knowledge affecting the teachers' confidence in their own ability to teach (Jarvis and Pell 2004). A study carried out in Ireland reviewing the implementation of the primary Science curriculum raised a number of concerns also found in international studies which included: The lack of and depth associated with pupil-led hands on, open investigation; and helping pupils link their learning in Science to the wider world (Varley, Murphy and Veale 2008). These results suggest teachers pedagogy of Science was being affected by their subject knowledge and understanding about scientific concepts (Parker and Heywood 2000).

It is argued that poor Science teaching being carried out in schools is due to the teachers' inadequate subject knowledge, and this in turn affects the teachers' confidence in their own ability to teach the subject (Newton and Newton 2009). An incomplete understanding of Science concepts can affect a teacher's ability to pose meaningful questions, selection of investigatory tasks and assessing children's understanding of a topic (Mc Diarmid, Ball and Anderson 1989). Effective Science teaching incorporates pedagogical content knowledge (PCK) and Subject Matter Knowledge (SMK) (Shulman 1986; Cox and Carpenter 1989; Hollingsworth 1989; Appleton 1995). Therefore, in order to be an effective teacher you not only need a strong scientific background knowledge (Shulman, 1986) but also a coherent understanding and a strong PCK (Cox and Carpenter 1989; Appleton 1995).

CPD sessions must focus on developing the teachers' scientific knowledge, inquiry based learning strategies before the integration of literacy strategies can be effectively tackled. A report by Murphy *et al.* (2007) found that teachers who had carried out professional development in Science were significantly more confident to teach Science. It is recommended that the nature of in-service provision for Irish primary Science now needs to progress beyond a "show the teachers how to do it" approach to incorporate more opportunities for action and reflection (Jarvis and Pell 2004). In this way it is hoped that teachers would gain the confidence to develop their own ideas for teaching and promoting Science in schools. Varley *et al.,* (2008) recommended that a comprehensive support for Irish primary teachers needs to be provided in Science.

In order to address the bigger picture, teachers level of Science needs to be at a certain standard to develop their confidence in teaching Science and so they can effectively incorporate inquiry based learning into their classroom and in turn start to think about integrating literacy based inquiry based learning into their Science lessons. Therefore, it can be seen that in order to develop an integrated approach to literacy across the curriculum takes time and there is "No Quick Fix" (Allington and Walmsley, 2007). Significant reform requires knowledge and understanding, which all takes a significant amount of time, effort, support and commitment.

5.2.5 Integrating Reading and Writing in Science Lessons

Data from the questionnaire and interviews highlighted that pupil reading was less prominent in lessons that teacher reading and over all reading was not prioritised in Science. Overall, a greater percentage of time was spent on teacher reading and writing when compared to pupil

reading and writing in Science lessons. Many teachers used the set primary school Science book and the teachers in the interviews did use information through a variety of media sources both on-line and hard copy (newspapers). Some teachers asked the children to look up the information themselves online either at home or collaboratively in the classroom. However, a high proportion of the teachers ‘’Never’ incorporated Children’s English Literature (98%) or Poems (100%) into their Science lessons.

It is worth nothing when this was investigated further in the interviews, reading was used for read aloud and information gathering purposes. Children were not asked to critically analyse the piece of reading, or no structured activity with a focus on higher level scientific and reading skills were employed. Cervetti *et al.* (2005) state that reading a book about animals to pupils is not the same as engaging them actively in scientific inquiry about animals. Simply supplying texts in print or online is not enough to ensure that children engage with them. Children need explicit support to acquire the composing and comprehension processes needed for successful reading and writing in Science (Miller and Calfee 2004). Dickinson and DiGisi (1998) found in a study of first-grade students that higher reading achievement scores resulted when students engaged in narrative and informational writing. Students’ reading skills may be enhanced as a result of writing incorporated into Science experiences.

Writing across the curriculum can be an effective link between the language, arts and Science (Atwater, 1995; Akerson and Flanigan, 2000, p. 346). 8% of the teachers surveyed in this study indicated that they focused ‘Always’ on writing skills in the Science class, with the majority 92% stating they sometimes focus on this. 83% never used worksheets. 19% ‘Always’ and 46% ‘Sometimes’ use Science notebooks and diaries. However, 35% ‘Never’ use a Science notebook. The majority of the teachers (59%) only ‘Sometimes’ use Word Walls and 64% only ‘Sometimes’ use sentence stems.

It is argued that teachers have little access to well-designed texts that readers can understand given their developing knowledge base and varying reading skill levels (Schleppegrell 2004). One teacher commented in the interviews commented that Science books for the older class groups limiting that they find it *‘difficult to find new material on some topics from 6th class books’* (teacher #2) to challenge the students and find in the upper class levels they are *‘repeating’* what has been previously covered. Another teacher felt they would like *‘more interesting/challenging experiments’* (teacher #1). Teachers in this study did also call for

teaching resources and CPD sessions where they could obtain and be introduced to such resources be made available.

5.2.6 Continuous Professional Development of Teachers

70% of the teachers in the questionnaire and all three interviewed expressed an interest in attending Science CPD courses on developing oral language skills in Science. Only 1 out of the 42 and none of the teachers that were interviewed had attended a CPD session on developing oral language skills specifically in Science lesson and no teacher out of those surveyed or interviewed had attended CPD session on developing reading and writing skills specifically in Science lessons. 80% of the teachers stated that there was not an emphasis placed on literacy in Science CPD courses they had attended, 75% felt the level of literacy in such courses was unsatisfactory, and 81% feeling they were insufficient.

The findings discussed in previous sections above show that there is a need to support and target teachers' professional development in utilising a range of pedagogies in inquiry based active teaching methods not only in Science but across all subject areas to ensure an integrated approach to developing children's oral language skills (Murphy, 2004). One teacher commented '*It is vital that teachers seek and use methodologies that promote the integration of literacy and numeracy into Science, drama and SPHE in order to teach concepts and themes in context and in a meaningful manner'* (questionnaire response - teacher 'h'). Some teachers commented that they require support in order for this to happen calling for '*more creative CPD courses'* (questionnaire response - teacher 'j'). CPD and the provision of strategies, methodologies and resources for teachers on effective integration was needed and were open to attending CPD sessions with a specific focus on integrating literacy skills in Science. INTO (2011) in its paper on Literacy in a Changing World identified CPD as an area which needs development. They also recommend the need to up-skill teachers in the areas of the teaching of writing, of comprehension strategies and the use of multi-genre texts. There is however no mention of how primary Science or any other subject areas can be used effectively to teach literacy skills. Its focus seems to be on English, Mathematics and Irish. The teachers in this study provided an insight into how they feel CPD could and should be delivered suitable for their wants and needs. This will be further discussed in the recommendations below.

5.3 Limitations of this Research

- The sample size of teachers involved in this research was small and this was due to the time limits that were set to complete this research and also due to the lack of resources including cost and personnel. The research does not include pupils' perceptions and attitudes on how literacy skills can be integrated, fostered and encouraged in primary school Science.
- An area that was not addressed in this research was the parents' impact on their children's literacy development and how parents could help in liaison with the teacher on improving their children's oral language through Science. Parents can make a difference to the success of their children in school. It is essential that teachers have knowledge about parents and on what parents can do to support their children's oral language development. There needs to be a good partnership between teachers and parents, home-school support for parents to fulfil this role would be valuable as parents have a pivotal role to play in their children's education and lifelong learning.
- ICT was not investigated in any great detail except in the interviews with the teachers. This area need to be looked at in regards to digital literacy in further detail.

5.4 Conclusions and Recommendations

5.4.1 Continuous Professional Development of Teachers in Science

It is important that teachers need access to **high-quality Science CPD** courses. Teachers' responses to the survey and the interviews has raised concerns with regard to the delivery of inquiry based Science teaching in primary classrooms incorporating collaborative, dialogic and higher order literacy skills in oral language, reading and writing. The following therefore should be addressed in future Science CPD sessions:

- **Classroom management:** Teachers reported experiencing difficulties with classroom management due to large class sizes to adequately teach problem solving and critical thinking skills.
- **Planning and integrated approach to the curriculum:** Teachers' **lack of time** to teach all the requirements of the over-crowded curriculum and the requirements of the National Literacy and Numeracy Strategy was an issue which must be addressed through the exploration of best approaches and practices to school planning when developing integrated approaches to the curriculum and primary Science.
- **The needs of teachers in Science: S**pecific scientific content, developing teachers' scientific knowledge and thus their confidence in teaching. Teachers' **lack of scientific**

knowledge prevents them from carrying out effective inquiry based learning in Science.

- **Planning, managing and incorporating more effective inquiry based learning and co-operative learning strategies in Science lessons.**
- **Exploratory talk, dialogue and dialogic teaching in Science lessons.**
- **IBL and scientific process skills -** with regard to inadequate teachers' knowledge of content area in the Science curriculum particularly in the senior classes and in particular and with the lack of pupil self-directed learning skills which develops pupil ownership of their inquiry and enhances pupil interest in the subject matter.
- **Developing critical thinking and argumentation skills.**
- **Scientific Language: Scientific Language, vocabulary, descriptive language and scientific terminology.**

A spiral approach to the CPD sessions are needed focusing firstly on the key issues mentioned above. Following on from this s***pecialised Science CPD courses with regard to integrating literacy skills in Science*** focusing on:

- **Integrating Literacy Skills** through Inquiry Based Science Teaching.
- The development of resources that can be used across the curriculum and for the integration of 1. **Oral Language, 2. Writing Skills and 3. Reading Skills** in Science using methodologies that have been proven to be effective in English lessons.
- **Developing critical literacy and argumentation skills.**
- **School Planning: Developing and implementing an integrated balanced curriculum.**

5.4.2 Models of Continuous Professional Development of Teachers

CPD Science courses with specific content must be strategically planned and developed to address any deficiencies in content and pedagogical skills and drive improvement in Science and literacy teaching. Many CPD courses tend to be short, sporadic and are designed to achieve short term goals. As mentioned previously there is 'No Quick Fix' to ensuring and integrated literacy curriculum is employed in schools around the country. There is no going support or follow up on these courses after the courses are completed. Many of the teachers asked for on-site school based CPD with **whole school staff** during term time rather than during the summer when teachers forget all they have learned or will not apply the strategies until two months

later after their summer holidays. CPD courses which are more **long-term and context-specific** is likely to be more beneficial. Courses should be carried out at a relevant pace and be attainable. Therefore, teachers' confidence and their ability to teach Science and integrating literacy effectively into Science will be developed effectively over time.

It was also raised in both the surveys and the interviews the difficulties associated with some schools just targeting one member of staff for a Science course that was made available. The DES would benefit from establishing a common vision of Science goals in schools and to implement collaborative professional development programme for teachers as a means to achieving these by:

- Providing support to teachers raising their understanding and confidence with 'constructivist' methodologies through a system of modelling, mentoring and/or coaching.
- Providing specific training for everyone in the identified target concepts (e.g. Forces and Materials).
- focusing on teaching strategies on how to implement oral language effectively.
- Good school leadership and a support culture needs to be implemented and fostered.
- provision for substitute cover to facilitate teachers attendance at CPD courses.
- devising strategies for improving the behaviour for learning of students in Science lessons and with regard to group work.
- Supplying a range of methods to build positive relationships with students at all class levels.
- A mentor leadership programme could also be implemented as this was proved to be very successful in the IDEAS program that was examined in the literature review (see Appendix B).
- CPD courses to be face-to-face courses and to provide teachers with direct, hands-on, problem-solving, pedagogical strategies, and content knowledge.
- Offering ICT tools can support the teacher in scaffolding each pupil in his/her learning.

With regard to other professional development courses such as post-graduate programmes, there is no ***incentive for teachers to progress*** with regard to promotion, monetary gain or study leave to help teachers complete these course which are not exam based. At this present time

the DES only grants study leave to teachers for courses that are exam based. Most postgraduate courses are not exam based. The DES needs to address these deficiencies to inspire teachers to want to learn and promote life-long learning which is what the DES hopes to instil in pupils through the primary curriculum.

