Educational Innovation and Change in the Teaching and Learning of Science in the Contemporary Irish School and Classroom

Submitted by:
Sancha Anne Power

A thesis submitted in fulfilment of the requirements for Doctor of Philosophy

Supervised by: Dr. Geraldine Mooney Simmie

Submitted to the University of Limerick, May 2012
Abstract

EDUCATIONAL INNOVATION AND CHANGE IN THE TEACHING AND LEARNING OF SCIENCE IN THE CONTEMPORARY IRISH SCHOOL AND CLASSROOM.

This research study is focused primarily on educational innovation and change in the Irish lower secondary science classroom. The overall goal of the research was to encompass three domains through the development of a cultural context from a national perspective, followed on by an in-depth case study analysis in the mid-west region of Ireland. The thesis begins by offering a background to the research project, and outlining the rationale for its development. The study then aims to contextualise the setting of the research, by outlining the place of science and exploring the ideologies and organisation that underpin the system of education in Ireland.

The subsequent literature review explores three themes in the fight for innovation and change (curriculum, professional and pedagogical). The study offers an appraisal of the international and national literature surrounding curriculum change, professional change and pedagogical change. It examines the impact of school culture and explores the possibility of school-university partnerships for the professional development of teachers. The review of the research literature incorporates an exploratory analysis of the literature around science education and in-depth look at the promotion of scientific literacy and pedagogical content knowledge. All three themes at the end of each section are placed within the context of educational research in Ireland.

The study has developed a theoretical framework in the pursuit for innovation and change. This theoretical framework unites the knowledge literature and the practicalities of the research methodology. It provides a framework for developing, interpreting and analysing educational innovation and change in the contemporary Irish science classroom and school.

This study explores the impact of policy in Ireland from 1960 on lower secondary science teaching, developing themes around teaching and learning of science in Ireland. The methodology of content analysis is employed and what is missing is just as pertinent as to what is present. The emergent themes subsequently helped identify the literature for review and shape the development of further study. In the fight for change the study explores the view and attitudes of the teachers of lower secondary science on a national scale, at a time when new innovations were just being introduced. Finally the emerging framework is implemented in three case study schools in the mid-west of Ireland in order to investigate a new adaptable and flexible approach for innovation and change.

Findings from the research identify that teaching and learning in Ireland is centralised and bureaucratic, with minimal teacher voice present at policy level. Traditional pedagogies are still dominating the contemporary science classroom. Findings from the case study research show that there was some form of measured success from the implementation of the framework and that there is an authenticity in these concepts from the research literature.
Declaration

This is to declare that the work presented is an original study, carried out by the undersigned. It has not been submitted previously to this or any other third level institute for this or any other academic award. Where use has been made of the work of other people, it has been acknowledged and referenced

_______________________________________
SANCHA POWER, 2012
The implication is clear.

The rhetoric for change at junior cycle has emerged from research evidence, public and political consensus, and professional concern.
Dedication

I dedicate this dissertation to the memory of all those who have gone too early.

A special mention to those who have helped and supported me to get me where I am today:

Séan Aherne – Principal St. Declan’s Community College
- for setting me off on the right road and giving me the encouragement to keep going

David Power
- for the never-ending love and encouragement but most importantly for being my
  Mick Dundee x

Nora Power and Edmund Whelan
- for standing beside me every step of the way and answering all my prayers

“Go raibh an ghaoth go brách ag do chúl agus teás na gréine ar d’aghaidh”

Ar dheis Dé go raibh nanamnacha
Acknowledgements

This thesis would still be a work in progress were it not for the help and support of so many people. While I cannot thank each and everyone individually, I would like to mention a special few:

Firstly, I would like to thank my supervisor, Dr. Geraldine Mooney Simmie, who has helped and supported me through this journey. Thank you for your guidance, support and wisdom.

Thank you to all the schools, principals and teachers who took the time to partake in my research: and shared their experiences and wisdom.

Sincerest thanks to all my colleagues in EPS and in the Access Office. Special mention to my one and only Limerick mammy Maureen in EPS, thanks for listening to all the rants, and providing all the laughter, support and cdc! Special mention also to Dónal whose west Corkionan humour always managed to keep me upbeat and positive that I’d see the end. Thanks all to my past and present HODs: Tom, Roland and Patrick.

A special mention to Lisa, Joanne and Orla for best induction into the PG life; thank you for sharing all your experiences, your wisdom, your holidays and your weddings! But most importantly thank you for all your support both inside and outside the flag poles of UL.

Special thanks to my internal examiner and mentor Dr. Peter E. Childs.

I’m forever indebted to Sarah for all the late nights - tea, ginger nuts and red biros. I’d never have completed this without your unwavering support and encouragement in me so thank you. Least not forget the comic and IT support DJ, Damien, Eoin and John – thank you!

A special mention to the 2006 college crew; Lisa, Catríona, Carol and Jennifer for your patience and understanding, I’m ever indebted for your friendship and of course the Limerick Crew Laoise, Fiona, Judie, Karen, Diane and Rhonwen.

To Lisa and Brendan, for the best viva preparation anyone could possibly have imagined... and of course those fabulous red velvets, such inspiration for answering!

A big thank you to Ciara, who has been right beside me from day one.

To my entire family, from Kilmacthomas to Old Parish and from London to Perth

A big thank you to Nigel – who has come through this journey every day with me: the ups, the downs, the deadlines, the never ending IT problems...thank you for making me laugh through it all and thank you for believing in me.

And finally to my Mum and Dad...I’m forever indebted to the support, encouragement and belief that you have had in me over this journey and indeed throughout my entire life. Sitting somewhat in the background you have been my rocks these past years I am so grateful. I would never have achieved this without either of you x
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<td>ALM</td>
<td>Active Learning Methodology</td>
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<tr>
<td>ASE</td>
<td>Association for Science Education</td>
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<td>ASTI</td>
<td>Association of Secondary Teachers Ireland</td>
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<tr>
<td>CDC</td>
<td>Curriculum Development Centre, (Dublin)</td>
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<tr>
<td>CDU</td>
<td>Curriculum Development Unit (Shannon)</td>
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<tr>
<td>CDVEC</td>
<td>City of Dublin, Vocational Education Committee</td>
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<tr>
<td>CEB</td>
<td>Curriculum and Examinations Board</td>
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<tr>
<td>CLISP</td>
<td>Children’s Learning in Science Project</td>
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<tr>
<td>CPD</td>
<td>Continuous Professional Development</td>
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<tr>
<td>DES</td>
<td>Department of Education and Skills</td>
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<td>EPS</td>
<td>Department of Education and Professional Studies</td>
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<tr>
<td>ERC</td>
<td>Educational Research Centre</td>
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<td>ESRI</td>
<td>Economic and Social Research Institute</td>
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<td>GIMMS</td>
<td>Gender, Innovation and Mentoring in Mathematics &amp; Science</td>
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<td>HEA</td>
<td>Higher Education Authority</td>
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<td>IBEC</td>
<td>Irish Business and Employers’ Confederation</td>
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<td>IBSE</td>
<td>Inquiry Based Science Education</td>
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<td>ICDU</td>
<td>In-Career Development Unit</td>
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<td>ICE Report</td>
<td>Intermediate Certificate Examination Report</td>
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<td>ICSTI</td>
<td>Irish Council for Science, Technology and Innovation</td>
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<td>I &amp; I</td>
<td>Innovation and Identity Report 2010 (Ideas for Junior Cycle)</td>
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<td>ISTA</td>
<td>Irish Science Teachers Association</td>
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<td>LCA</td>
<td>Leaving Certificate Applied</td>
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<td>LCVP</td>
<td>Leaving Certificate Vocational Programme</td>
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<td>NCCA</td>
<td>National Council for Curriculum and Assessment</td>
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<td>NEC</td>
<td>National Education Convention</td>
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<td>NUI Maynooth</td>
<td>National University of Ireland, Maynooth</td>
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<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>PCK</td>
<td>Pedagogical Content Knowledge</td>
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<td>PISA</td>
<td>Programme for International Student Assessment</td>
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<td>PK</td>
<td>Pedagogical Knowledge</td>
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<td>PLC</td>
<td>Post Leaving Certificate Course</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>REB</td>
<td>Regional Education Board</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<td>SEC</td>
<td>State Examinations Commission</td>
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<td>SESE</td>
<td>Social, Environmental and Scientific Education</td>
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<td>SMK</td>
<td>Subject Matter Knowledge</td>
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<td>SUPs</td>
<td>School-University Partnerships</td>
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<td>SUPER</td>
<td>School-University Partnership for Educational Research</td>
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<td>TALIS</td>
<td>Teaching and Learning International Survey</td>
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<td>TES</td>
<td>Teacher Education Section</td>
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<td>TUI</td>
<td>Teachers Union of Ireland</td>
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<td>TY</td>
<td>Transition Year</td>
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<td>UL</td>
<td>University of Limerick</td>
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<td>VEC</td>
<td>Vocational Education Committee</td>
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## Glossary of Key Terms