5.4.3 School Planning

It would be desirable that a shared vision for an integrated approach to the curriculum would be developed in every **school community**, specifically planning and making a conscious effort at integrating literacy skills in all areas of the curriculum and in particular in Science. This may be achieved by:

- Encouraging **staff development and a networking** culture within the school and the wider community.
- If teachers are moving from teaching at infant level to 5th class, adequate training/handover needs to be provided.
- **Co-ordinator** role in the school to ensure an integrated broad balanced curriculum is being provided to pupils.
- **Primary teachers, schools and teachers could work collaboratively with experts in both Literacy Education and Science Education**.
- Having **regular access to and opportunities to attend high-quality CPD** to ensure that their expertise is sustained.

5.4.4 ICT, ICT Resources and Infrastructure

- ICT offers educational tools and resources to teachers and pupils' which extends their learning. ICT can help to support the development of the pupil's social skills through collaborating and communicating, problem-solving, student directed learning and discovery based learning activities. It also allows pupils' to communicate with pupils' in other schools. ICT tools can support the teacher in scaffolding each pupil's individual learning. Multimedia software provides opportunities for pupils to document, through typing, audio or video or a combination of the three. This interaction between language and experience is also highly effective by pupils' recording and reflecting on their learning. Publishing of pupils' work on the school website for viewing by parents, collaborating schools and the wider community will help pupils to read and evaluate

their own material as well as others. ICT can help pupils' develop social skills particularly in collaborative project work through turn taking and sharing resources.

- CPD, support and information on how to integrate higher level literacy skills in Science through ICT should be developed and made available to all teachers.

5.5 Future Research

Further research could be carried out in the following areas:

- Critical literacy in primary classrooms. Critical Literacy is more than understanding what we are reading. This approach involves the progression of children as they move through the primary years are able to take critical literacy stances with more independence.
- Developing critical thinking and argumentation strategies in children, by immersing children in the process of inquiry with open-ended questions through investigation, coalescence and demonstration of learning. These methods enable students to seek deeper meaning, build background knowledge, search for new information, develop questions and synthesize information. The process also involves communicating/collaborating with others and arguing/debating and explaining outcomes and points of view with their peers.
- Developing a model for the integrated approach to the teaching of Science and literacy. Further research is required in finding ways that are engaging in the specialized ways of talking and writing in the teaching and learning of Science. Language and literacy are crucial in supporting the goals of inquiry-based Science. First-hand experiences in science and literacy are essential tools for inquiring about the natural world.

5.6 Conclusion

Overall, the integration of literacy skills across the curriculum needs to be addressed. Science offers a wonderful opportunity for children to develop literacy skills. If Science can be envisioned as a subject matter that welcomes the inclusion of literacy practices, it is more likely that primary teachers will find ways to integrate Science into their curriculum.

It was found that teachers incorporate oral language skills as much as possible in Science lessons. However, employing higher-order inquiry based oral language skills that encourage argumentation, collaborative discussions, pupil questioning, open ended-questioning, reading

and writing strategies did not feature as prominently in Science lessons. Difficulties impeding the use of such strategies were identified as follows: class sizes, overloaded curriculum, classroom management issues, teachers' poor scientific knowledge, lack of familiarity with and confidence with pupil lead activities and argumentation strategies.

It is clear from the results that high-quality Science CPD and supports are needed focusing firstly on developing the teachers' Inquiry Based Learning skills, Science Knowledge, Critical Thinking and Argumentation Skills and secondly on school planning of Science and integrated approaches to teaching.

If researchers in Literacy Education and Science Education in Ireland work together on developing an effective model of curricular integration, Integrating Literacy in Primary Science Education, Ireland could lead the way internationally in this space. Teachers have much experience and knowledge of what works and what does not work on the ground in the classroom and have many suggestions on how to integrate literacy into their Science teaching. Collaborative structures where teachers and researchers work together over time to create such a model would be very desirable where they both professionally gain from the experience.

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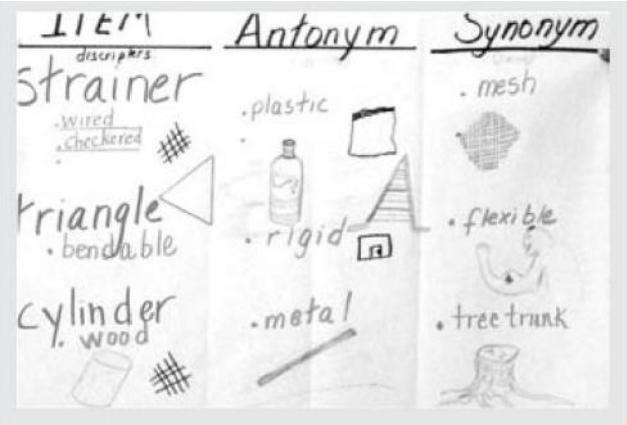
Appendix A

Vallé Imperial Project in Science (VIPS)

VIPS is a systemic programme in Science and teacher professional development. VIPS was developed in partnership with 5 third level institutions and 16 school districts of Imperial County, USA. Vocabulary building is the main focus where teachers can help students build on their vocabulary by keeping a record of these using a "working word chart" when discussing Science materials before the lesson begins. Strips of paper with the new word or reviewed word can be added to the word wall chart by the teacher. The teacher models how to read the information from the chart to the students. The "working word chart" helps the English language students with their writing.

Students can construct a word wall chart with the name of the item, its description, its antonym, its synonym and an illustration.



Items, Antonyms and Synonyms students Working Word Wall (Douglas *et al.*, 2006)

Words from the "working wall chart" are now categorised into the following groups:-

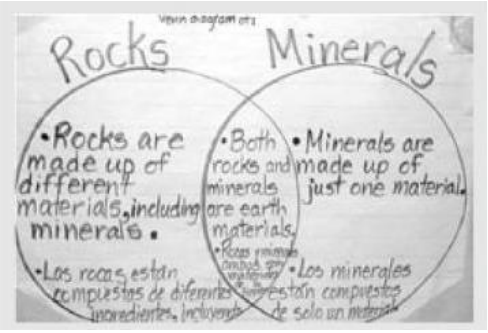
1. Scientific Vocabulary: - These are usually process skills and include predictions, hypothesis, evidence and reflections.
2. Content Vocabulary: - These are words relating to what is being studied (e.g. minerals, rocks, sedimentary).
3. Additional Vocabulary: - These are words that connect descriptive words such as into, and, for. English language learners find these connecting words difficult when constructing sentences.

This is then followed up by the teacher asking the students the reason for their groupings of the words. This creates repletion of words which is beneficial to the English language learners' fluency. The building up of vocabulary can be carried out by taking a Science kit inventory and by examining and discussing the items in the kit that will be used in their study. Students can also make predictions on how an item will be used from the kit in the experiments that will precede this stage. The teacher will ask the students questions so that they will access their prior knowledge. Students understanding of the vocabulary can also be accessed in this way. Sorting and classifying can also be carried out by the students once they are comfortable with the definitions, descriptions and properties of the items. There is no right or wrong category as long as the student can explain their reasoning and justification of their choice. The aim of this exercise is to reinforce properties of these items. This can be further expanded to include the concepts being taught.

Item	Teacher	Students
goggles	What are these? What are they made of? Where have you seen them before? Why do people have them at the swimming pool? Why do you think they are in our science kit?	goggles plastic at the swimming pool to cover their eyes to cover our eyes
nail	What is this called? When do you normally see these? What do you do with a nail? Look at this nail, the ends are different. What can you tell me about it? Do you have any predictions about what we might be studying in this unit?	a nail when we are building pound it; put it in wood one end is flat, and one end is sharp. maybe building
paper clip	What is this item called? Why are paper clips in our kit? What do you think we are going to be studying?	paper clip to hold paper together building

Kit Inventory for a Unit on Rocks and Minerals (Douglas *et al.*, 2006)

When the students are familiar with sorting and classifying they can then create Venn diagrams using scientific, content and additional vocabulary to construct sentences that show the relationship of the items being studied. See Figure 9 below as an example.



Venn Diagram (Douglas *et al.*, 2006)

Sentence Stems

Sentence stems can be used by the teacher as a starting point to help the students with their writing process. It offers correct grammatical sentence structures. These can be expanded on and students can create their own when they become familiar with the format of expository writing. Examples from the VIPS project include:

- Today I _____.
- Today I learned _____.
- I wondered _____.
- I noticed _____.
- Questions I have now are_____.

Cloze procedures can also be used with the key words being missing from the text. The missing words can be included in a word box with the close procedure and the students must choose the correct word to suit the gap in the sentence. Technology can be used to help students revisit the vocabulary and revise it through PowerPoint presentations that include pictures and the word underneath it. Students can scroll though the PowerPoint slides and familiarise themselves with the words and the associated pictures. VIPS has displayed how Science and English can complement each other and how this programme allows English Language Learners participate fully in Science classes and how it is possible to improve one literacy skills through Science.

Reference: Douglas, R., Klentschy, M. P., Worth, K., and Binder, W. eds. (2006*) Linking Science and literacy in the K-8 classroom.* Arlington, VA: National Science Teachers Association.

Appendix B

In-Depth Expanded Applications of *Science* IDEAS

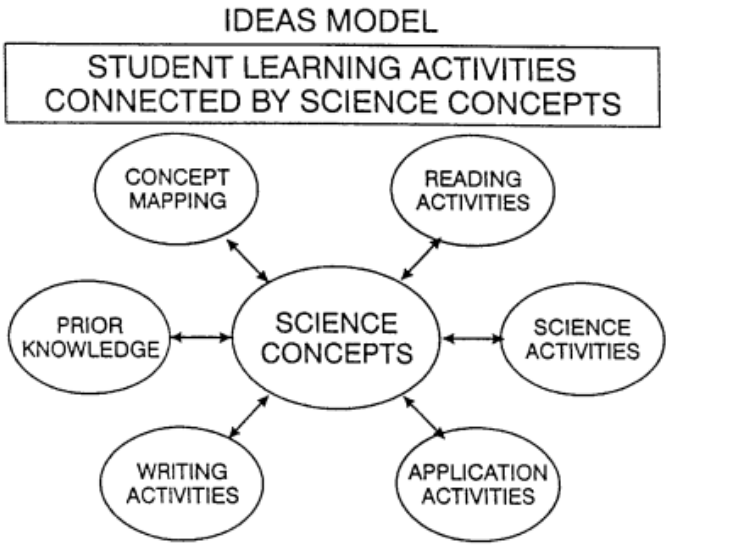
IDEAS was setup initially to help students master the core concepts of Science within the Science curriculum in the USA. IDEAS provides an overlap between reading and Science process skills. The IDEAS model of integrated Science and language arts instruction was developed by Romance and Vitale (1992, 2001). The time allocated for traditional literacy instruction was replaced with a 2-hour block of Science (IDEAS) instruction that included attention to reading and language arts skills. The Science instruction involved first hand experiences, being concept-focused, giving attention to Science process skills, reading, concept mapping, having discussions and journal writing.

In implementing IDEAS, teachers usually engaged the students with hands-on activities first and then reading activities in order to ensure "that students had the learning experiences needed to make critical reading more purposeful" (Romance & Vitale, 1992, p. 547). Romance and Vitale (1992) argue that schools are unlikely to increase the amount of time needed for teaching Science and therefore by embedding reading/language into the 2 hour block for Science, this could remedy the problem within the Primary School Curriculum framework.

The conceptual structure that teachers used for the IDEAS programme in their Science was the textbook, 'Journeys in Science' to provide a common set of reading materials and strategies and to organize instruction or their
classrooms. The research reports on IDEAS states that "in principle, the
conceptual structure of any curriculum organization would work as well as long as it maintained integrity with the underlying scientific concepts and principles".

The IDEAS model was studied over a 5 year period. The study was conducted in a multicultural urban school system in south-eastern Florida with a wide range of student demographics (e.g. ability levels, , parental income, ethnicity). Science IDEAS is an
integrated instructional model that serves as a replacement to traditional reading and literacy programmes. IDEAS has six instructional parts which are implemented within a two hour daily time block. The six instructional part
include: -

1. Prior Knowledge
2. Prepositional concept mapping
3. Reading comprehensive activities (reading informational text books/internet/Science materials),
4. Science Activities i.e. Science process skills (e.g. hands on activities, inquiry based projects),
5. Writing Activities (keeping a written Science journal),
6. Application Activities.



IDEAS Model – Conceptual structure for teaching Science of Science concepts. There is a natural link between Science, reading and writing.

Within IDEAS themes are built and core Science concepts are explored, identified, organised and a sequence of different activities particularly hands-on activities are undertaken which seems to contribute to and sustain the desired Science learning outcomes (Douglas *et al.*, 2006). As a result, students are motivated to enhance their own conceptual understanding by reading more purposefully. As part of the Ideas programme, there was also a focus on the professional development of the teachers involved in this study. This was to insure that teachers had:-

a. sound understanding of the Science concepts they would be teaching,

b. proficiency on the basic elements of the Science IDEAS model (e.g., simple concept mapping, age-appropriate hands-on activities, reading comprehension guidance, journaling),
c. sufficient assistance in lesson planning that focused on the Science concept clusters to be taught in relation to the curriculum.

Romance and Vitale's findings also showed that participating students consistently displayed significantly more self-confidence and positive attitudes towards both reading and Science. A mentor leadership programme was implemented and this programme consisted of meetings between experienced IDEAS teachers and project researchers who were serving as teacher-mentors for the project. The main focus was on issues involving support of IDEAS teaching.

Reference:

Romance, N. R., and Vitale, M. R. (2006). Science IDEAS: Making the case for integrating reading and writing in elementary Science as a key element in school reform. In R. Douglas, M. Klentschy, and K. Worth eds., *Linking Science and literacy in the K-8 classroom*. Arlington, VA: NSTA Press.

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Appendix C

Wondering, Exploring, and Explaining (WEE)

WEE Science is a reading/Science programme designed for students in the middle classes of Primary school to promote Science through reading and Science activities. The programme is structured to result in improved Science instruction as well as to make the instruction of Science meaningful for the classroom teacher. This programme also strives to promote fun in "wondering". This research noted the fact that reading to learn or content-area reading is sorely absent from most primary school classrooms. With these insights in mind the WEE programme (an integrated Science and reading programme for the middle to upper primary school classes) was designed by Anderson, West, Beck, Macdonell, and Frisbie (1997).

Co-operative learning is used in the WEE programme where learning Science is carried out in groups. Each group were asked to assign roles/responsibilities to its members. These roles were explained.

Group Roles included: -

1. Project manager: - encourages students to work cooperatively and to keep order within the group.
2. Resources coordinator: - in charge of the group resource list (a notebook page was designed for this purpose), organizes and takes care of the groups equipment.
3. Data recorder: - writes down the required information for the group
4. Communicator: - liaison person between group, other groups and the teacher.

The WEE programme involves students in three phases of scientific investigation: which were wondering, exploring and explaining. Each of these will be discussed in detail:-

1. Wondering: - Students pose wonderments and choose wonderments to explore. Students use books to find out information about their wonderments. These wonderments are then turned into questions that can then be researched in a first-hand way. After choosing a "wonderment" to pursue, the students formed and implemented a plan for investigating (Exploring). Groups were formed based on the topics of the books and asked questions (Wondering) about the content.

Making Researchable Questions out of Wonderments.

The WEE Science pilot programme found that the students were able to create researchable questions (see Figure 11 as a guide to help with research questions). Students had to choose a wonderment that was not only interesting, but also met the following constraints: -

(a) classroom time (1 or 2 days),

(b) supplies (what was available immediately or could be made available very quickly),

(c) space (desktop, the floor, the school grounds).

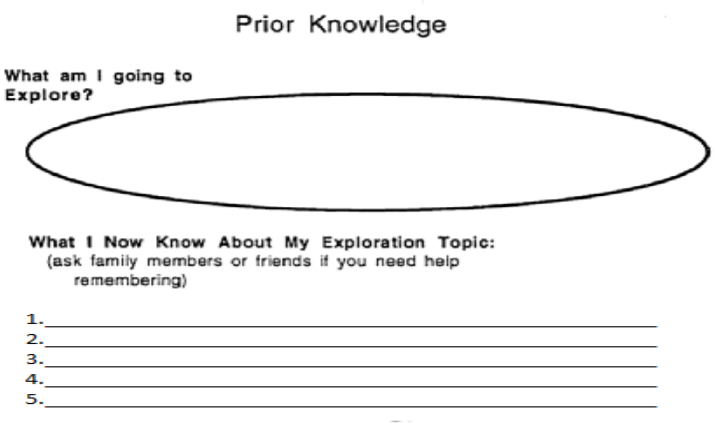
Wonder (if, how, why, who, what, when, where, whether, which):	What in the book helped me wonder:

Wonderment Worksheet

2. Exploring: - Students discuss then prior knowledge and make exploration plans. Students gather information through additional reading, first-hand exploration, consultation with experts, etc., each student explored, working in cooperating groups of two or more.

   Examples of the type of exploration carried out in the pilot programme was model building, observations of various kinds, microscope work and experiments, and reading of the Science text books**.** Some of the exploring plans chosen included: building models of tornadoes and rainforests; collecting samples of fish; observing morning dew and cloud patterns; and visiting museums or planetariums.

Exploring Worksheet



What do I think I will Find?

_____

Why?

_____

How am I going to explore?

'First, I'm going to:
Next, I'm going to:
Then, I'll probably:
Then, I'll probably:
Then, I'll probably:
Finally, I'll:
To explore like this, I'm going to need these resources:
Each of my group members understands these plans and the Data Recorder makes sure that this is done:-

3. Explaining: - Students then summarize what they have discovered, and what they still wonder, and they give presentations to their classmates. The WEE programme encourages students to answer questions for themselves by using text to inspire investigations rather than relying on text as the ultimate authority in Science.

The classroom teacher presented an explanation of the explaining process and students were given the opportunity for questions and discussion. Students were instructed to complete the: -

(a) Explaining Summary page: - a synopsis of the actions that were taken, the discoveries, and suggestions for further exploration.

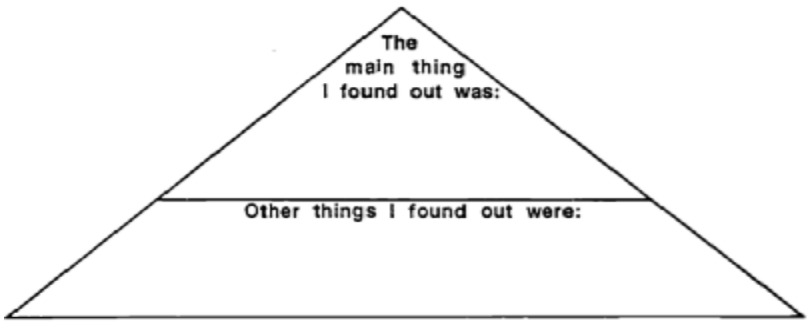
(b) Explaining Plans page: - an outline of the groups' explanation and a presentation plan, including an estimate of its length and a list of necessary materials (in their notebooks), (see Explaining Plan diagram).

On the explaining day, each group member explained to their group colleagues, the results of the students' WEE Science projects. The purpose of this presentation was to further clarify and organize their efforts. Models, demonstrations, posters, and the students Science books were used to aid in their presentations.

Explaining – Summary Sheet

The Actions I took were……
I found out that……..
I'm still wondering about……I

Explaining – Plan



Who is the Audience for this presentation?

- How am I going to Explain these things to the Audience so that they are Clear and Believable?

What Materials am I going to need for this Presentation?

How long is it going to take to get my presentation ready?

Each of My Group Members Understands These Plans and Thinks That They Should Be Used: (Data Recorder makes sure that this is done.)

_____ _____

_____ _____

Student Evaluation Day

On the last day of the programme, the students were asked to participate in a self-assessment and in a project assessment questionnaire. Students were given an opportunity to critique their WEE Science experience and summarize the new Science they learned as a result of participating in it (see Evaluation Sheet).

Students Evaluation Sheet

Name: _____

My "Wonderment":_____

_____

Date/Time	What I Did:	What I Found Out:

Evaluation of the WEE programme

Evaluation of Students work was carried out during the pilot studies relied on actual classroom observations and notebook assessments. There were also two video tapes of almost every classroom component of the WEE Science programme and the post-project assessments and questionnaires to analyse and discuss. In all phases of the programme, it was found that students asked very insightful questions about wonderments, procedures, planning, Science facts and principles. Questions were not answered directly. Instead students were encouraged to:

(a) refer their questions to other group members

(b) the teacher gave suggestions about where/how they could find possible answers.

The WEE Science pilot implementation noted the excitement that students showed in choosing and reading their trade books, the students displayed:

(a) success at generating and explaining wonderments,
(b) enthusiasm and creativity in directing their own explorations,
(c) thoughtfulness and carefulness with the presentations of their projects,
(d) enthusiasm in the amount and type of Science ideas that students reported learning from their own projects, as well as from other students diverse projects.

However, other observations indicated that the students needed more instruction in the following areas: -

(a) modelling,
(b) formulating researchable questions,
(c) planning an exploration and presentation
(d) writing exploratory steps in their logs

The pilot studies were successful in that most students eagerly participated in all phases of the project. However, some problems were encountered for example responding to the students Science misconceptions, evaluating students' work, teaching some students to record observations in their notebooks. It was found that the students who spent more time consulting books prior to using other strategies were more informed and had successful projects than the students who progressed directly to model building or experimenting.

Teachers and Science teaching in the WEE Science Programme.

The WEE programme found that few teachers have a basic grounding in Science. It also suggested that many teachers may feel a reluctance to approach Science instruction in an open-ended way. However, the WEE programme emphasis the scientific process and the search for knowledge so a teacher should need never feel hesitant to say, "I don't know," or be pressured into giving a vague answer. During the pilots, in addition to the class teacher, there was always at least another person and two or more other persons were present during the exploring phase of the project. The researches of this programme suggest that maybe the teacher's desire for help during phases of WEE Science could present an opportunity to bring parents, grandparents, secondary school helpers and/or other teachers into the classroom. This also

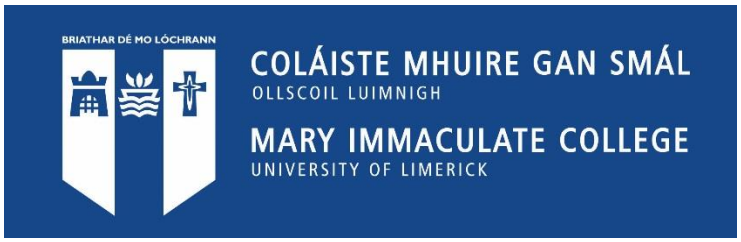
highlights that the cooperative learning/reciprocal teaching environment would also make use of the resources of everyone in the classroom, making it easier for students to perform well. An understanding of the scientific process and a positive attitude is necessary for doing "good Science" are vital if students are to become a nation of Science literates. WEE Science has strived to incorporate the best attributes of good reading instruction with the learning of Science.

Reference:

Anderson, T. H., West, C. K., Beck, D. P. McDonell, E. S., and Frisbie D. S., (1997) Integrating reading and Science education: On developing and evaluating WEE Science. *Journal for Curriculum studies*, 29(6), 711 -733.

Appendix D

Advertisement for Recruitment of Participants



Attention all primary school teachers.

Would you be willing to get involved in a study on 'How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.

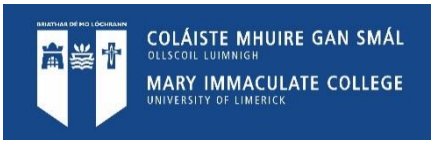
Have you time to fill in a questionnaire and/or be willing to take part in an interview?

This research is being carried out by a Primary School Teacher carrying out research in part fulfilment of their Master's Degree.

Please contact *researchintoprimaryScience@gmail.com* **for further details**

Appendix E

Information sheet



Information Sheet

An Exploration into How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.

What is the project about?

This research is an inquiry into the current practices of integrating Literacy and Numeracy Skills and associated teaching methodologies into Science lessons in Irish Primary Schools. The project will also investigate teachers' experiences of and opinions on the use of Science lessons to enhance children's literacy and numeracy skills.

Why is it being undertaken?

The National strategy to improve literacy and numeracy among children and young people 2011-2020 state that we need to prioritise literacy and numeracy through positive interventions and integrating these skills across the curriculum (Department of Education and Skills 2011). To date there have been no specific strategies, models and courses designed and implemented informing teachers how literacy and numeracy skills can be effectively developed in the Primary Science Classroom.

This project therefore will investigate teachers':

- experiences of and practices in integrating literacy and numeracy skills and strategies into the primary Science classroom
- perspectives on the use of Science lessons to enhance children's literacy and numeracy skills.