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<tr>
<th>Term</th>
<th>Meaning</th>
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<tr>
<td><strong>Change</strong></td>
<td>&quot;change&quot; within the project is not defined by a specific amount or by a level of achievement but rather as any modification or adjustment to current practice that brings about an increase in pupil understanding and teacher professionalism</td>
</tr>
<tr>
<td><strong>Curriculum Change</strong></td>
<td>The manner in which curriculum change is developed within the thesis is reflected from the definition applied to curriculum “curriculum as a selection from the culture”</td>
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<tr>
<td><strong>Democracy</strong></td>
<td>The representation of democracy within the project follows closely the work of Giroux (1988). Where democracy is viewed as a site for struggle, informed by competing concepts of power, politics and community. The role of the citizen (teacher) is as an active agent who questions, and explores to define and shape the wider society (classroom and society). Democracy is seen as an active social movement, where active citizenship would see an extension in the rights of participation in larger matters, e.g. curriculum development, teacher professional development.</td>
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<tr>
<td><strong>Eclectic</strong></td>
<td>Developed from “eclecticism”. A conceptual approach where there is no rigid hold to one specific method or paradigm. In this project “eclectic pedagogy” is meant to identify the authors belief that there is no one philosophy of learning to hold the teaching and learning of science rigidly too, for example constructivism. Instead the author believes that there should be an eclectic mix of philosophies of learning science combining perhaps aspects of constructivism, traditional and perhaps social-constructivism.</td>
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<tr>
<td><strong>Innovation</strong></td>
<td>The manner in which innovative and innovation is used within this research project is to push boundaries and explore something new. It does not have to be something extravagant or expensive, once it is new to teacher practice or pupil learning it is deemed to be innovative.</td>
</tr>
<tr>
<td><strong>Lower Secondary Education</strong></td>
<td>Also referred to in policy documents as “junior cycle” or “junior certificate” Lower secondary education in Ireland, is the first stage of post-primary education for pupils aged 12-15. There are two programmes within lower secondary education a) Junior Certificate and b) Junior Certificate Schools Programme (JCSP). Both programmes comprise of a three years programme and complete with a national state examination called the “Junior Certificate Examination”.</td>
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<tr>
<td><strong>Mid-West of Ireland</strong></td>
<td>Describes a region in Ireland that encompasses counties Limerick, Clare, Tipperary North</td>
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<td><strong>Partnership</strong></td>
<td>Joint venture between two bodies who share ideas for the betterment of the common good</td>
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<tr>
<td><strong>Pedagogy</strong></td>
<td>The term pedagogy encompasses teaching, learning and assessment.</td>
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<tr>
<td><strong>Pupil</strong></td>
<td>Describes a child aged between 12-18 that attends secondary education in Ireland</td>
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1.0 Introduction
1.0 Background and Rationale to the Project

1.0.1 Background

The last decade has witnessed an enhanced campaign towards the professionalisation of teachers in Ireland (Teaching Council Act 2001, The Teaching Council 2007, 2011). Ireland has a strong tradition of valuing education, with teaching held in high esteem (Drudy 2001, OECD 2005). For generations the local teacher was the backbone of many communities, and still today teaching remains as a very attractive career choice and is competitive for new college entrants (CAO 2012). However, this the concept of teacher as professional is being undermined and discouraged by the centralised top-down approach which in essence disconnects the teacher from matters pertaining to policy formation and curriculum development. As Levin (1998) identified, the educational landscapes of the last 25 years have witnessed a worldwide epidemic of centrally initiated innovation. The result of this central control has been felt strongly by schools and teachers. Teachers are professionally marginalised, buried under mounting paperwork and tied by bureaucracy (Wallace and Priestley 2011).

In the midst of the pressures to achieve the espoused goals of the curricular changes and professional marginalisation, the classroom has remained somewhat unchanged. Sarason (1990) documents how many of the initiatives for change in the classroom have a common theme of persistent failure. Cuban (1988) suggests that many change programmes are largely failing because they do not introduce what he calls “second order changes”. Second order changes include the fundamental structures such as curricula for subjects, examinations and teacher delivery of content along with the social practices of the school or classroom (Wallace and Priestley 2011). This project aims to explore the literature around curriculum change, professional development and pedagogical change in order to make change successful, to embrace these so called “second order changes”.
1.2 Rationale for the Study

The research project was influenced from a variety of forums and arenas. The main variable for consideration was the decline in the uptake of science at upper secondary and tertiary levels of education in Ireland. National and international literature had identified the problems associated with this decline on both an economic and societal level (HEA 2002, Kaiser 2005, Department of Enterprise Trade and Employment Ireland 2006, OECD 2006, Smyth and Hannan 2006, European Commission 2007, OECD 2007, Department of Education and Skills 2011, Stolk et al. 2011). Smyth and Hannan (2002) noted that the kind of subjects taken at junior cycle level, along with the attitudes and occupational aspirations of students at age fourteen, were highly predicative of subsequent educational choices and careers (2002, pg: xvi).

It was evident on a national level that many of the interventions that were put in place were focused on change at a curricular content level, rather than at a pedagogical level (Department of Education and Science 2003, NCCA 2007). The main intervention that has taken place in lower secondary science education in Ireland was the introduction of the revised syllabus in 2003 (Department of Education and Science 2003). This new syllabus brought a new wave of mandatory practical coursework into the lower secondary classroom that had not been there prior to this. While the new syllabus outlined a heavy focus on inquiry-based learning, research has shown that this has frequently failed to reach the classroom (Higgins 2009). Research on curriculum change has demonstrated that for change to be successful and lasting change must occur across a multitude of levels, integrating beliefs and values, content and practice (Fullan 1991, Dalin 1993, Prosser 1999b, Stoll 1999, Goodson 2001). Research has also shown that student engagement improves when curriculum deals with contemporary issues, and when teaching styles are less didactic and student choice is allowed, and where a conscious effort was made to make science less difficult (Driver 1983, Lyons 2006, Osborne 2007, Hampden-Thompson and Bennett 2011, Stolk et al. 2011). Research has also shown that there is a need for more engagement than just “recipe style” practical work. Mandatory practical work is not enough, where students have a more hands-on and minds-on approach to science in the classroom greater levels of enjoyment and motivation were achieved (Bennett 2003, Kaiser 2005, Gilbert et al. 2011, Hampden-Thompson and Bennett 2011pg: 16).
One of the main aspects the researcher wished to explore was the notion of how the curricular change was implemented in Ireland. The top-down centralised approach to curriculum was in stark contrast to the new teaching and learning methodologies being portrayed in the policy documents surrounding the new science syllabi. One of the aspects this project wished to explore was a move towards professional partnership: the integration of policy maker, teacher and university teacher educator / researcher in the development of curricular and pedagogical approaches.

1.3 Strategy of Inquiry

This section sets out the overall aim of the research followed by the research questions that have driven the inquiry. This section also explores the paradigms of research and outlines the approach taken within the project.

1.3.1 Aim of Research

The aim of this research project is to empower teachers professionally to develop curriculum ownership and pedagogical innovation in the teaching and learning of science in the contemporary Irish school and classroom.

1.3.2 Research Questions

- To explore the impact of policy on the teaching and learning of science through content analysis of International and Irish Government documents from the 1960s
- To investigate the attitudes and beliefs of lower secondary science teachers in Ireland to curriculum development, teaching and learning methodologies and assessment
- To examine the role of a school-university partnership as a means for implementing curricular change and developing teachers as professionals in the Mid-West of Ireland
1.4 Description of the project

The purpose of this study was to research and develop a new way of initiating educational innovation and change in lower secondary education in Ireland. The investigation considers the role of policy and the attitudes and beliefs of practising lower secondary science teachers on a national level. More specifically, it examines the role of school-university partnerships as a method for approaching innovation and change around curriculum, professionalism and pedagogy in the mid-west region of Ireland.

The study sought to develop a framework that could be employed in the fight for innovation and change in the school and classroom, while considering the importance of:

- The influence of policy
- The opinion of the teacher
- The need for democratic levels of communication and dialogue, and
- An appreciation of cultural context

The study examines a collection of policy documents to ascertain a cultural understanding around innovation and change thus far. From here it explores and examines the views and attitudes of teachers of lower secondary science on a national level towards curriculum development and pedagogical matters. Finally the project sought to examine the literature and cultural context to develop a theoretical framework for innovation and change through multiple case studies carried out in the mid-west of Ireland. The research project was not going to repeat history by initiating top-down change, nor was it focusing on changing just content but instead the project aimed to innovate and empower teachers around their practice, their profession and their pedagogy.
1.5 Methodological Approach

The methodological approach taken within the research project was that of mixed methods, with the two paradigms being viewed as complementary, each phase of data collection offering more valid and reliable knowledge (Burrell and Morgan 2005, pg: 25, Parahoo 2006, pg: 89). The mixed methods approach offers the project a different way of viewing society and therefore a more in-depth perspective. The rationale behind the three stages of the research design was to scaffold the research and findings from one phase to the next. The third and final phase was informed from both phase one and two. This allowed a more robust understanding of the current situation before engagement with teachers and schools.

1.5.1 Validity and Reliability

1.6 Significance of the study

Within this section of the chapter the author will outline the importance and originality of the research study. The research contributes to both the field of education and science education in a number of manners. The research offers a critical interpretation of national policy documents from 1960 through a subject-specific lens surrounding the teaching and learning of science at lower secondary level. It provides a synthesis of what policy is saying, and more importantly not saying, in relation to the teaching and learning of science on a national level. This is then further enhanced by a national survey which provides a snapshot of lower secondary science teacher’s attitudes and beliefs towards curriculum and pedagogy. The amalgam of these contributions culminates in an adaptable and flexible framework for change and innovation in the contemporary school and classroom in Ireland (see Figure 1.1).