This data will then be used to inform the design and development of future frameworks, guidelines and CPD courses for the integration and effective development of literacy and numeracy skills in Science lessons.

What is required of the participant?

Participants are required to complete a questionnaire and/or an interview investigating your experiences and perspectives on integrating literacy and numeracy skills in Science lessons.

Right to withdraw

Anonymity is assured and you are free to withdraw from the project at any time without giving a reason.

How will the information be used / disseminated?

The data will be used in a dissertation for a Master's Degree and in research publications. Summary data will only appear, individual participant data will not be identified.

How will confidentiality be kept?

All information gathered will remain confidential and will not be released to any third party. Participants in the survey will not be identifiable. All interview participants will be given pseudonyms to protect their anonymity.

Hard copies of questionnaires will be stored in a locked filing cabinet in the home of the researcher and electronic data will be stored on an encrypted USB key. The data will be kept for the duration of the study + 3 years after it's completion in adherence to the MIC Research Storage Retention Policy.

Who is undertaking this research?

Contact details:

If at any time you have any queries please contact:

Rachel Galvin, Email: rachel.galvin@gmail.com

Or

Dr. Maeve Liston, Lecturer in Science Education, Mary Immaculate College, Limerick, ++353 61 774726, Email: maeve.liston@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:

MIREC Administrator

Mary Immaculate College

South Circular Road

Limerick

061-204980

mirec@mic.ul.ie

Appendix F

Consent Forms for the survey questionnaires and the interviews

An Exploration into How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.

Consent Form - Survey

You are invited to take part in the research; you are under no obligation to participate in the research and may withdraw at any time. Should you agree to take part, and sign this consent form, you can still decide to withdraw after data collection, if you do not wish for your data to be included for analysis.

Requirements of Participation in Research Study:
Participants will be required to take part in a 45 minute interview relating to the development of literacy skills in the primary Science classroom

If you have any concerns about this study and wish to contact someone independently, you may contact the MIREC Administrator, Mary Immaculate College, South Circular Road, Limerick, 061 204954 mirec@mic.ul.ie.

Please read the following statements before signing the consent form.

- I have read and understood the participant information sheet.
- I understand what the project is about, and what the results will be used for.
- I know that my participation is voluntary and that I can withdraw from the project at any stage.
- I am aware that my results will be kept confidential.

"I have read and understand the Information Sheet provided in relation to this research. I understand how the research will be conducted and disseminated. I know that participation is voluntary and that I can withdraw from the project at any stage without giving any reason"

Signed:_____Date_____

An Exploration into How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.

Consent Form - Interview

You are invited to take part in the research; you are under no obligation to participate in the research and may withdraw at any time. Should you agree to take part, and sign this consent form, you can still decide to withdraw after data collection, if you do not wish for your data to be included for analysis.

Requirements of Participation in Research Study:
Participants will be required to take part in a 45 minute interview relating to the development of literacy skills in the primary Science classroom

If you have any concerns about this study and wish to contact someone independently, you may contact the MIREC Administrator, Mary Immaculate College, South Circular Road, Limerick, 061 204954 mirec@mic.ul.ie.

Please read the following statements before signing the consent form.

- I have read and understood the participant information sheet.
- I understand what the project is about, and what the results will be used for.
- I know that my participation is voluntary and that I can withdraw from the project at any stage.
- I am aware that my results will be kept confidential.

"I have read and understand the Information Sheet provided in relation to this research. I understand how the research will be conducted and disseminated. I know that participation is voluntary and that I can withdraw from the project at any stage without giving any reason"

Signed:_____Date_____

Appendix G

Survey Monkey ©

An Exploration into How the Development of Literacy Skills are being Integrated, Fostered and Encouraged in the Primary Science Classroom

All questions are multiple choice.
There are also comment boxes that you can fill in if you wish. Thank you.

1. What type of school do you teach in?

- ○ Rural Deis
- ○ Urban 1 DEIS
- ○ Urban 2 DEIS
- ○ Mixed School
- ○ Girls Primary School
- ○ Boys Primary School
- ○ Gaelscoil

2. I am

- ○ Male
- ○ Female

3. How many years have you being doing primary school teaching?

- O 0 to 5 years
- O 6 to 10 years
- O 11 or more years

4. Please state what class level you are currently teaching?

- ○ Juniors/Seniors
- ○ First/Second
- ○ Second
- ○ Third
- ○ Fourth
- ○ Fifth
- ○ Sixth
- ○ Multigrade

If you teach multigrade please specify the class level

5. How many courses or CPD in Science have you undertaken in the past 5 years?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

Please provide details (title, course content)
If yes, please answer questions 6a - 6e below.

6 (a). Was there an emphasis placed on literacy skills in the Science CPD courses?

- ○ Yes
- ○ No

Please explain your answer (in what way? Strategies? Activities?)

6 (b). Please rank your opinion on the level of literacy in the Science courses.

- ○ Very Satisfactory
- ○ Satisfactory
- ○ Neutral
- ○ Unsatisfactory
- ○ Very Unsatisfactory

6. (c). Have you attended a CPD session on developing oral language skills specifically in the Science lesson?

- ○ Yes
- ○ No

6. (d). Have you attended a CPD session on developing writing skills specifically in the Science lesson?

- ○ Yes
- ○ No

6. (e). Have you attended a CPD session on developing reading skills specifically in the Science lesson?

- ○ Yes
- ○ No

7. How many courses or CPD in literacy have you undertaken in the past 5 years?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ >5

Please provide detail (title, course, content)

8. Rate your satisfaction level on CPD courses in Science you have attended in the past under the following

	Very satisfied	Satisfied	Neutral	Unsatisfied	Very Unsatisfied
Content	○	○	○	○	○
Updating pedagogical skills(teaching methodologies)	○	○	○	○	○
Update subject matter knowledge in Science	○	○	○	○	○
Increase my confidence in teaching Science	○	○	○	○	○
The provision of Teaching resources (eg Worksheets and booklets)	○	○	○	○	○
Increase my confidence in teaching Science	○	○	○	○	○

Any additional comments

9. To what extent do you agree/disagree with the following statements with regard to CPD courses on primary school Science?

	Yes	**No**	**I don't know**
I would like more Opportunities to undertake CPD courses in Science.	○	○	○
Would you like to attend a Science CPD session on developing oral language skills specifically in the Science lesson.	○	○	○
Did your undergraduate / Postgraduate primary teaching course incorporate the development of oral language skills specifically in the Science lesson.	○	○	○

If "yes" please provide details

10. Please rank the proportion of time spent in Science lessons on the follow:-

	10%	20%	30%	40%	50%	60%	70%	80%
Teacher talk	○	○	○	○	○	○	○	○
Pupil talk	○	○	○	○	○	○	○	○
Teacher writing	○	○	○	○	○	○	○	○
Pupil writing	○	○	○	○	○	○	○	○
An individual child discussing their ideas.	○	○	○	○	○	○	○	○
An individual child arguing/debating their ideas.	○	○	○	○	○	○	○	○
Whole class discussion	○	○	○	○	○	○	○	○

Argumentation strategies	○	○	○	○	○	○	○	○

Please provide details

11. To what extent do you agree/disagree with the following statements with regard to incorporating higher order oral language into your Science lesson?

What are your opinions on implementing higher order oral language into your Science lessons	Strongly Agree	Agree	Neutral	Strongly Disagree	Disagree
Think-pair-share are used a lot in my Science lessons	○	○	○	○	○
Group work to "build" answers and solutions between students discussing problems and pooling knowledge and experience.	○	○	○	○	○
Students are encouraged to ask (the teacher and others) questions.	○	○	○	○	○
Students are encouraged to make connections e.g. can you remember something else that we did like this?	○	○	○	○	○
I sometimes respond to the students questions with further questions to prompt them to think for themselves	○	○	○	○	○
I always use starting points for Investigations and guide the Students through open-ended Questioning.	○	○	○	○	○
Students are encouraged to think aloud…e.g. asking the students to go through that step by step.	○	○	○	○	○
Productive argumentation such as concept cartoons, the use of puppets, competing theories, cards sorts (students work collaboratively to match, arrange or sort information on cards) and evidence statements.	○	○	○	○	○

12. How often do you use the following *teaching strategies/activities* in the primary Science lesson?

	Always	Sometimes	Never
Science books	○	○	○
Scientific process skills	○	○	○

Inquiry based learning	○	○	○
Writing process skills	○	○	○
Concept cartoons	○	○	○
Concept mapping	○	○	○
Use of scientific Notebooks/diaries	○	○	○
Childrens English Literature	○	○	○
debating	○	○	○
Sentence stems (starting A sentence e.g. I learned) `	○	○	○
worksheets	○	○	○
Students KML charts	○	○	○
Use of wordwalls/ wordbanks	○	○	○
card sorting/matching	○	○	○
English poems	○	○	○
collaborative groupwork	○	○	○
Explorative talk in which Everyone is invited to give their ideas. Challenge one another respectfully, shares information, gives/asks for reasons. The teacher organises shapes the talk.	○	○	○
Dialogic teaching and talk. 1. students share information and exchange ideas and problem solve. 2. Dialogue "where students are Achieving common understanding Through structured and cumulative Questioning.	○	○	○
Talking points – groups agree/ Disagree with a statement even though they are unsure of the idea presented to them. Whole class discussion is orchestrated by the teacher. This allows students to share their ideas.	○	○	○

13. How strongly do you agree/disagree with the following statements?

	Strongly agree	**Agree**	**Neutral**	**Strongly disagree**	**Disagree**
'One consequence of the introduction of 3 new subjects	○	○	○	○	○

(drama, Science and SPHE) In the curriculum may have Been a reduction in the amount of time devoted to the core areas of literacy and numeracy.' (from Better Literacy and Numeracy document)

Please provide your opinion on the comment above.

14. How strongly do you agree/disagree with the following statements:

	Strongly agree	Agree	Neutral	Strongly disagree	Disagree
It can be challenging To implement inquiry Based learning in your class.	○	○	○	○	○

Please provide your opinion on the comment above.

Thank You

Appendix H: Postal Survey

COLÁISTE MHUIRE GAN SMÁL
OLLSCOIL LUIMNIGH
MARY IMMACULATE COLLEGE
UNIVERSITY OF LIMERICK

An Exploration into How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.

Section 1: Background

Please tick the appropriate boxes in the following questions below

1. What type of primary school do you teach in? (Tick as many boxes as required)

Rural DEIS	Urban 1 DEIS	Urban 2 DEIS	Mixed	Girls school	Boys School	Gaeilscoil

2. I am

Male	Female

3. How many years have you been teaching at primary level?

0 – 5yrs	6 – 10yrs	11 or more yrs

4. Please indicate what class level you are currently teaching.

Class level	**Tick the appropriate box below**
Junior or Senior Infants	
First Class	
Second Class	
Third	
Fourth	
Fifth	
Sixth	
Please tick if you teach any multi-grade classes	

Section 2: Continuous Professional Development (CPD)

Please tick the appropriate boxes in the following questions below

5. How many Courses or CPD in *Science* have you undertaken in the past 5 years?

0	1	1	3	4	5	>5

Please provide detail (title, course content).

Title of the course:_____

Other details:_____

If yes please answer questions 60a – 6e below.

6a.Was there an emphasis placed on Literacy skills in the Science CPD courses?

Yes	No

Please explain answer (in what way? Strategies? Activities?_____

6b. Please rank your opinion on the level of literacy in the Science Courses

V. Satisfactory	Satisfactory	Neutral	Unsatisfactory	V. Unsatisfactory

6c.

V. Sufficient	Sufficient	Neutral	Insufficient	Not at all Sufficient

6 d. Have you attended CPD session on developing oral language skills specifically in Science lesson?

Yes	No

6 e. Have you attended CPD session on developing writing skills specifically in Science lesson?

Yes	No

6 f. Have you attended a Science CPD session on developing reading skills specifically in a Science lesson?

Yes	No

7. How many Courses or CPD in *Literacy* have you undertaken in the past 5 years?

0	1	1	3	4	5	>5

Please provide detail (title, course content).
Title of the course:_____
Other details:_____

8. Please rank your level of satisfaction with CPD Provision in Science

	% of Levels of satisfaction with CPD Provision in Science				
	Very satisfied	Satisfied	Neutral	Unsatisfied	Very Unsatisfied
Content					
Update pedagogical skills					
Update subject matter knowledge					
Increase confidence in teaching Science					
The provision of teaching resources					
Cost of the CPD course					

9. To what extent do you agree/disagree with the following statements with regard to CPD courses on primary school Science?

	Yes	No	I don't know
A. I would like more opportunities to undertake CPD in Science.			
B. Would you like to attend a Science CPD session on developing oral language skills specifically in the Science lesson?			
C. Did your undergraduate/ postgraduate primary teacher education course incorporate the development of oral language skills specifically in Science education?			

If "yes" please provide details

_____

Section 3: Literacy skills in the Science Classroom

10. Please rank the proportion of time spent in Science lessons on the following

	≤10 %	20 %	30 %	40 %	50 %	60 %	70 %	≥80 %
Teacher talk								
Pupil talk								
Teacher writing								
Pupil writing								
Teacher Reading								
Pupil Reading								
An individual child discussing his/her ideas								
An individual child arguing/debating their ideas								
Whole class discussion								
Argumentation strategies								

Please explain answer

_____

11. To what extent do you agree/disagree with the following statements with regard to incorporating Higher order oral language into your Science lessons?

What are your opinions on implementing *Higher order oral language* into your Science lessons	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A. Think-pair-share are used a lot in my Science lessons.					
B. Working in pairs or groups is encouraged to 'build' answers and solutions between them by discussing problems and pooling knowledge and experience.					

C. students are encouraged to ask (the teacher and others) questions.					
D. Students are encouraged to make connections… e.g. can you remember something else that we did like this?					
E. I sometimes respond to student questions with further questions to prompt them to think for themselves					
F. I always supply starting-points for investigations, and guide the students through open-ended questioning.					
G. Students are encouraged to think aloud….eg asking the students to go through that step by step					
H. Productive argumentation is used such as concept cartoons, the use of puppets, competing theories, cards sorts (students work collaboratively to match, arrange or sort information on cards), and evidence statements.					

12. How often do you use the following activities in the primary Science lesson?

Teaching strategies/activities	**Always**	**Sometimes**	**Never**
Science books			
Science process skills			
Inquiry based learning			
Writing process skills			
Concept cartoons			
Concept Mapping			
Children's English Literature			
Debating			
Sentence stems (starting a sentence e.g. I learned ….)			
Worksheets			
Use of Science notebooks/diaries			
Student KWL Charts			
Use of word walls/ word banks			
Card sorting/matching			
English Poems			
Collaborative group work			
Strategies to promote talk. **(see A, B, C below and rate as appropriate)**			
A. Exploratory talk			

"Exploratory talk is effective talk in which everyone is invited to give their ideas and to challenge one another respectfully, share information, and give and ask for reasons. The teacher organises and shapes the talk.			
B. Dialogic Teaching and talk:- uses 1. Discussion where students share information, exchange ideas and problem solve. 2. Dialogue where students are "achieving common understanding through structured and cumulative questioning			
C. "Talking Points" which consists of small groups allow every child to speak. This also allows the group to support one another in subsequent whole-class discussions. Students need to be familiar with exploratory talk and working together in their groups they can agree/disagree of state if they are unsure with the ideas presented to them. Subsequent whole-class discussion orchestrated by the teacher enables all the students to share their thinking, consider a range of points of view, develop vocabulary and ideas and to establish areas of uncertainty for further investigation. It is essential that children know that their suggestions are highly valued by the teacher and by one another.			

13. Please read the following statement and record your opinion on the statement below.

"One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a ***reduction in the amount of time devoted to the core areas of literacy and numeracy***." (From: Better Literacy and Numeracy for Children and Young People p28).

Please tick the appropriate box that reflects your feeling on the statement above	Strongly agree	Agree	Neutral	Strongly disagree	Disagree

Please state your opinion on the comment above.

_____
_____
_____
_____
_____
_____

14. Please read the following statement and record your opinion on the statement below.

"*It can be challenging to implement IBL effectively in your Class*."

Please tick the appropriate box that reflects your feeling on the statement above	Strongly agree	Agree	Neutral	Strongly disagree	Disagree

Please state your opinion on the comment above.

_____
_____
_____

Thank you for taking the time to complete this questionnaire.

Appendix I

Semi-structured Interviews

1. How many Courses or CPD in *Science* have you undertaken in the past 5 years?

2. Would they consider doing CPD courses on Science outside of school time?

3. What model of CPD do you find most desirable for your needs?

4. How effective were the Science CPD courses and/or past Science courses that you have taken have helped you in teaching Science in the classroom and with regard to teaching oral language?

5. Please comment on the statement:

   One consequence of the introduction of three new subjects (drama, Science and SPHE) in the curriculum may have been a *reduction in the amount of time devoted to the core areas of literacy and numeracy*." (From: Better Literacy and Numeracy for Children and Young People p28).

6. How do you currently incorporate literacy into your Science lessons with regard to reading, writing and through dialogue?

7. Would you be interested in attending CPD sessions in how to incorporate Literacy skills into Science in the future?

8. How is IBL and scientific process skills utilised in your Science lessons?

9. How effective is collaborative group work in your Science lessons?

10. How do you think group work could be improved in order to promote dialogue and discussions among the pupils?

11. Do you integrate technology in Science? Do you think ICT can develop or hinder children literacy skills in Science?

Appendix J

Transcribed Interviews

1. How many Courses or CPD in Science have you undertaken in the past 5 years? (Teachers were asked to elaborate on the cost of CPD courses that they had undertaken).
Teacher #1 commented that *'the most recent science courses that I have attended in the past 2 years have been free with the Mallow Science Partnership initiative that is in collaboration with Mary Immaculate College'* and added that *'I have found it useful and very practical.'*

Teacher #2 commented that '*the science courses that I have taken have been online courses over the summer months which were very expensive in excess of seventy euros!'*

Teacher #3 commented that *'I have found that the online science [CPD] courses are expensive and some face-to-face ones are cheaper and more tangible'* and added *'I prefer to get resources in hardcopy form or information that I can store easily and that it is easily accessible.*'

2. Would you consider doing CPD courses on science outside of school time?
Teacher #1 commented that *'due to family commitments, I don't have the time or the energy to focus on a CPD course in science during the summer months that is quality time with my family.' And added that 'it would be great if courses could be held during Croke Park times and this would be more productive I would think or in-service courses during the school day.'*

Teacher #2 commented that *'I have done some online courses and face to face courses. I found the face to face courses in science much better. It's great to get the hand-on experience of doing an experiment and being able to ask the instructor stuff that I don't understand. It makes it easier when the modelling of lessons is being carried out by the instructor.'*

Teacher #3 commented that *'it's nice to talk to other teachers on how they teach certain areas of the science curriculum' and added that 'the CPD courses are very good but I usually do these courses in July and by the time September comes I have forgotten a lot of what was covered on the course.'*

3. What model of CPD do you find most desirable for your needs?

Teacher #1 commented that *'in the school I teach in, we [teachers] are told what class we will be teaching in the following September in May and I find that this can be too short notice to get up to speed with the science content especially like this year I was moved from senior infants to fifth class. I did a science CPD course online over last summer. It was a good course but I felt I was still unprepared for the science curriculum. I had to do a lot of research in it throughout the year.'* And added that *'it would be great to have a science folder available on each class level. It has been a steep learning curve for me and not just in science.'*

Teacher #1 commented that *'I find face-to-face courses better but the downside is that it takes a week to complete the course whereas the online course you can do at your leisure.'*

Teacher #1 commented with regard to science courses where *'only 1 representative of staff could attend. This should have been a whole staff approach as it would have benefited the teachers' level of content knowledge and experiences will differ especially in the middle and the senior end of the school classes.'*

Teacher #2 commented that *'face-to-face courses are better but there is no allowance for support afterwards.'*

Teacher #3 commented that '*There are always new methods and resources on how to teach the strand and strand units better. I use the teachers' forums for example education posts [a web based forum for teachers queries] to talk to other teachers on how they teach certain areas of the science curriculum. It is very useful and people are really helpful on it.'*

Teacher #3 noted that with postgraduate programs 'there is *no incentive to do masters as there is no promotional prospects or monetary gain in furthering ones education. The DES does not even offer study leave days for teachers who are completing a Masters or PHD in Education. This does not incentivise teachers.'*

4. How effective were the science CPD courses and/or past science courses that you have taken have helped you in teaching science in the classroom and with regard to teaching oral language?

Teacher #1 stated that '*we can develop children literacy skills in science I think in line with writing genres, it will give children time to expand and report or provide explanations and develop their procedural writing skills.*'

Teacher # 2 felt that '*science can develop literacy skills by using for example predicting, pre and post activity reviews, vocabulary building and reading science texts like for example how things work etc.'* And noted that '*classroom discussion is used at the start of the lesson to see what are the children's ideas or perceptions of the science topic and then I usually put the pupils into groups for experiments or for project work.'* And added that '*sometimes the discussions around the experiments can be rushed due to time constraints, and pupils share what they have found out with the rest of the class towards the end of the lesson.'* And added *'sometimes I use concept mapping on the board to help guide the pupils through their discussion on the experiment they are working on.'*

Teacher #3 stated '*we can develop children oral language through pre-experiment discussions and writing skills by recording materials, steps and outcomes of an experiment'* and added *'if you integrate literacy with science and numeracy both areas are covered very effectively.*'

5. How do you currently incorporate literacy into your science lessons with regard to reading, writing and through dialogue?

Teacher #1 commented that *'I like to use **think-pair and share** for quick responses to questions given to the students in class and I would use group work where the students would do science experiments and to have them complete the task within a certain timeframe to try and prevent the disruptive kids from upsetting the groups purpose and to keep them on task.'* And added *'I try to get **every group to report** to the class how they got on with the experiment time permitting. I find that the pupils really enjoy **project work** and discuss it with their group members outside of class time and work on it together independently in the computer room if they get free time to work on it.*'

Teacher #2 noted that '*classroom discussion is used at the start of the lesson to see what are the children's ideas or perceptions of the science topic and then I usually put the pupils into groups for experiments or for project work.'* And added that '*sometimes the discussions around the experiments can be rushed due to time constraints, and pupils share what they have found*

out with the rest of the class towards the end of the lesson.' And added *'sometimes I use concept mapping on the board to help guide the pupils through their discussion on the experiment they are working on'* and added that '*all 3 new subjects have a literacy component, but in my opinion there should be more of a focus on methodologies across the subjects rather than discrete subject areas. Hours in school haven't changed.*'

Teacher #3 commented *'I use think-pair and share with my class and I find it works well in using card sorting and sequencing in a science lesson or when the children are doing a basic experiment, they have assigned roles and talk about what they are supposed to do, how they will do it and help each other to complete the task through discussion.'* And added *' I would have a whole class discussion at the start of the lesson and ask the children what they know already and during the lesson I would observe and ask questions and at the end I would ask the pupils how did they do x, y and z during a whole class discussion.'*

The teachers were probed further to provide any further details of any other higher order oral language activities that promote debating, argumentation and pupil questioning etc.:
Teacher #1 commented that *'I would like quick snappy activities that promote reading and writing skills in my Sciences class.'*
Teacher #2 asked *'is it is similar to debating?'*
Teacher #3 felt that '*In order to promote debating and argumentation I would need to have a good knowledge of science which I will be honest I do not have.'*

With regard to reading:
Teacher #1 commented that *'with regard to reading the school science book is used and the pupils get turns to read aloud from it' and added 'I have found that when teaching the older classes like for example 6th class they would do project work that would involve them looking up information on the internet on their particular area of interest.'*

Teacher #2 noted that the class science book was used for reading also and added 'I also supplement information from other science books and newspaper and photocopy these for the pupils so that they can read it in class.' And also noted that 'not having adequate access to computers for pupils use in the school is challenging in science when it is so useful for pupils to read up on facts and other information on a science topic.'

Teacher #3 found that 'I have no other choice when teaching the older classes but to tell them to look up information on their own computers at home as there are no computers in the school for students to use to access information' and added 'I rely heavily on the class science book and I find that I need to supplement this with more information which means researching the internet especially in teaching science to the older classes.'