![Innovative Approach for the Contemporary Irish Classroom](image)

**Figure 1.1 Theoretical Framework for Innovation and Change in the Contemporary Irish Classroom**

This framework is both original in its development and approach. It will contribute to the knowledge of both education and science education on a national and international level. The originality of the research project is this emerging framework and the
overarching awareness of the impact of culture and the inclusion of teacher voice in a
democratic partnership. Findings from the research show that there was some form of
measured success from the implementation of the framework and that there is an
authenticity in these concepts from the research literature.

1.7 GIMMS – A European Comenius 2.1 Research Project

This research project has been part funded by a European Comenius 2.1 research and
development project called Gender, Innovation and Mentoring in Mathematics and
Science (GIMMS). The GIMMS Project was a research and development project across
six European countries (Ireland, German, Denmark, Spain, Czech Republic, and
Austria). Within each participating country, the project was co-ordinated from a
university, with overall co-ordination directed from the University of Limerick (see
Appendix A, for full list of participating universities). This section will offer a brief
summary of the aims and objectives of GIMMS.

The co-ordinators of the GIMMS project considered that innovation, mentoring
and gender were all inextricably linked. Developed across six European countries the
GIMMS project consisted of seven small case studies “developmental interventions in
each country with a cross-nationally agreed framework” (Mooney Simmie and Lang
2012, pg: 11). Six of these were developmental case studies that took place in schools
while one was an analytical case study that was undertaken in the IPN, Leibnitz
Institute, University of Kiel.

The GIMMS project – Gender, Innovation and Mentoring in Mathematics and
Science - sought to develop new ways of teaching science in four case study schools in
Ireland. Traditionally these projects are researched, developed and disseminated by
policy makers and curriculum experts (Stolk et al. 2009, pg: 166). However, the
GIMMS research project was innovative in that it was teachers and schools who were
expected to implement the new curriculum methods, designing and adapting new
teaching materials to fit their classroom needs. The university researchers were there to
help support, mentor and challenge, in a partnership of “distributed leadership”. The
outcome of the GIMMS project was the development of some innovative ways of
teaching science at junior cycle that were both teacher and pupil friendly. One of the benefits of the project was the assistance offered to teachers in their personal and professional growth and development. The project also assisted in the development of networking between schools and teachers in the mid-west of Ireland where the project was developed.

1.8 Place of the Researcher

Due to the interpretative nature of the study the author felt it was pertinent to outline her background. The background of the author is significant as it brings its own beliefs and values to the research (see Appendix K). For secondary education the author attended a vocational secondary school, where lower secondary science was compulsory for all pupils. Having completed her Leaving Certificate in Waterford, the author took a position on the BSc in Biological Science with Physics at the University of Limerick. This position brought further influences to the study as part of the programme was the study of curriculum and the teacher as a professional. While completing the undergraduate course, two teaching practices placements were undertaken one at a voluntary secondary school and another at a community college. Each placement brought its own influences in relation to cultural context and impact on the teaching and learning of science at lower secondary. Since the beginning of the research study the author has been an active member of the Department of Education and Professional Studies (EPS), participating in the teaching of pre service teachers in both science and other disciplines. While undertaking in postgraduate study the author has been fortunate to work as a research assistant on two separate European projects. These projects have allowed the author to explore and experience science education at a European level. Currently the author works for the Access Office in Student Academic Administration at the University of Limerick, which offers a further insight to education from an alternative education setting.
1.9 Structure of Thesis

The research project is presented across seven chapters (see Table 1.1).

*Chapter One* provides an introduction to the research project. It includes a brief description of and background to the project, and seeks to outline the research projects contribution to knowledge. This section also describes the strategy for inquiry and methodological approach, the place of the researcher is also explored.

*Chapter Two* aims to set the context for the research project. The chapter explores the contextual factors of the research project. The first section seeks to offer a portrayal of the Irish education system, by examining the values and ideologies that shape the system of education in Ireland. The structure of the education system and the place of science in the Irish context are also explored.

*Chapter Three*, is the literature review and is separated into three sections relevant to the research project

- Curriculum change
- Professional Change
- Pedagogical Change

In each section the author explores the national and international literature relevant to each area, and offers a contextual example from Ireland. The curriculum change section sets out to define what is curriculum, the different process of curriculum change, and the impact of school culture. The section on professional change explores what is meant by teacher professionalism, tools for promoting professional change and finally the role of establishing partnerships for the professional development of teachers. The concluding piece is around pedagogical change and this section specifically explores the trends in science education at the start of the twenty-first century. The chapter concludes with a summary which brings these three areas together for the betterment of educational change and innovation in the science classroom.

*Chapter Four* identifies the unique theoretical framework that was developed from the research literature. This framework will be used within the research as a tool for change and innovation. Within this chapter the author explores how the three areas of
curriculum, professional and pedagogical change all need to be interlinked in the fight for innovation and change. The framework was developed independently drawing on main aspects from key frameworks within the literature.

Chapter Five is the research methodology. This chapter returns to the research questions and outlines the methodologies used within the research project. The chapter is presented in three sections, each representing a phase of data collection. Each phase of data collection explores the research design, research instruments and approach for analysis implemented. Within each section the concepts of validity and reliability and ethical considerations are outlined.

Chapter Six presents the research findings under the framework of the research questions. The research findings are presented individually representing each phase of data collection carried out. Within this chapter the content analysis of policy documents is outlined along with the findings from the national survey carried out with lower secondary science teachers. The final phase of results explores the case studies in relation to the emerging framework.

Chapter Seven seeks to analyse the findings through discussion relating to the published literature. This chapter also outlines the recommendations and conclusions for the study.
| Chapter 1       | Chapter 2               | Chapter 3                   | Chapter 4                              | Chapter 5                        | Chapter 6               | Chapter 7        | Chapter 8      |
|-----------------|-------------------------|-----------------------------|----------------------------------------|----------------------------------|-------------------------|------------------|----------------|----------------|
| **Introduction**| Setting the Context     | Literature Review           | Emerging Theoretical Framework (TF)   | Research Methodology             | Research Findings      | Discussion       | Conclusion     |
| **Background**  | Values that Shape       | Rationale                  | Review of Inquiry                      | Link to Literature               | Findings Phase One     | Addressing       | Recommendation |
| **Rationale**   | Organisation of the system | Curriculum Change           | Development of a TF                   | Strategy of Inquiry              | Phase Two              | Addressing       | Conclusions    |
| **Strategy of Inquiry** | Place of Science | School Culture              | Summary of TF used                     | Approach to the study            | Findings Phase Two     | Addressing       | Directions for Future Work |
| **Project Description** | Place of GIMMS | Professional Change | TF for Contemporary Irish Classroom | Phase One Content Analysis       | Phase Three Demographic |                  |                |
| **Significance of study** | School-University Partnership |                         | Phase Two National Survey             | Findings Phase three             |                         |                  |                |
| **GIMMS**       | Pedagogical Change      | Phase Three Case study research | Summary                              |                                  |                         |                  |                |
| **Place of the Researcher** | Pedagogical Trends |                          | Limitations                           |                                  |                         |                  |                |
2.0 Setting the Context
2.0.1 Introduction

This chapter sets out to create a cultural context for the reader. It explores the “balancing act” that is teaching in contemporary Ireland. This chapter will develop on from the rationale and aims to put the study into context.

Being a science teacher in Ireland can be portrayed or illustrated as a balancing act. On the one side is the heavy burden of the top-down structure and organisation of the system, while on the other is the need for autonomy, collegiality and professional development. The chapter explores the values that underpin the education system, and have shaped the system that exists today. The impact of policy and assessment on teaching and learning in Ireland has been and still is very influential in the Irish classroom (Trant 2007, Gleeson 2009). This chapter seeks to portray how the organisation and politics of the Irish education system dominate what happens in the schools and classrooms. Teaching becomes a balancing act, with the teacher caught in the middle striving for professional recognition on the one hand and bound by the centralised system on the other. The chapter also explores recent proposes by the National Council for Curriculum and Assessment (NCCA) surrounding change at lower secondary education in Ireland and the issues raised by this document Innovation and Identify: Ideas for a new Junior Cycle (NCCA 2010).

**Figure 2.1 Being a science teacher: an Irish context**
In summary the author wishes to use this chapter to outline how the structure and organisation of the Irish education system leads to a complex classroom, where matters are dictated from the outside. The chapter also aims to put the research project in context in relation to the larger E.U. Comenius 2.1 GIMMS project from which this research was funded.

2.1 The Values that shape the Education System of Ireland

2.1.1 Ideologies that underpin the shape and structure of Education in Ireland

The structure of education in Ireland has been dominated by the ideologies and values that shape society and underpin its teachings. An ideology, while often taken as pejorative, can be objectively defined as “a system of values held by social groups, which helps bind those groups together and further their own interests” (Trant 2007, pg: 14). Skilbeck and Harris (1976) distinguished three great ideologies or value traditions in the history of western education: these include

- Classical Humanism
- The Progressive Movement
- Reconstructivism.

All three ideologies have impacted the Irish system; however, classical humanism and reconstructivism have had most influence. The researcher will offer a brief synopsis of how each of these ideologies has impacted on the structure of the Irish education system.

Classical Humanist ideology brings values of elitism, cultural heritage and a knowledge-based curriculum (Trant 2007, pg: 15, 16). The roots of Classical Humanism lie in pre-industrial society and have remained dominant from classical times (Carr 1998). It has been the dominant ideology within Irish education stemming from its relationship to the Roman Catholic Church (OECD 1991, Trant 2007, pg:32, Gleeson 2009). The ideology places an emphasis on clear and rigid discipline, high achievement, with a regard for myths and rituals (Callan 1995, pg: 93, Carr 1998, Trant
The influence of the ideology in today’s classrooms includes a heavy dependence on the textbook and a strong emphasis towards rote learning and traditional methods for the acquirement of knowledge (OECD 1991, Shiel et al. 2009). Central control over curriculum and a burden on teachers to “cover the course” are all elements of the Classical Humanist ideology witnessed in Irish system today. Possibly the most over-arching influence has been the strong concentration on cognitive knowledge, observed and reinforced by the elitist entry system to third level, which rewards high levels of attainment of cognitive knowledge (OECD 1991, Trant 2007, pg: 13, Gleeson 2009, pg: 123). In terms of subjects, science, in particular the physical sciences are viewed as elitist subjects in Irish society. This view is a throwback to the provision of the “hard” academic subjects of the Classical Humanistic, Catholic-run, conservative secondary schools, contrasting with the “soft” vocational subjects typically provided in vocational schools, with their more liberal and progressive influences.

The Progressive Movement was developed after Classical Humanism and is a response to all that Classical Humanism portrays. The most influential philosophers of this movement include John Dewey, Paulo Freire, Jean Jacques Rousseau and Mary Wollstonecraft. The movement is about liberation, freedom, enlightenment and equality. The purpose of education is the development of the person: developing the ability of the learner to think and learn for themselves, and to achieve their own personal best. The task of education is therefore to develop curiosity and facilitate learning, and to embrace the active engagement of the learner to “discover” knowledge. It is not for adults to impose subjects upon learners, nor is it for adults to “bank” or “deposit” knowledge into “empty vaults” (Rousseau 1972, Freire 2009). In his book Emile, Rousseau said that “tutor” was better suited than “teacher”, as it was “less a question of instruction than of guidance” (Rousseau 1972). The dominant voice is that of the learner and pupil. Rousseau also remarked that subjects should not be divided up for learning, as it was an unnatural way to learn. The ideology also strives for equality between genders and the different classes of society. The level to which the liberal progressive ideology impacts upon the Irish classroom is open to debate; it is often viewed more in the abstract than in practice.
The Classical Humanism ideology in Ireland remained the dominant ideology however market values and government strategies became prominent to the point where they eventually overshadowed everything else (Drudy and Lynch 1993, Trant 2007). The last twenty years saw a huge drive towards education for the economy; education is now seen as more of an economic investment. This approach for the betterment of the economy is referred to as the reconstructivist ideology / reconstructivism.

With the change from a rural and craft economy to an industrial and technologically complex one, improved scientific and technical education is seen increasingly as the key to national progress in dozens of areas (Atkin and Black 2003, pg: 2)

The reconstructivist ideology is more “socially orientated” and “views education a major force for improving and reconstructing society” (Trant 2007, pg: 25). Gleeson (2009) documents that Ireland’s involvement in the 1961 Washington-led conference, established the drive towards reconstructivism and human capital theory (2009, pg: 34). The onset of reconstructivism brought with it “a noticeable shift away from the humanities towards technical and scientific subjects” (Gleeson 2009, pg: 34). Methods of teaching are egalitarian in nature, with no hierarchy of subjects, as all “are equally important” (Trant 2007, pg: 26, 27). Nonetheless, Classical Humanism still remains the dominant classroom experience. Reconstructivism has been noticeable in recent years with the strong support and development to increase numbers taking science and mathematics (Department of Education Ireland 1995, Department of Education and Science Ireland 2002b, c). The existence of this ideology within the system is also witnessed by the presence of Irish Business and Employers Confederation (IBEC) and other members from industry on syllabus committees (NCCA 2011b). The negative aspect of this ideology is the concept of education as a financial return, thus allowing for the development and promotion of external measurement of product. It has brought the need to standardise and measure a teacher’s worth. In some countries the need for standardisation has also led to the publication of school league tables. This remains a contested issue in Ireland today (Gildea 2011, ASTI 2012).
2.1.2 A fragmented and contested system

The last thirty years have witnessed educational policy debates become a highly politicised issue in Ireland (O' Buchalla 1988, Drudy and Lynch 1993). Changes in education are not always created and developed by those interested in scholarship but by the power of dominant interest groups (Goodson 1983). Frequently the impact of these dominant interest groups is more powerful than educational research and practice. McCormack (2010) in her doctoral thesis identified how different interest groups impacted on the implementation of the Exploring Masculinities Programme. This section of the chapter aims to put into context the affect of some of these interest groups on the education system.

Secondary schools assist in the development of ideologies within society, and as a result “conflicts over knowledge and power relations within and outside” the system of education are not surprising or uncommon (Callan 1995, pg: 95). In the Irish education system there are several dominant interest groups, and the result of these is a system of education that is very disjointed and contested (Callan 1995, Trant 1998, Gleeson 2000, Trant 2007, Gleeson 2009). This has in turn led teachers and schools to be on the receiving end of a system continually seeking a means to an end (Leat et al. 2006, pg: 657). Even the OECD acknowledged how the Department of Education was held accountable to “non-governmental interest groups” such as the Church in their 1991 review of National Policies for Education, acknowledging that the task for curriculum development would require “better co-ordination of existing agencies” (1991, pg:38). The dominant interest groups within the Irish education system include: teacher unions, religious bodies, subject associations and parent’s associations, all of whom are fighting their own personal battles and protecting their interests.

The battle for power and control between the Catholic Church and Irish State has led to a very difficult position for the teacher, as it has isolated the teacher. The development of education was relinquished into the hands of the policymakers, who believed that teaching was relatively simple and straightforward (Hall 1995, pg:102). The role of the teacher was viewed as “hired man”, a mediator, negotiating between curriculum and its intended outcomes/objectives: “teachers were generally told what to do” (Sarason 1990, pg: 50, Clandinin and Connelly 1992, pg:367, Gleeson 2009). Teachers taught their subjects and controlled their classrooms but outside of that they
were overlooked especially in relation to curriculum matters (Sarason 1990, pg: 51, Clandinin and Connelly 1992, pg: 365). The non-involvement of the teacher in critical school planning and decision-making in Ireland has had an adverse affect especially in relation to curriculum innovation and professional development matters. The influence of the church on educational policy has maintained a “traditional, conservative” approach (Gleeson 2009, pg: 17).

However, it should be acknowledged that it is not just the relationship between Church and State that has developed this fragmented system. The introduction of social partnership in the 1980s seems to have only strengthened the fragmentation and contestation in Education. The formation of statutory bodies such as the National Council for Curriculum and Assessment (NCCA), the State Examinations Commission (SEC) and Teacher Education Section (TES), has also added to the lack of coherence and disjointedness.

### 2.2 Organisation of the Education System

#### 2.2.1 Background

The development of the education system in Ireland is rooted in the development of the nation as an emerging state (Department of Education 1965, pg: 5, Coolahan 1981, pg:52), Established in 1921 after the formation of the State, the education system is described as a state-aided system. The developmental history of the Irish state led to a high value being placed on the importance of education, with many interest groups contending with each other for their own dominant reasons. The church was one such player, which has demonstrated a very influential role on the context and history of Irish Education (O' Buchalla 1988, Breen et al. 1990, OECD 1991, Callan 1995, Trant 2007). At one stage, 88% of secondary schools were owned and controlled by Catholic orders (Breen et al. 1990, pg: 125). Up until the mid 1960s the State merely administered a managerial role within the system (Breen et al. 1990, pg: 123). The Department of Education and Skills (DES) does not operate schools, but instead assists other bodies to do so, mainly through financial means (Department of Education 1965, pg: 5).

The administration of the education system is operated by the Minster for Education and Skills, who is responsible for the identification and implementation of
“appropriate curricular and assessment reforms” (Department of Education 1965, pg: 5, Department of Education and Science Ireland 2004a, pg: 7, Halbert and MacPhail 2010, pg: 26). The NCCA advises the minister on curriculum and assessment, while the SEC designs, administers and marks the national examinations. This has in turn led to a centrally fragmented system. The literature has shown that a gap exists between the rhetoric and reality of the classroom as a result, especially when it concerns implementation of new changes and reform (OECD 1991, Gleeson 2009, Halbert and MacPhail 2010, pg: 25). This centrally reinforced, top-down approach to curriculum development can only seek to separate the reality from the rhetoric, the classroom from the policy. What is the role of the teacher? Where are his/her thoughts and ideas? Both teachers and policy makers have been identified as the stakeholders within a child’s education, but where is the democracy, where is the partnership, where is the sense of community?