With regard to writing:

Teacher #1 noted that *'report writing is used by the students when they are doing projects on an area like Bats and will do the write up about their habitats for example'* and the '*students type up their projects in the computer room in the school and can edit and add in pictures from the internet also.'* Adding *'the students would use explanation writing and procedural writing when is required also and I use concept mapping and key words to help students with writing up experiments.'*

Teacher #2 also uses report writing for the senior classes adding that *'the students do about edits on their report writing and they are familiar with reading over their work so as to improve it on the next edit.'* Adding *'I would also use the explanation writing genre if the students have to explain a natural phenomenon for example.' And added 'when I was teaching 3rd class I used to have specific headings on a topic that the students would have to write about.'*

Teacher #3 noted *'I use STEM sentence starters with the younger pupils as they tend to find it difficult to get started and worksheets are great also for these junior classes.'* And added *'the pupils sometimes draw their experiment when they have completed carrying it out on paper or in the science class book where there is a space for drawing.'*

6. Would you be interested in attending CPD sessions in how to incorporate Literacy skills into science in the future?

Teacher #1 commented that *'Yes I think I am ok with oral language, we do a lot of talking in my science class but now that I am thinking about it I probably do not do enough reading and writing but I do not want it to take over the science lesson either*.'

Teacher #2 felt that '*I think I do well enough incorporating writing into my science lessons even though my pupils are not overly impressed by this. I would like quick snappy activities*

that promote reading and writing skills in my sciences class, and that they would not take over from the overall process or time to carry out the experiment.'

Teacher #3 stated that *'I would like to attend future sessions to develop knowledge of how I can do this more effectively. I would love ideas on literacy skills and oral language in science and also developing more thought provoking discussions and discussions in general.'*

7. How is IBL and scientific process skills utilised in your science lessons?
Teachers were also asked to elaborate in the interview on how IBL and scientific process skills were being implemented in their science lessons? as it was implied in the questionnaires that maybe more teacher-directed science lessons and teacher led investigations were being used due to class sizes, time constraints and classroom management issues.

Teacher #1 commented that '*the scientific process skills that I use in IBL varies and depends on what I will be teaching the children. I use the science book for 5th class and I try and use as many of them as I can over the year. I would say to be honest we would not have enough time to get through all the science process skills in depth. I have a lot of children who would just mess also so I concentrate on the experiment with the children and what the outcomes should be.*'

Teacher #2 responded that '*my scientific knowledge is not great but I do the best I can.'*

Teacher #3 added that '*class size has an effect on how much inquiry can be done 'as keeping control of large class working in groups is challenging.*'

To expand on the above question in the interview the teachers were asked if they prefer to use closed or open ended experiments. Similar to the findings of the questionnaires the same issues arose: time, overcrowded curriculum, planning, class sizes, resources and scientific knowledge.

Teacher #1 commented that '*I preferred closed activities as classroom management can be an issue in a large class of more than 30 pupils all doing a hands on experiment. Problems arise within the groups such as arguments that some pupils are trying to take over and do most of the work, excluding others. Some pupils get distracted and start to mess and distract others, and others just tune out.'* And added *'it's the time constraint in an already overcrowded curriculum*

that is big problem in trying to carry out open ended investigations, it just takes too long and I have a whole school curriculum to cover too.'

Teacher #2 explained that '*I sometimes use open ended investigations but I find it very time consuming and try to have investigations that do not take up too much time. I also find it requires a bit more planning and I have to buy the resources needed.*'

While teacher #3 noted that '*class size is not very conducive to open investigations as having more than 30 kids in the classroom with regard to classroom management of these kids and the experiments they are trying to get to grips is very challenging*.'

To expand on the above question in the interview the teachers were asked if they felt about knowledge skills and resources on the content in the science curriculum to make IBL more effective. Similar to the findings of the questionnaires the same issues arose.
Teacher #1 noted that '*I would like to know more interesting/challenging experiments that 5th and 6th class pupils can do and that are relevant to them and how these if possible can be related to their lives if possible'* and added that '*my own understanding of some of the science content is limited.'* All of the participants interviewed found time as a constraint and therefore the investigations are more teacher directed rather than pupil directed.

Teacher #2 commented that they found it challenging, '*with teaching 6th class I find it difficult to find new material on some topics from 6th class books for the science lessons as 5th class material is very similar and sometimes I find I am repeating what was done in 5th class*'.

Teacher #3 commented that '*I don't have enough resources available to allow the pupils to work in smaller groups…I end up buying them [resources]'* and added that *'trying to develop critical thinking skills and problem solving skills among pupils with little resources and large class size is challenging.'*

8. How effective is collaborative group work in your science lessons?
Teacher #1 commented that *'I like to use think-pair and share for quick responses to questions given to the students in class and I would use group work where the students would do science experiments and to have them complete the task within a certain timeframe to try and prevent the disruptive kids from upsetting the groups purpose and to keep them on task.'* And added *'I*

try to get every group to report to the class how they got on with the experiment time permitting. I find that the pupils really enjoy project work and discuss it with their group members outside of class time and work on it together independently in the computer room if they get free time to work on it.' And also found that '*with an SEN pupil in her class with 'Asperger's work better in pair work than in a large group and so the class has some pair work and group work being carried out simultaneously and the pupils are moved around from pair work to group work and this works well.'*

Teacher #2 commented '*pair work in particular helps the academically weaker pupils to be more confident and helps build up their self-esteem. However, sometimes with the larger group work, the quieter more reserved pupils can be lost in the mix unless definite roles are assigned to the members in the group but still some of the more boisterous ones try to dominate the activity.'* And also noted that *'I find having small groups of 3 or 4 works best in my class. I am lucky though my class size is small' adding that 'its manageable and the groups are more focused. Pupils can ask each other questions to clarify their understanding in the small groups and I think it's less intimidating for the shyer/quieter pupils to get more involved also.*' This kind of group work is also conducive to helping pupils develop their scientific skills.
Teacher #2 also relayed that *'closed activities were much quicker to accomplish [rather than open ended investigations] due to time constraints with trying to get all of the other subjects on the school curriculum done also.'*

Teacher #3 noted that *'its very time consuming for the teacher to go around to each group in a large classroom of pupils to see how they are getting on and to have the lesson completed in the allocated timeframe. Also trying to have enough resources is an issue and can be an additional cost to the teacher.'*

09. How do you think group work could be improved in order to promote dialogue and discussions among the pupils?
Teacher #1 commented that *'station teaching seems to be popular for English and Maths and maybe this could be used in the science context but how exactly you would implement it I am not sure.'*

Teacher #2 suggested *that 'maybe having something similar to station teaching that has become popular in English and Maths for all classes and has proved to be very successful for*

pupils. This may work well in the science setting also and a station could be set up specifically for oral language skills development.'

Teacher #3 found that the pupils *'enjoy project work and are great at coming up with ideas on their own.' And added 'and maybe station teaching could be used in teaching science.'*

10. Do you integrate technology in Science? Do you think ICT can develop or hinder children literacy skills in science?

Teacher #1 commented that *'having a computer room is a great resource and it is great stimulation for the children as they work together on projects, there is a lot of talk and discussion and this is great and the kids are very helpful to each other helping one another out with explaining things and with new ways of inputting information onto the computer.'*

Teacher #2 noted that *'I use the school laptop to look up things in science'* and added that *'there are about 10 laptops available to pupils' in the school but it takes time to set them up in the classroom and sometimes the internet doesn't work or they won't print when they should, it can be very frustrating and everyone gets a chance to work on the laptops are there are too few of them.'*

Teacher #3 commented that *'the children don't have any access to laptops in the school so I give them research work to do at home as part of their homework. Its not ideal but it works for the most part, I suppose.'*

11. **Teachers were asked to comment on the statement: One consequence of the introduction of three new subjects (drama, science and SPHE) in the curriculum may have been a *reduction in the amount of time devoted to the core areas of literacy and numeracy*." (From: Better Literacy and Numeracy for Children and Young People p28).**

Teacher #1 commented that *'we have reduced the drama time to allow for more literacy and numeracy and taken 10 minutes from science, history and geography also. I think drama and SPHE gives children lots of oral language time and science has plenty of opportunity with report writing etc.'*

Teacher #2 noted that '*all 3 new subjects have a literacy component, but in my opinion there should be more of a focus on methodologies across the subjects rather than discrete subject areas. Hours in school haven't changed.*' And added '*sometimes I just have to leave these subjects (Science, SPHE and Drama) out in the timetable during the week.'*

Teacher #3 stated *'this statement is not true entirely, if you integrate literacy with science and numeracy both areas are covered very effectively.*'

Appendix K

Ethical Approval from Mary Immaculate Research Ethics Committee (MIREC)

COLÁISTE MHUIRE GAN SMÁL
OLLSCOIL LUIMNIGH
MARY IMMACULATE COLLEGE
UNIVERSITY OF LIMERICK

Mary Immaculate College Research Ethics Committee

MIREC-3: Application Form

Instructions:

1. *Complete all relevant sections of this form. The information provided must be comprehendible to non experts.*
2. *Attach a copy of all relevant documentation to the application. Failure to provide the necessary documentation will delay the consideration of the application.*
3. *If the applicant is a Research Postgraduate Student their Supervisor(s) must sign Section 4 of this form.*

1a Title of Research Project
An Exploration into How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.
1b Brief Outline

3 Project Investigators			
3a Principal Investigator			
Name	Rachel Galvin		
Faculty	Education		
Department	LSRE		
Position	Masters in Education	**Subject:**	Science Education
Qualifications	Bachelor of Technology Degree in Electronic Engineering (Honours) from W.I.T. in 1993, Masters in Safety and Health at Work (Honours) from D.C.U. in 2008, Higher Diploma in Higher Education (Honours) in 2010 from Hibernia College.		
E-mail:	rachel.galvin@gmail.com	**Phone:**	089 4980848

3b Other Investigators (use additional sheet if necessary)		
Name	**Qualifications & Affiliation**	**Signature**

3c Foresight

3d Ethical Guidelines / Ethical Clearance from Another Source				
Are there Ethical Guidelines to which you must adhere in your field of study? If yes, please specify below:	**Yes**	**√**	**No**	
The Mary Immaculate College Research Ethics Committee Guidelines will be adhered to in this study: *Participant Information Sheets* providing information about the study and detailing what is involved, will be issued to all participants; *Participant Informed Consent Forms* to ensure that participants understand the nature of the study, their role within it and their right to withdraw without consequence at any time, will be issued to all participants;				

Issues and guidelines regarding Confidentiality, Anonymity and Data Storage will be addressed in the Participant Information Sheets and throughout the research process.				
Do you require Ethical Clearance from another source? **If yes, please specify below:**	**Yes**		**No**	**√**

This research is an inquiry into the current practices of integrating Literacy and Numeracy Skills and associated teaching methodologies into Science lessons in Irish Primary Schools. It will involve an exploratory mixed methods design of data collection, investigating, identifying and examining the literacy and numeracy strategies and approaches used by teachers during Science lessons by gathering both quantitative and qualitative data through the means of teacher questionnaires and semi-structured interviews. The different approaches, practices and methodologies will then be compared and contrasted to recognised best evidence-based practices and evaluated in the context of policies.

The project will also investigate teachers' perspectives and experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy and numeracy skills. It will seek to evaluate the value teachers place on utilising Science lessons as an approach in developing literacy and numeracy skills in the classroom.

This study will unveil meaningful insights into the development and support of early literacy and numeracy competencies and behaviours in a more integrated manner across the curriculum.

6 Project Design and Methodology

6a Rationale, Purpose and Benefits of Research Project

The National strategy to improve literacy and numeracy among children and young people 2011-2020 states that we need to prioritise literacy and numeracy through positive interventions and integrating these skills across the curriculum (Department of Education and Skills 2011; Shiel 2002).

The practice and development of key scientific process skills contribute significantly to developing the child's language, communication and literacy skills and also their mathematical and numeracy skills. Internationally published literature details how Science can be successfully integrated with literacy to teach Science concepts (Barber *et al*. 2006; Burton and Campbell 1996; Heisey and Kucan 2010; Jackson *et al*. 2010; Poon 1990; Rule *et al*. 2004; Watts 2001).

Under this framework Irish Primary Schools are currently introducing best practice methodologies in literacy and numeracy teaching. Continuous Professional Development (CPD) courses are being rolled out all over the country by the PDST to facilitate this new national strategy. However, there have been no specific models and CPD courses designed and implemented showing teachers how literacy and numeracy skills can be effectively developed in the Primary Science Classroom, which is a wasted opportunity. No such framework has been published to date in relation to the curricular area of Science.

This project therefore is needed to investigate teachers' perspectives and experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy and numeracy skills to inform the design and development of future frameworks, guidelines and CPD courses for the integration and effective development of literacy and numeracy skills in Science lessons.

References

Barber, J., Nagy Catz, K. & Arya, D. (2006). Improving Science Content Acquisition through a Combined Science/Literacy Approach: A Quasi-Experimental Study. Berkley California: University of California.

Burton, Stephanie K. & Campbell, Phyllis. (1996). Science Times with Nursery Rhymes, Colorado: Panda Bear Publications.

Department of Education and Skills (DES), (2011). Literacy and Numeracy For Learning and Life The National Strategy to Improve Literacy and Numeracy among Children and Young People 2011 – 2020. Dublin: Stationary Office.

Heisey, N. & Kucan, L. (2010). Introducing Science Concepts to Primary Students Through Read – Alouds: Interactions and Multiple Texts Make the Difference. *The Reading Teacher*, 63 (8), 666-676.

Jackson, J. Dickinson, G. & Horton, D. (2010). Rocks and Rhymes!. *The Science Teacher,* January 2010, 27-31.

Poon, Kum Heng. (1990). Integrating poetry in Science teaching. *Teaching and Learning*, 10(2), 61-66.

Rule, Audrey C. Carnicelli, Luke A. & Kane, Sharon S. (2004). Using Poetry to Teach about Minerals in Earth Science Class. *Journal of GeoScience Education*, 52(1), 10-14.

Shiel, G. (2002). The performance of Irish students in reading literacy in the Programme for International Student Assessment (PISA). *Irish Journal of Education, 33*, 7-30.

Watts, M. (2001). Science and poetry: passion v prescription in school Science?. *International Journal of Science Education*, 23 (2), 197-208.

6b(i) Research / Data Collection Techniques

Phase 1:

A nationwide survey will be carried out to gather both quantitative and qualitative data, investigating literacy and numeracy strategies and approaches used by teachers during Science lessons and their perspectives and experiences of the use of Science lessons to enhance children's literacy and numeracy skills.

Data from a large population will support statistical inferences adding to the validity of the results.

The findings of the questionnaires in Phase 1 will then be used to further inform semi-structured interviews. In order to make the implementation of a nationwide questionnaire feasible, it will be distributed online through survey monkey. However, the

researcher considers the possible lack of internet access and for this reason, questionnaires may also be distributed by post or in person.

Phase 2:

Semi-structured interviews will be conducted to explore in further detail teachers' opinions on and attitudes towards the use of Science lessons to enhance children's literacy and numeracy skills.

Phase 1 & 2:

The Researcher will keep a reflective log through the data collection process.

6b(ii) Research Methodology

This study will be carried out using mixed methods of research. This involves combining both qualitative (Semi-structured interviews and researcher reflective journal) and quantitative (questionnaires) methods in the study (Punch 2009; Creswell 2009, 2014).

An Explanatory Sequential Design will be utilised, where by questionnaires will be distributed nationally followed by interviewing willing participants (Creswell 2014):

1. Collect and analyse quantitative and qualitative data in the first phase through questionnaires.
2. Examine and analyse the results by quantitative analysis (SPSS) and qualitative analysis (Coding answers into themes) to determine:
   (a) what results will need further exploration in the second, qualitative phase (interviews)
   (b) what questions to ask participants in this qualitative phase order to generate rich, meaningful data about teachers' experiences. .
3. Conduct qualitative data collection and analysis (NVivo) in the second phase by semi structured interviews to help explain the quantitative results.
4. Drawing inferences about how the qualitative results help to explain the quantitative results.

A Research Diary will be maintained throughout to document thinking points for the researcher.

Data from the questionnaires, interviews and reflective logs will be triangulated to ensure validity and reliability (Creswell 2014, p.201).

References

Creswell, John W. (2009). Research design: qualitative, quantitative and mixed methods approaches. 3. ed. Thousand Oaks, Calif.: Sage

Creswell, J.W. (2014) *Research Design: Qualitative, Quantitative and Mixed Methods Approaches,* 4th ed., London: Sage Publications.

Punch, Keith. (2009). Introduction to research methods in education. Los Angeles: Sage

6c Steps taken to Minimise Risk

Participants will contact the researcher if they are willing to get involved in the study.

The researcher will then send them out an information sheet and consent form to the participant via email with a link to the Survey Monkey. If the participants fill in the survey electronically there will be a consent form on the survey monkey along with a consent button to press if they agree to the terms of the research.

The participants that would prefer a postal questionnaire will be sent a SAE to return the consent form and completed questionnaire to the researcher.

The data collected will be kept on an encrypted key, stored in a locked filing cabinet in the home of the researcher.

The data will be accessible to the researcher and the supervisor Dr. Maeve Liston, from the Faculty of Education at Mary Immaculate College, Limerick.

Data collected will be stored for the duration of the study plus an additional three years in compliance with Mary Immaculate College retention schedule.

Should an individual participant / individual participants request a copy of their interview transcript, a copy of their individual transcript will be provided to them alone, upon request.

6d Location(s) of Project

Nationally, Ireland.

6e Questionnaires and Interview/Survey Questions

The questionnaire questions will be a mix of closed and open-ended questions gathering qualitative and quantitative data (Pleases see appendix).

The semi structured interviews will comprise of open questions which will not be biased, or will not try to influence the participants' answers in anyway. These questions will be based on what themes emerge from the questionnaire analysis.

7 Participants

7a How will potential research participants be identified and selected?

An advertisement will be placed on websites, social media pages and mailing lists of national educational institutions, organisations and associations to assist the recruitment of research subjects e.g. INTO, Education Centres around the country. Teachers will be invited to participate in the study investigating literacy and numeracy strategies and approaches used by primary level teachers during Science lessons. They will be invited to indicate their willingness to participate by e-mailing a given address. They will be asked to include contact details (mobile phone number and/or school postal address) for verification.

Interviewees will be recruited from the questionnaire respondents. At the end of the questionnaire, respondents will be provided with a link to a plain language statement regarding the interviews and invited to contact a given e-mail address with their contact details if they are interested in participating further. If they have completed a hard copy they will indicate their interest in entire by emailing the researcher or if they have filled out the survey monkey will include a button and page to fill in their interest in being interviewed.

7b	*To be completed in cases where the applicant intends to recruit students that they teach as research participants.*				
	Does the proposed research necessitate the participation of your current student cohort?	**Yes**		**No**	**√**
	If you have indicated that the proposed research necessitates the participation of students that you teach please provide:				
	A rationale as to why it is necessary that students that you teach participate in the research.				
	Details of the steps you will take to ensure that participation is voluntary and that participants may withdraw at any time without consequence or fear of consequence.				

7c How many participants will be recruited?

Questionnaires will be distributed on a nation-wide basis.

7d	**Will participants be reimbursed for taking part in this research project? If YES, please attach the details to this application.**	**Yes**		**No**	**√**
7e	**Will incentives / inducements be provided to participants for taking part in this research project? If YES, please attach the details to this application.**	**Yes**		**No**	**√**

7f	**Will Recruitment Letters/Advertisements/e-mails, etc. be used to recruit participants? If YES, please attach the details to this application.**	**Yes**	**√**	**No**	
7g	**Will a permission form be used to document permission to conduct the research within an institution? If YES, please attach the details to this application.**	**Yes**		**No**	**√**

8 Confidentiality of collected data and completed forms (e.g. informed consent)

8a What measures will be taken to ensure confidentiality of collected data?

Participants in the survey will not be identifiable. All interview participants will be given pseudonyms to protect their anonymity. The data itself will not contain any sensitive information and all questions relate to participants' professional views.
All contact details of the participants will be destroyed after the data collection process.

8b Where and how will the data be stored / retrieved?

Hard copies of questionnaires will be stored in a locked filing cabinet in the home of the researcher and electronic data will be stored on an encrypted USB key. The data will be kept for the duration of the study + 3 years after it's completion in adherence to the MIC Research Storage Retention Policy.

8c Who will have custody of, and access to, the data?

The Researcher will have sole custody of the data. If necessary, upon request – the supervisor will also have access to the data however the anonymity of participants will remain in the form of pseudonyms. The supervisor will not know the password to encrypted files.

8d For how long will the data from the research project be stored? *(Please justify)*

The data will be kept for the duration of the study + 3 years after it's completion in adherence to the MIC Research Storage Retention Policy.

9 Information Documents

Indicate which of the following information documents are applicable to your Research Project by ticking either Yes or No in the checklist below. Attach a copy of each applicable information document to the application.

	Applicable Please ✓	
Documents	***Yes***	***No***
Participant Information Sheet	**√**	
Parent/Responsible Other Information Sheet		**√**
Participant Informed Consent Form	**√**	
Parent/Responsible Other Informed Consent Form		**√**
Questionnaire (or sample)	**√**	

2	**Proposed Start Date**	**Month**	March	Year	2016
	Anticipated Completion Date	**Month**	*August*	*Year*	*2016*

4 Supervisor(s)

To be completed in cases where the applicant is a research postgraduate student.
I hereby authorise the Principal Investigator named above to conduct this research project in accordance with the requirements of MIREC-6 and I have informed the Principal Investigator of their responsibility to adhere to the recommendations and guidelines in MIREC-6.

Name	**Department**	**Date**	**Signature**
Dr. Maeve Liston	Maeve.liston@mic.ul.ie 061 774726	05/01/16	

5 Study Descriptors

Please mark the terms that apply to this research project with a ✓

Healthy Adults	√	Vulnerable Adults	
Children (< 18 yrs)		Vulnerable Children (<18yrs)	
Physical Measurement		Psychological Measurement	
Video Recording/Photography		Voice recording	√
Questionnaire/Interview	√	Observational	
Physical Activity		Record Based	
Project is Off-Campus	√	'Other' descriptor(s) not named here	
Please specify 'Other' descriptor(s)			

10 Declaration

The information in this application form is accurate to the best of my knowledge and belief, and I take full responsibility for it. I undertake to abide by the ethical principles outlined in the MIC Research Ethics Committee guidelines. If the research project is approved, I undertake to adhere to the study protocol without unagreed deviation, and to comply with any conditions sent out in the letter sent by the MIC Research Ethics Committee notifying me of this. I undertake to inform the MIC Research Ethics Committee of any changes in the protocol. I accept without reservation that it is my responsibility to ensure the implementation of the guidance of MIREC as outlined in MIREC-6.

Name (Print) _____ Signature _____

Instructions:

4. *Complete all relevant sections of this form. The information provided must be comprehendible to non experts.*
5. *Attach a copy of all relevant documentation to the application. Failure to provide the necessary documentation will delay the consideration of the application.*
6. *If the applicant is a Research Postgraduate Student their Supervisor(s) must sign Section 4 of this form.*

1a	**Title of Research Project**
An Exploration into How the Development of Literacy Skills are Being Integrated, Fostered and Encouraged in the Primary Science Classroom.	
1b	**Brief Outline**

This research is an inquiry into the current practices of integrating Literacy and Numeracy Skills and associated teaching methodologies into Science lessons in Irish Primary Schools. It will involve an exploratory mixed methods design of data collection, investigating, identifying and examining the literacy and numeracy strategies and approaches used by teachers during Science lessons by gathering both quantitative and qualitative data through the means of teacher questionnaires and semi-structured interviews. The different approaches, practices and methodologies will then be compared and contrasted to recognised best evidence-based practices and evaluated in the context of policies.

3 Project Investigators			
3a Principal Investigator			
Name	Rachel Galvin		
Faculty	Education		
Department	LSRE		
Position	Masters in Education	**Subject:**	Science Education
Qualifications	Bachelor of Technology Degree in Electronic Engineering (Honours) from W.I.T. in 1993, Masters in Safety and Health at Work (Honours) from D.C.U. in 2008, Higher Diploma in Higher Education (Honours) in 2010 from Hibernia College.		
E-mail:	rachel.galvin@gmail.com	**Phone:**	089 4980848

3b Other Investigators (use additional sheet if necessary)		
Name	**Qualifications & Affiliation**	**Signature**

3c Foresight

3d Ethical Guidelines / Ethical Clearance from Another Source				
Are there Ethical Guidelines to which you must adhere in your field of study? **If yes, please specify below:**	**Yes**	**√**	**No**	
The Mary Immaculate College Research Ethics Committee Guidelines will be adhered to in this study: *Participant Information Sheets* providing information about the study and detailing what is involved, will be issued to all participants; *Participant Informed Consent Forms* to ensure that participants understand the nature of the study, their role within it and their right to withdraw without consequence at any time, will be issued to all participants; Issues and guidelines regarding Confidentiality, Anonymity and Data Storage will be addressed in the Participant Information Sheets and throughout the research process.				
Do you require Ethical Clearance from another source? **If yes, please specify below:**	**Yes**		**No**	**√**

The project will also investigate teachers' perspectives and experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy and numeracy skills. It will seek to evaluate the value teachers place on utilising Science lessons as an approach in developing literacy and numeracy skills in the classroom.