2.2.2 Structure

Education is compulsory in Ireland from the ages of 6-16 (Department of Education and Science Ireland 2002a, pg: 5). Second level education consists of a three year junior cycle (lower secondary level), followed by a two or three year senior cycle (upper secondary) (Department of Education 1965, pg: 10, Department of Education and Science Ireland 2004a, pg: 13, Halbert and MacPhail 2010). Lower secondary level education is completed by pupils between the age of twelve and fifteen years (Department of Education and Science Ireland 2004a, NCCA 2006). The senior cycle can be two or three years in duration, depending on each school. Transition Year (TY) is an optional year available to senior cycle pupils, also called 4th year (Department of Education Ireland 1993, Department of Education and Science Ireland 2002b, Department of Education and Science Ireland 2004a, pg: 13). The option to proceed with the TY programme for senior cycle pupils is left for individual school management bodies to decide. TY provides pupils with an opportunity to experience a wide range of different aspects of education, including experience of industry and sports (Department of Education Ireland 1993, Department of Education and Science Ireland 2004a, pg: 132). A visual representation of the Irish education system is offered in Figure 2.2.
(Department of Education and Science Ireland 2004a)

**Figure 2.2** Graphic representation of the Irish Education System
Lower secondary level or “Junior Cycle”

Lower secondary level education is a three year programme on entry to secondary education and is formally assessed, largely on the basis of a written exam at the end by a state commissioned exam, referred to as the Junior Certificate Examination (Department of Education and Science Ireland 2004a, pg: 13, Smyth 2009, pg: 2). The principal objective of lower secondary level education is designed around completing a broad and balanced, relevant, coherent study in a variety of curricular areas (Department of Education and Science Ireland 2002b, Department of Education and Science 2003, Department of Education and Science Ireland 2004a, pg: 13) In reviewing the literature, references to the “Intermediate Certificate” or “Group Certificate” will be found. These names refer to lower secondary level education before the reforms of the 1980s. The Group Certificate was seen as a vocational counterpart to the Intermediate Certificate and ran in vocational schools only (Department of Education 1965, pg: 133). The Junior Certificate programme was introduced to replace the Intermediate Certificate in 1989. Within science, the new syllabus was created to cater for all abilities and levels of achievement; and it was to be offered at two levels, higher and ordinary. Former syllabi such as Science (Syllabus A including ISCIP), Science (Syllabus E) and Rural Science were all disbanded and instead replaced by one common syllabus (Department of Education 1989, pg:1, NCCA 1989, pg: 1).

Currently lower secondary level education is under a comprehensive review with the NCCA, Teacher Unions and the newly established government calling for change. These changes will be outlined further on in this chapter under the heading “Lower Secondary Education: Moving Forward”.

Upper Secondary or “Senior Cycle”

Senior cycle education caters for pupils aged between 15 and 18 (Department of Education and Science Ireland 2004a, pg: 13). The overall aim of the senior cycle programme is to encourage pupils to stay in full time education after secondary school (Department of Education and Science Ireland 2002b). There are two phases within upper secondary education in Ireland. The first phase of upper secondary is an optional year, called Transition Year (TY). The second phase is the last two years of the secondary system and is the examinable stage of upper secondary notably referred to as
fifth and sixth year. Transition year is often viewed as a “bridging year” between lower secondary and upper secondary education (Hayes 2011, pg: 2). Transition Year (TY) programme is an optional year so not all schools are obliged to offer this supplementary year, nor are pupils obliged to take part within this optional programme. The mission of TY is “promote the personal, social, educational and vocational development of pupils and to prepare them for their role as autonomous participative and responsible members of society” (Department of Education 1993, pg: 1). Phase two of upper secondary education in Ireland can be delivered through three different programmes

- Leaving Certificate Established,
- Leaving Certificate Vocational Programme (LCVP) and
- Leaving Certificate Applied (LCA).

While there are some significant differences in content and structure between these programmes, each programme leads to a form of the state commissioned Leaving Certificate Examination, (Department of Education and Science Ireland 2004a, pg: 13).

2.2.3 Lower Secondary Education: Moving Forward

In February 2010, the NCCA launched their Innovation and Identity: Ideas for a new Junior Cycle (NCCA 2010). This paper was not a set of proposals but rather a set of ideas outlined by the NCCA in facing the “dilemma” that is lower secondary education (NCCA 2010, pg:5). There has been for some time numerous points for concern within lower secondary education outlined both by the NCCA and by previous research namely the Economic and Social Research Institute (ESRI). These points for concern included:

- The dominating effect of the Junior Certificate examination on teaching and learning practice
- The dominating effect of the Junior Certificate examination on the strategies and structures of the school
- The perception of an inflexible overcrowded curriculum
- The disengagement of many students at an early stage in the cycle
- Inadequate time for engagement with deeper learning
The narrow range of assessment activity

The limited access to a single qualification

(NCCA 2010, pg: 13)

One of the main implications of the current system of lower secondary education outlined in the document based on previous research was the need to broaden the curriculum; they recommended a “wider perspective than the mere choice and range of subjects and their examination” (NCCA 2010, pg: 13).

The new programme to be developed for lower secondary education in Ireland is aimed at addressing the “problems of rote learning and curriculum overload while providing for greater creativity and innovation” (NCCA 2011c). It is envisaged that the new programme will offer school communities more flexibility and scope to address their customised curricular needs. It is envisaged that they will provide “learning opportunities for their student, which reflect more accurately their learning needs or local and community contexts” (NCCA 2010, pg: 22). The publication of the document by the NCCA openly recognises the need for schools and teachers to become key agents of change, acknowledging that real lasting change requires a change in pedagogy not just a change in content. The process of change outlined by the NCCA acknowledges that “change should be centred on the students, teachers, school leaders, school communities and other partners who will be the main agents of change” (NCCA 2010, pg: 16). There is an acknowledgement for the need for partnership, shared meaning and mutually beneficial goals. Four stages were developed by the NCCA for the incorporation of teachers and the development of a new lower secondary programme.

- The dilemmas of Lower Secondary education
- A process for developing Junior Cycle
- Schools working on their big ideas for Junior Cycle
- The Framework and models in all schools

(NCCA 2010)

The ideas outlined by the NCCA were formally approved by the Minister on the 4th November 2011, and offer quite a radical and innovative approach to teaching and learning in Ireland. Currently the new programme is at stage three, where schools are working in partnership with the NCCA “working on their big ideas for junior cycle”.

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To support schools in developing change and in order to outline some level of degree for change, the Innovation and Identity (I&I) Report identified five pathways for change and invited discussion on what change should happen at junior cycle, and how far it should go (NCCA 2010). The table below outlines the five pathways and gives a brief synopsis of each pathway (see Table 2.1). It should be acknowledged that the NCCA outline the amount of change is up for debate however as shown previously “our tradition in Ireland has been slow, steady, incremental change” (NCCA 2010, pg: 21)

Table 2.1 Innovation and Identity (2010) Pathways for Change

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Pathway Title</th>
<th>Brief synopsis of Pathway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathway 1</td>
<td>From curriculum conformity to schools having freedom to be different</td>
<td>Reduced levels of curriculum requirement Opportunity to develop curriculum elements Allow choice among schools for local needs</td>
</tr>
<tr>
<td>Pathway 2</td>
<td>From the junior Certificate to qualifications designed for all</td>
<td>Examination scaled back to ‘core’ modules Framework is developed to gain multiple qualifications from multiple sources, summative and formative</td>
</tr>
<tr>
<td>Pathway 3</td>
<td>From the three years in junior cycle to three years of junior cycle</td>
<td>Retain three year model Develop greater scope for experience perhaps as a one or two year part of three year model</td>
</tr>
<tr>
<td>Pathway 4</td>
<td>Towards a renewal of learning and teaching</td>
<td>Introduction of activity based learning in all aspects of curriculum Emphasis on student voice, co-operative learning</td>
</tr>
<tr>
<td>Pathway 5</td>
<td>From generating an examination grade towards generating evidence of learning</td>
<td>Using a greater variety of tools for generating evidence of learning Student reflections Balance between local and central tools</td>
</tr>
</tbody>
</table>

As part of the reforms the NCCA have carried out consultations with young people through the Office of the Minister for Health and Children (2011). They have also published a “Framework towards a new Junior Cycle” (NCCA 2011d). The “Framework for a new Junior Cycle” will bring together a set of key skills and provide a more flexible approach to learning. Schools will play a much bigger role than previous educational change programs; the new approach will allow schools to build their own lower secondary programme from the “framework” (NCCA 2011d, pg; 3). It is envisaged that the new programme will roll out through a phased introduction in 2014, with the first assessment in 2017. There is currently no information on any specific proposed changes to science under this new framework.

At the Easter 2011, Teacher Union conferences there was a call for change in response to last year’s OECD report, which was supported by the new Minister of
Education Ruairí Quinn (Flynn 2011, P. A 2011). Changes already proposed, include a decrease in the number of subjects for those sitting the Junior Certificate Examination to eight subjects from the ten – twelve currently taken (O’ Halloran 2011). As of the 3rd November 2011, Minister Ruairí Quinn approved plans for “radical changes in the way Junior Cycle pupils are taught and assessed in second level schools (NCCA 2011c). It is clear that since the inception of this research project, there has been national recognition that educational innovation and change is moving forward.
2.2.4 Types of Schools

Within the organisation of the secondary education system it is essential that there is an appreciation and understanding for the different types of schools within the system. Each school brings its own set of beliefs and values to a research project, and therefore their cultural context should be recognised. The secondary education sector comprises of three different school categories Secondary, Vocational, and Community and Comprehensive (Department of Education and Science Ireland 2002b). The syllabus provided to each school is the same; however each category would have certain subjects that would gain special emphasis. The table below offers a description and differentiation of each school type (see Table 2.2).