This study will unveil meaningful insights into the development and support of early literacy and numeracy competencies and behaviours in a more integrated manner across the curriculum.

2	**Proposed Start Date**	**Month**	March	Year	2016
	Anticipated Completion Date	**Month**	*August*	*Year*	*2016*

6	Project Design and Methodology
6a	**Rationale, Purpose and Benefits of Research Project**

The National strategy to improve literacy and numeracy among children and young people 2011-2020 states that we need to prioritise literacy and numeracy through positive interventions and integrating these skills across the curriculum (Department of Education and Skills 2011; Shiel 2002).

The practice and development of key scientific process skills contribute significantly to developing the child's language, communication and literacy skills and also their mathematical and numeracy skills. Internationally published literature details how Science can be successfully integrated with literacy to teach Science concepts (Barber *et al*. 2006; Burton and Campbell 1996; Heisey and Kucan 2010; Jackson *et al*. 2010; Poon 1990; Rule *et al*. 2004; Watts 2001).

Under this framework Irish Primary Schools are currently introducing best practice methodologies in literacy and numeracy teaching. Continuous Professional Development (CPD) courses are being rolled out all over the country by the PDST to facilitate this new national strategy. However, there have been no specific models and CPD courses designed and implemented showing teachers how literacy and numeracy skills can be effectively developed in the Primary Science Classroom, which is a wasted opportunity. No such framework has been published to date in relation to the curricular area of Science.

This project therefore is needed to investigate teachers' perspectives and experiences of, opinions on and attitudes towards the use of Science lessons to enhance children's literacy and numeracy skills to inform the design and development of future frameworks, guidelines and CPD courses for the integration and effective development of literacy and numeracy skills in Science lessons.

References

Barber, J., Nagy Catz, K. & Arya, D. (2006). Improving Science Content Acquisition through a Combined Science/Literacy Approach: A Quasi-Experimental Study. Berkley California: University of California.

Burton, Stephanie K. & Campbell, Phyllis. (1996). Science Times with Nursery Rhymes, Colorado: Panda Bear Publications.

Department of Education and Skills (DES), (2011). Literacy and Numeracy For Learning and Life The National Strategy to Improve Literacy and Numeracy among Children and Young People 2011 – 2020. Dublin: Stationary Office.

Heisey, N. & Kucan, L. (2010). Introducing Science Concepts to Primary Students Through Read – Alouds: Interactions and Multiple Texts Make the Difference. *The Reading Teacher*, 63 (8), 666-676.

Jackson, J. Dickinson, G. & Horton, D. (2010). Rocks and Rhymes!. *The Science Teacher,* January 2010, 27-31.

Poon, Kum Heng. (1990). Integrating poetry in Science teaching. *Teaching and Learning*, 10(2), 61-66.

Rule, Audrey C. Carnicelli, Luke A. & Kane, Sharon S. (2004). Using Poetry to Teach about Minerals in Earth Science Class. *Journal of GeoScience Education*, 52(1), 10-14.

Shiel, G. (2002). The performance of Irish students in reading literacy in the Programme for International Student Assessment (PISA). *Irish Journal of Education, 33*, 7-30.

Watts, M. (2001). Science and poetry: passion v prescription in school Science?. *International Journal of Science Education*, 23 (2), 197-208.

6b(i)	Research / Data Collection Techniques

Phase 1:

A nationwide survey will be carried out to gather both quantitative and qualitative data, investigating literacy and numeracy strategies and approaches used by teachers during Science lessons and their perspectives and experiences of the use of Science lessons to enhance children's literacy and numeracy skills.
Data from a large population will support statistical inferences adding to the validity of the results.
The findings of the questionnaires in Phase 1 will then be used to further inform semi-structured interviews. In order to make the implementation of a nationwide questionnaire feasible, it will be distributed online through survey monkey. However, the researcher considers the possible lack of internet access and for this reason, questionnaires may also be distributed by post or in person.

Phase 2:

Semi-structured interviews will be conducted to explore in further detail teachers' opinions on and attitudes towards the use of Science lessons to enhance children's literacy and numeracy skills.

Phase 1 & 2:

The Researcher will keep a reflective log through the data collection process.

6b(ii) Research Methodology

This study will be carried out using mixed methods of research. This involves combining both qualitative (Semi-structured interviews and researcher reflective journal) and quantitative (questionnaires) methods in the study (Punch 2009; Creswell 2009, 2014).
An Explanatory Sequential Design will be utilised, where by questionnaires will be distributed nationally followed by interviewing willing participants (Creswell 2014):
1. Collect and analyse quantitative and qualitative data in the first phase through questionnaires.
2. Examine and analyse the results by quantitative analysis (SPSS) and qualitative analysis (Coding answers into themes) to determine:
(a) what results will need further exploration in the second, qualitative phase (interviews)
(b) what questions to ask participants in this qualitative phase order to generate rich, meaningful data about teachers' experiences. .
3. Conduct qualitative data collection and analysis (NVivo) in the second phase by semi structured interviews to help explain the quantitative results.
4. Drawing inferences about how the qualitative results help to explain the quantitative results.

A Research Diary will be maintained throughout to document thinking points for the researcher.
Data from the questionnaires, interviews and reflective logs will be triangulated to ensure validity and reliability (Creswell 2014, p.201).

References

Creswell, John W. (2009). Research design: qualitative, quantitative and mixed methods approaches. 3. ed. Thousand Oaks, Calif.: Sage

Creswell, J.W. (2014) *Research Design: Qualitative, Quantitative and Mixed Methods Approaches,* 4th ed., London: Sage Publications.

Punch, Keith. (2009). Introduction to research methods in education. Los Angeles: Sage

6c Steps taken to Minimise Risk

Participants will contact the researcher if they are willing to get involved in the study.

The researcher will then send them out an information sheet and consent form to the participant via email with a link to the Survey Monkey. If the participants fill in the survey electronically there will be a consent form on the survey monkey along with a consent button to press if they agree to the terms of the research.

The participants that would prefer a postal questionnaire will be sent a SAE to return the consent form and completed questionnaire to the researcher.

The data collected will be kept on an encrypted key, stored in a locked filing cabinet in the home of the researcher.

The data will be accessible to the researcher and the supervisor Dr. Maeve Liston, from the Faculty of Education at Mary Immaculate College, Limerick.

Data collected will be stored for the duration of the study plus an additional three years in compliance with Mary Immaculate College retention schedule.

Should an individual participant / individual participants request a copy of their interview transcript, a copy of their individual transcript will be provided to them alone, upon request.

6d Location(s) of Project

Nationally, Ireland.

6e Questionnaires and Interview/Survey Questions

The questionnaire questions will be a mix of closed and open-ended questions gathering qualitative and quantitative data (Pleases see appendix).

The semi structured interviews will comprise of open questions which will not be biased, or will not try to influence the participants' answers in anyway. These questions will be based on what themes emerge from the questionnaire analysis.

7 Participants

7a How will potential research participants be identified and selected?

An advertisement will be placed on websites, social media pages and mailing lists of national educational institutions, organisations and associations to assist the recruitment of research subjects e.g. INTO, Education Centres around the country. Teachers will be invited to participate in the study investigating literacy and numeracy strategies and approaches used by primary level teachers during Science lessons. They will be invited to indicate their willingness to participate by e-mailing a given address. They will be asked to include contact details (mobile phone number and/or school postal address) for verification.

Interviewees will be recruited from the questionnaire respondents. At the end of the questionnaire, respondents will be provided with a link to a plain language statement regarding the interviews and invited to contact a given e-mail address with their contact details if they are interested in participating further. If they have completed a hard copy they will indicate their interest in entire by emailing the researcher or if they have filled out the survey monkey will include a button and page to fill in their interest in being interviewed.

7b	*To be completed in cases where the applicant intends to recruit students that they teach as research participants.*				
	Does the proposed research necessitate the participation of your current student cohort?	**Yes**		**No**	
	If you have indicated that the proposed research necessitates the participation of students that you teach please provide:				
	A rationale as to why it is necessary that students that you teach participate in the research.				
	Details of the steps you will take to ensure that participation is voluntary and that participants may withdraw at any time without consequence or fear of consequence.				

7c How many participants will be recruited?

Questionnaires will be distributed on a nation-wide basis.

7d	**Will participants be reimbursed for taking part in this research project? If YES, please attach the details to this application.**	**Yes**		**No**	**√**
7e	**Will incentives / inducements be provided to participants for taking part in this research project? If YES, please attach the details to this application.**	**Yes**		**No**	**√**
7f	**Will Recruitment Letters/Advertisements/e-mails, etc. be used to recruit participants? If YES, please attach the details to this application.**	**Yes**	**√**	**No**	
7g	**Will a permission form be used to document permission to conduct the research within an institution? If YES, please attach the details to this application.**	**Yes**		**No**	**√**

8 Confidentiality of collected data and completed forms (e.g. informed consent)

8a What measures will be taken to ensure confidentiality of collected data?

Participants in the survey will not be identifiable. All interview participants will be given pseudonyms to protect their anonymity. The data itself will not contain any sensitive information and all questions relate to participants' professional views.
All contact details of the participants will be destroyed after the data collection process.

8b Where and how will the data be stored / retrieved?

Hard copies of questionnaires will be stored in a locked filing cabinet in the home of the researcher and electronic data will be stored on an encrypted USB key. The data will be kept for the duration of the study + 3 years after it's completion in adherence to the MIC Research Storage Retention Policy.

8c Who will have custody of, and access to, the data?

The Researcher will have sole custody of the data. If necessary, upon request – the supervisor will also have access to the data however the anonymity of participants will remain in the form of pseudonyms. The supervisor will not know the password to encrypted files.

8d For how long will the data from the research project be stored? *(Please justify)*

The data will be kept for the duration of the study + 3 years after it's completion in adherence to the MIC Research Storage Retention Policy.

9 Information Documents

Indicate which of the following information documents are applicable to your Research Project by ticking either Yes or No in the checklist below. Attach a copy of each applicable information document to the application.

	Applicable Please ✓	
Documents	***Yes***	***No***
Participant Information Sheet	**√**	
Parent/Responsible Other Information Sheet		**√**
Participant Informed Consent Form	**√**	
Parent/Responsible Other Informed Consent Form		**√**
Questionnaire (or sample)	**√**	

4 Supervisor(s)

To be completed in cases where the applicant is a research postgraduate student.
I hereby authorise the Principal Investigator named above to conduct this research project in accordance with the requirements of MIREC-6 and I have informed the Principal Investigator of their responsibility to adhere to the recommendations and guidelines in MIREC-6.

Name	**Department**	**Date**	**Signature**
Dr. Maeve Liston	Maeve.liston@mic.ul.ie 061 774726	05/01/16	

5 Study Descriptors

Please mark the terms that apply to this research project with a ✓

Healthy Adults	√	Vulnerable Adults	
Children (< 18 yrs)		Vulnerable Children (<18yrs)	
Physical Measurement		Psychological Measurement	
Video Recording/Photography		Voice recording	√
Questionnaire/Interview	√	Observational	
Physical Activity		Record Based	
Project is Off-Campus	√	'Other' descriptor(s) not named here	
Please specify 'Other' descriptor(s)			

10 Declaration

The information in this application form is accurate to the best of my knowledge and belief, and I take full responsibility for it. I undertake to abide by the ethical principles outlined in the MIC Research Ethics Committee guidelines. If the research project is approved, I undertake to adhere to the study protocol without unagreed deviation, and to comply with any conditions sent out in the letter sent by the MIC Research Ethics Committee notifying me of this. I undertake to inform the MIC Research Ethics Committee of any changes in the protocol. I accept without reservation that it is my responsibility to ensure the implementation of the guidance of MIREC as outlined in MIREC-6.

Name (Print) _____