Table 2.2 Differentiation of School Types

<table>
<thead>
<tr>
<th>Types of School</th>
<th>Voluntary Secondary School</th>
<th>Vocational School</th>
<th>Community / Comprehensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of school sector</td>
<td>58%</td>
<td>32%</td>
<td>10 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8% Community</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2% Comprehensive</td>
</tr>
<tr>
<td>Denomination</td>
<td>Religious</td>
<td>Non denominational</td>
<td>Non denominational</td>
</tr>
<tr>
<td>Composition</td>
<td>Single Sex</td>
<td>Co-educational</td>
<td>Co-educational</td>
</tr>
<tr>
<td>Owned by</td>
<td>Catholic Church</td>
<td>Vocational Education Committees (VECs)</td>
<td>The State</td>
</tr>
<tr>
<td>Managed By</td>
<td>Board of Management</td>
<td>Local VEC Committee &amp; Board of Management</td>
<td>Board of Governors</td>
</tr>
<tr>
<td>Funding; school building</td>
<td>State and Church</td>
<td>State and local VEC</td>
<td>State or Public Private Partnerships (PPP)</td>
</tr>
<tr>
<td>Fee Paying / Free Education Scheme</td>
<td>Some remain fee paying</td>
<td>Free education Scheme</td>
<td>Free Education Scheme</td>
</tr>
</tbody>
</table>
2.3 The Place of Science in Ireland

This section of the context chapter aims to put context around the issues that dominate the participation levels of science. It explores the factors that influence the uptake of science within secondary education in Ireland. By contextualising the place of science, the author hopes to give the reader insight to the experiences of science prior to lower secondary level and help to identify some of the current issues with science education in Ireland at school level.

The Importance of Science in Ireland

To date, national policy in Ireland has been “successful in targeting and facilitating inward investment by the high-tech multinational sector” which helped to build a successful and rapidly growing economy (Politis et al. 2007, pg: 39). Currently over half the GNP of Ireland is being delivered through exports from the pharmaceutical and science sector (Moran 2009). A key factor to this success has been the output of science, technology and engineering graduates. The Higher Education Authority (HEA 2002) acknowledged the need to develop science and technology within the Irish Education system and they called for an “innovation society”. To offer a complete context to the study the author felt it was only appropriate that the “place” of science be acknowledged.

2.3.1 Science at primary level

Science at primary level was made compulsory in Ireland in 2003 (Murphy et al. 2007). Science at primary level in Ireland is part of the Social, Environmental and Scientific Education (SESE) programme (NCCA 1999b, Childs and Sheehan 2009). The purposes of the SESE curriculum are to “provide opportunities for pupils to explore investigate and develop understanding” (NCCA 1999b, pg: 2). The science curriculum for primary level was first published in 1999, and was aimed at developing “basic scientific ideas and understanding” (NCCA 1999b, pg: 2, 6). It was introduced into the classroom in 2003, and pupils study a broad science syllabus over their six year period in primary education (Childs and Sheehan 2009, pg: 204). The aims of the science curriculum at primary include: developing the scientific approach, knowledge and understanding of scientific concepts, encouraging exploration and fostering a natural curiosity. It also
aims to enable pupils to communicate and appreciate the contribution of science (NCCA 1999b).

2.3.2 Science at lower secondary level

The rationale for studying science at lower secondary level is to:

- Extend the principles established at primary level,
- Contribute to the development of scientific literacy and
- The development of skill processes associated with science; it also aims to
- Develop an appreciation for the impact science has on the world around us.

(Department of Education and Science 2003, pg: 3)

It is envisaged that after lower secondary level science pupils will go on to study one or more science subjects at upper secondary level. Science at lower secondary level, however, is not compulsory in Ireland; globally this is an exception, as science is obligatory in most European countries and in other systems such as New Zealand (Smyth and Hannan 2002, pg: 5). Nevertheless, science is offered by the majority of schools and studied by the vast majority of pupils: an average of 90% of pupils now take science at lower secondary level (Childs and Sheehan 2009, pg: 204, SEC 2010, pg: 4), with 99% of schools providing science at lower secondary level (Department of Education and Skills 2012).

2003 saw the introduction of the new revised syllabus in science; this was a revision on the syllabus implemented in 1989. The new course was activity-based in its design and emphasised the practical element of science, with a strong focus on inquiry-based science education (IBSE) (Department of Education and Science Ireland 2003, pg: 3). The aims and objectives of the lower secondary science syllabus are outlined in Table 2.3.
### Table 2.3 Junior Certificate Science Syllabus Aims and Objectives

<table>
<thead>
<tr>
<th>Aims and Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Syllabus Aims</strong></td>
</tr>
<tr>
<td>1. Encourage the development of manipulative, procedural, cognitive, affective and communication skills through practical activities that foster investigation, imaginations and creativity.</td>
</tr>
<tr>
<td>2. Provide opportunities for observing and evaluating phenomena and process and for drawing valid deductions and conclusions.</td>
</tr>
<tr>
<td>3. Enable students to acquire a body of scientific knowledge appropriate to their age, and an understanding of the relevance and applications of science in their personal and social lives.</td>
</tr>
<tr>
<td>4. Foster an appreciation of and respect for life and the environment, while at the same time developing awareness of the potential use, misuse and limitation of science, and of health and safety issues relating to science.</td>
</tr>
<tr>
<td>5. Provide a balance understanding of the physical, biological and chemical dimensions of science thus facilitating the further study of science in the senior cycle.</td>
</tr>
<tr>
<td>6. Develop a sense of enjoyment in the learning of science.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Syllabus Objectives</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge and Understanding</strong></td>
</tr>
<tr>
<td>Various forms of matter and the reactions and interactions which enable matter to be transformed.</td>
</tr>
<tr>
<td>The ways in which the composition of materials around us affects our quality of life.</td>
</tr>
<tr>
<td>Energy in its various forms, the application of energy conversions, and the need for economical use of energy sources.</td>
</tr>
<tr>
<td>The composition of the atmosphere and the importance of air and water to life.</td>
</tr>
<tr>
<td>The nutritional needs of plant and animal and their interdependence.</td>
</tr>
<tr>
<td>Important principles, theories and facts relating to science and their application in everyday living.</td>
</tr>
<tr>
<td>The scientific method and the concept of a valid experiment.</td>
</tr>
<tr>
<td>The underlying scientific principles applied to industry, at local, national and international level.</td>
</tr>
<tr>
<td>The ways in which a code of safety can be applied in scientific and technological investigations and activities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulation of equipment and manual dexterity, with due regard to issues of health and safety.</td>
</tr>
<tr>
<td>Procedural plans and the use of scientific method in problem solving.</td>
</tr>
<tr>
<td>Observation, measurement and the accurate recording of data.</td>
</tr>
<tr>
<td>Obtaining and using information from a variety of sources.</td>
</tr>
<tr>
<td>Numeracy and the manipulation and interpretation of data in various forms, including the use of symbols, charts and graphs.</td>
</tr>
<tr>
<td>Logical thinking, inductive and deductive reasoning, and the formation of opinions and judgements based on evidence and experiments.</td>
</tr>
<tr>
<td>The preparation and presentation of reports on scientific topics, experiments etc.</td>
</tr>
<tr>
<td>Independent study and co-operative learning.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Attitudes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A sense of safety in the laboratory, at homes and in the workplace, and in the environment.</td>
</tr>
<tr>
<td>A sense of accuracy and attention to detail.</td>
</tr>
<tr>
<td>An appreciation of the role of science in the everyday world.</td>
</tr>
<tr>
<td>A scientific interest in the local community and environment.</td>
</tr>
<tr>
<td>An awareness of health issues.</td>
</tr>
</tbody>
</table>

*adapted from Department of Education and Science (2003)*
In a consultation with young people carried out in 2011 for the NCCA, pupils acknowledged that they did enjoy science at lower secondary because of the experiments and practical element (Office of the Minister for Health and Children 2011). Pupils also identified that they felt a need for more assessment of the practical elements in lower secondary and listed science as one such subject (Office of the Minister for Health and Children 2011, pg: 11). Since the introduction of the revised junior science syllabus participation has increased (SEC 2006, 2010) (see Figure 2.3).

Figure 2.3: The uptake of science at lower secondary level education in Ireland

The 2001 Chief Examiner’s Report identified that 83.7% of the lower secondary level pupil cohort took science; this increased to 86% in 2006 and now stands at around 90% participation (SEC 2001, 2006, 2010). The number of candidates taking the higher paper has also increased; it now typically stands between 62% and 63%; an 8% increase was seen alone in 2006 from the previous year (SEC 2006, pg:7, SEC 2010, pg: 4, 5). Tables 2.4 and 2.5 below shows participation and gender participation of those opting to take science at lower secondary level in 2006 and 2010.

Table 2.4 Analysis of the Junior Certificate Cohort by gender in relation to participation in Science  
2006

<table>
<thead>
<tr>
<th>2006</th>
<th>Total Candidature</th>
<th>Number of Females</th>
<th>Number of Males</th>
<th>Percentage of Female</th>
<th>Percentage of Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>JC Cohort</td>
<td>57784</td>
<td>28511</td>
<td>29273</td>
<td>49.3%</td>
<td>50.7%</td>
</tr>
<tr>
<td>Taking Science</td>
<td>50069</td>
<td>23628</td>
<td>26441</td>
<td>47.2%</td>
<td>52.8%</td>
</tr>
<tr>
<td>Not taking Science</td>
<td>7715</td>
<td>4883</td>
<td>2832</td>
<td>63.3%</td>
<td>36.7%</td>
</tr>
</tbody>
</table>

(Data sourced from the SEC)
Table 2.5 Analysis of the Junior Certificate Cohort by gender in relation to participation in Science 2010

<table>
<thead>
<tr>
<th></th>
<th>2010 Total Candidature</th>
<th>Number of Females</th>
<th>Number of Males</th>
<th>Percentage of Female</th>
<th>Percentage of Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>JC Cohort</td>
<td>54951</td>
<td>27066</td>
<td>27885</td>
<td>49.3%</td>
<td>50.7%</td>
</tr>
<tr>
<td>Taking Science</td>
<td>49448</td>
<td>23661</td>
<td>25787</td>
<td>47.9%</td>
<td>52.1%</td>
</tr>
<tr>
<td>Not taking Science</td>
<td>5503</td>
<td>3405</td>
<td>2098</td>
<td>61.8%</td>
<td>38.1%</td>
</tr>
</tbody>
</table>

(Data sourced from the SEC)

It is clear to see from Table 2.4 and 2.5 that those less likely to participate in science are girls. However, the percentage of non-participation by females is beginning to drop, with: 63% not taking science in 2006, reducing slightly to 61% in 2010. Further national research has indicated that it is not just girls who are less likely to participate. Pupils with lower ability and those allocated to lowest steams in streamed schools are also less likely to participate in science (Smyth and Hannan 2002, pg: xiv, SEC 2006, 2010). This was supported by the 2006 and 2009 Programme for International Student Assessment (PISA) studies. These studies indicated that in relation to lower ability Ireland showed no decrease in pupils obtaining low levels of proficiency. Between 2006 and 2009 the percentage, 15.5% and 15.2% respectively, of those obtaining low levels of proficiency in science remained unchanged, while the majority of OECD countries saw a decrease in the percentage performance at this level (Perkins et al., 2012, pg: 94). This is a cause for concern, as it indicates that “one in six PISA students in Ireland is struggling with the application of basic science concepts, knowledge and skills” (Perkins et al., 2012, pg: 97).

The 2009 PISA study offers a good insight into the place of science in Ireland. In the last PISA study (2009). Ireland ranked 14th out of 34 OECD countries, with national average mean scores well above the international OECD average. Pupils in Ireland were scoring 9% proficiency at levels five and six compared to 8.5% in other OECD countries (Perkins et al., 2012). Furthermore, performance in the lower levels e.g. level two were also significantly lower than other OECD counterparts (15% compared to 18%) (Perkins et al. 2010, pg: 23, Perkins et al. 2012).
Within the competency “identifying scientific issues”, the competency in which Ireland did best, females outperformed males (OECD 2007, pg: 66, 69). Although the percentage of females taking science is considerably less than males (see Table 2.4 and 2.5), the Programme for International Student Assessment (PISA) study 2009 indicated that girls who do take part in science are outperforming boys. This corresponds with Chief Examiner’s Report where it was reported that, while females are less likely to participate in science, those that do, outperform boys (SEC 2006, pg: 6). The 2009 PISA was the first time Ireland had witnessed a gender bias within the area of science, as the 2006 PISA assessment had acknowledged Ireland as gender balanced. While the difference was not significant, girls were gaining marginally higher averages than their male counterparts (Perkins et al., 2012, pg: 92, 93).

Further analysis carried out by the OECD identified that while overall science is gender balanced in Ireland, there is a gender bias between schools and within classrooms and also between the science competencies that it measured (OECD 2007, pg: 60, 61). Alternatively, however, in the competency “explaining phenomena scientifically” Ireland only ranked average and males out-performed females (OECD 2007, pg: 67, 70). In the final competency, “using scientific evidence” used by PISA, Ireland was just ranked above the OECD average in 11th place, but interestingly there was no gender difference between males and females for this competency (OECD 2007, pg: 71).
2.3.3 Science at Upper Secondary

Science within upper secondary education in Ireland is offered through five specialist programmes: Biology, Chemistry, Physics, Physics and Chemistry combined (Phys-Chem) and Agricultural Science. Schools are urged to offer as many science subjects as possible within their schools, and pupils should be able to choose as many as they wish to complete. Statistics from the DES Statistical Report 2010/2011 (Department of Education and Skills 2012) indicate however that the provision varies substantially across the five programmes (see Table 2.6).

Table 2.6 Percentage uptake of Upper Secondary Science Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>No. of Schools Providing Subject</th>
<th>% of total schools (n=698)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>685</td>
<td>98</td>
</tr>
<tr>
<td>Chemistry</td>
<td>563</td>
<td>80</td>
</tr>
<tr>
<td>Physics</td>
<td>535</td>
<td>77</td>
</tr>
<tr>
<td>Phys-Chem</td>
<td>40</td>
<td>6</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>316</td>
<td>45</td>
</tr>
</tbody>
</table>

(Data sourced from the DES Education Statistics Report 2010/2011)

It is evident from Table 2.6 that the majority of schools 98% are providing biology for the upper secondary cohort of pupils, with only 80% and 70% providing Chemistry and Physics respectively. Perhaps the low percentage of schools providing the physical sciences syllabi may be contributing to the low uptake of the subject. In September 2000 revised syllabi were introduced for both physics and chemistry at upper secondary, while, in 2002 a revised syllabus was introduced for biology. It is evident from Figure 2.4, however, only the uptake of biology was influenced by the introduction of revised syllabi. As Figure 2.4 demonstrates since 2000, the level of uptake of the physical science has remained low, while Biology rectified itself in 2002 (Smyth and Hannan 2002, Regan and Childs 2003, Politis et al. 2007, pg: 39).
These declines raise major concern within the Irish context for two main reasons:

- The economy: the impact on scientific and technical skills and
- Scientific literacy and ability of the Irish population.

As outlined early the Irish economy and its GNP depend heavily on the pharmaceutical industry and the science sector (Moran 2009). These industries rely on high quality graduates from the physical science sector, if the decline in physical science at upper secondary continues these unfortunately so too will the number of graduates. However, within science education there is not only a responsibility for producing the scientist but there is also a social responsibility for developing the scientific consumer. As Osborne (2007) indicated science education has two roles developing and producing the scientist for industry but also developing the consumer of science: developing the scientific literacy of society so that there is an understanding within the general population of the world around especially in what is becoming a technological and scientific era.
2.4 Educational Innovation and Change in Europe

As mentioned previously in the introduction chapter to the thesis, this research project is part of a larger European Comenius 2.1 project called Gender, Innovation and Mentoring in Mathematics and Science (GIMMS). This section of the context chapter aims to put the research project into the context of the wider study across Europe.

2.4.1 Research Questions and Collaborative Framework

Educational innovation and change within the GIMMS project was interpreted as

Developing new ways of teaching and teacher mentoring through co-planning, reflecting and purposive debate with teachers across their professional lifespan about science and mathematics in lower secondary education

(Mooney Simmie 2012, pg: 12)

The development of the project was guided by an evolving framework and a number of key questions. The key questions included:

- What is needed to elicit motivation in learning science and mathematics in motivating teachers to teach these subjects in pupil-centred ways?
- In what ways can educational innovation and change be introduced in the teaching and learning of science and mathematics?
- How can we develop better forms of collaboration and mentoring between teacher and between teacher and teacher educations, and significant others, for the improvement of teaching and teacher continuing education?

(Mooney Simmie 2012, pg: 13)

The collaborative framework that guided the GIMMS project is detailed on the next page (see Figure 2.5):
The GIMMS team maintained that for the generation of innovation and change teachers needed to network together at their schools and beyond their classrooms. The framework (see Figure 2.5) was designed to capture the multiplicity of the relationships and actors within the project. The framework was to become a democratic web of relationships across the teacher’s professional lifespan with teacher educators and policy makers (Mooney Simmie 2012, pg: 13).
2.4.2 Guiding Principles of GIMMS

The theoretical framework that was developed within the GIMMS project was developed and shaped over time from relevant literature and the policy and practices from the six partner countries. The result of this was the development of “guiding practices”, which are outlined below:

- Principle 1: The team situated teaching within a teaching continuum and professional lifespan with knowledge and insights flowing in non-linear and dynamic ways between student teachers, beginning teachers, in-career teachers, teacher educators and other significant actor’s such as policy makers.
- Principle 2: The team asserted that teacher educators needed to find innovative, inclusive and critically engaging ways to work alongside teachers, ways that were democratic, and displayed equality of respect, across the teacher’s professional lifespan.
- Principle 3: The team posited that changing pedagogical practices to inquiry-oriented, inclusive and communicative learning involved a deep cultural challenge and conceptual change for teachers and teacher educators as well as change in practices.
- Principle 4: The team posited that educational innovation, gender and mentoring were social constructs and, as such, were all subject to change, challenge and improvement.

(Mooney Simmie and Lang 2012)

2.4.3 Developing GIMMS

The initial preparation and planning was developed from November 2006 to January 2007 (see Appendix B for GIMMS meeting agendas). A team meeting was held in February 2007 at the University of Limerick, Ireland, to develop the strategic plan for the project (Mooney Simmie 2009, pg: 5). There was a checklist drawn up at this stage to ensure meeting targets of the first two stages of the project. The checklist included:

- Selecting and working with four case study schools, and a minimum eight in-career teachers, to develop gender-proofed and innovative classroom materials for the teaching of some aspect of science and mathematics education in the lower secondary part of the education system.
• Identified a number of key stakeholders in each country & to inform them of this project, to keep them alert on developments and to network with as strategic allies to the GIMMS project.
• Engage in a process of self-reflection, and send occasional reflections - to track the thinking and development of the project.
• Prepared documents for the web-site, in the home language and with an English abbreviation.
• Hold a workshop/seminar with the case study schools, at the mid-way stage, to share work to date and to gain ideas for improving the classroom materials produced which are gender-proofed and innovative.
• Hold a seminar to share the findings with student teachers, in-career teachers and teacher educators and to prepare for stage three which is the dissemination phase.

(Mooney Simmie 2009, pg: 13)

At this meeting partner countries worked collaboratively to develop a shared meaning around key questions, developing a shared understanding of what is meant by: “gender”, “innovation” and “mentoring”, while also developing a transnational framework for the development of the individual country projects. Working together, there was agreement that a comparative education approach was needed for the project, as this would lead to a more socio-cultural context for understanding findings that the project would produce.

The project would build up the voices of teachers and students teachers and would assist in a process of re-culturing schools, Cochran-Smith (1999), and have the practices contextualised to the cultures in each country and with gender sensitivity.

(Mooney Simmie 2009, pg: 6/7)

The external evaluator for the project Dr. Rose Malone, also spent some time at this initial meeting getting to know the group and a flavour for the work (Mooney Simmie 2009, pg: 5). There was agreement at this initial meeting for flexibility and “it was agreed that the time-line needed to be more flexible in the creation of innovative resources, in the case study schools, and the dissemination stage with initial teachers” (Mooney Simmie 2009, pg: 5).
### 2.4.4 GIMMS National Case Study

Table 2.7 outlines the case study projects that took place in the six European countries involved in GIMMS 2006-2009 (see Table 2.7). The case study approach followed within the research project was methodologically guided by principles advocated by theorists such as Hammersley (1986), Merriam (1998) and Yin (2003).

<table>
<thead>
<tr>
<th>Country</th>
<th>Processes</th>
<th>Product(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Video analysis for teacher learning. Egalitarian, democratic and organic models of mentoring between teacher educators and teachers</td>
<td>Key questions for analysing physics teaching, including gender awareness questions Reflective account of work with student teachers</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>New ways of working with pupils in groups that were social and motivating. Largely novice-expert relations</td>
<td>CD of a range of interactive classroom materials for teaching physics, mathematics and computer science</td>
</tr>
<tr>
<td>Denmark</td>
<td>Models of egalitarian mentoring that included face-to-face meetings, seminars and a virtual learning platform for teaching as a reflective, inclusive and research practice</td>
<td>Classroom resource material in Nuclear Energy, including web pages and videos, from a multiplicity of perspectives including gender awareness</td>
</tr>
</tbody>
</table>
| Germany         | Project 1, used a comparative study of mentoring in different states  
|                 | Project 2 developed an innovative approach to teaching biology taking ethics into account | A web page for the project and a range of reflective and innovative classroom resources on the teaching of human biology taking ethics and gender inclusion into account |
| Ireland         | Using democratic and reflective models of mentoring to develop higher order co-operative thinking among science and mathematics teachers | A resource pack with multiplicity of approaches to teaching aspects of chemistry, physics, biology, and mathematics using inquiry-orientated and reflective approaches |
| Spain           | Developing an interactive model of mentoring between student teachers, teacher educators and experienced teachers for co-learning and co-ownership. Largely novice-expert relations of mentoring | A resource pack and we site pages for innovative approaches to planning teaching and reflection on materials science |
| GIMMS General   | Initial Website: www.ul.ie/gimms  
|                 | Final Website: www.gimms.eu | (Adapted from Mooney Simmie and Lang 2012) |

A more in-depth analysis of each country is outlined in chapter two of Mooney Simmie and Lang (2012).
2.4.5 The Irish Case Study

The GIMMS project in Ireland was focused within lower secondary education in the Irish education system, and involved teachers and teacher educators in a mentoring framework (Mooney Simmie, 2012). This framework involved crossing the boundaries between the school and the university, and was facilitated in a reflective and collaborative manner, generating a discourse of co-inquiry (Lang 2012). The Irish team sought to develop a sense of co-ownership among the teachers and the schools involved. It was then imperative that the school became the site for developing shared meaning and partnership within the Irish project.

The framework for the development of the project as outlined by Mooney Simmie and Power (2012, pg: 28-39) was evolved throughout the lifetime of the project. It was based on the work of Maynard and Furlong (1995), Brookfield (1995) and Darling Hammond and Bransford (2005). Maynard and Furlong (1995) offered a preferred option for co-inquiry within the GIMMS Ireland study, as “it was not based on a reproductive frame and held the potential for real engagement and mutual learning for all stakeholders” (Mooney Simmie and Power, 2012, pg: 30). Brookfield (1995) afforded the research project an approach to developing the critically reflective teacher. Brookfield’s critical lenses offered a way for teachers to interrogate their practice through many lenses: pupils, colleagues, autobiographical and theoretical. The final literature that informed the framework of the Irish GIMMS project was that of Darling Hammond and Bransford (2005), who offered a framework for the professional development of the teacher. The framework outlined by Darling Hammond and Bransford (2005) presented the project with a key way of considering “professional practice as requiring knowledge of subject matter, knowledge of the learner and learning and knowledge of assessment” (Mooney Simmie and Power, 2012, pg: 30).

There were four schools involved in the Irish case study: three who worked on science innovation, while the fourth explored the development of teaching of mathematics. The impetus for these areas was developed from the recent changes within the syllabi. The revised syllabus in Science (2003), for example, had brought a new way of thinking into lower secondary science. It brought a more ‘hands-on’ approach to the teaching and learning of science at lower secondary through the integration of mandatory experiments and pupil-centred investigations. The revisions
had also brought a new approach to assessment. This research project is focused on the development of the science innovation only. The three schools that investigated lower secondary science explored three different areas: data logging in science education, ICT-enhanced learning and eco-friendly science. Educational innovation in all schools involved in the GIMMS Ireland project was interpreted as teachers using higher-order collaborative discourse and practices, developing reflective teaching and mentoring approaches to professional learning (Lang, 2012, pg: 20). Table 2.8 below outlines the development of definitions that assisted in the clarification and development of the project:

<table>
<thead>
<tr>
<th>Table 2.8 Definitions used in the GIMMS Ireland Case Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational Innovation</strong></td>
</tr>
<tr>
<td>Educational innovative practices were interpreted as eliciting higher-order co-operation among science/mathematics teachers for the development of pupil-centred curricular practices. For example, teachers worked together in GIMMS Ireland in public incubation spaces that developed planning teams focused on a deliberative discourse on curriculum, learning and innovation within their school, across different schools and with the university.</td>
</tr>
</tbody>
</table>

| **Mentoring**                                             |
| Mentoring was interpreted as a reflective relationship of learning between teachers, across their professional lifespan, and across borders between teachers and teacher educators with interchangeable novice-expert roles for the purpose of mutually enriching understanding, appreciation and learning. |

| **Gender Awareness**                                      |
| Gender-awareness required that teachers and teacher educators consider gender as a specific criterion when co-planning, designing materials, teaching and evaluating teaching to ensure both boys and girls learning needs were included in their science and/or mathematics classroom. |

(adapted from Mooney-Simmie and Power 2012)
2.5 Chapter Summary

The purpose of this chapter has been twofold: 1) to develop awareness of the issues that impact on the teaching and learning of science in secondary education in Ireland and 2) to provide a context to the European Comenius 2.1 project GIMMS of which this research project is a component.

The education system in Ireland has historically been inextricably linked with both the Catholic Church and State. In order to develop a thorough awareness of the values that have shaped the current system it was essential to this thesis that these early foundations be outlined. The values underpinning education are strongly dominated by the Classical Humanist approach of the “great books” and the Reconstructivist approach which places value on the importance of science for the economy. The ideologies discussed in this chapter have not only impacted on teaching and learning but also on the provision and purposes of school science, with the subject frequently being viewed as elitist.
3.0 Review of the Research Literature
3.0.1 Introduction

This chapter offers a review of the literature researched within the study. Due to the exploratory nature of the project the chapter begins with a rationale for the literature search implemented in the study. Hereafter it comprises of three main areas: curriculum, professionalism and pedagogy, each individually addressing a concept of “change”. The initial section explores the concept of curriculum and the different change processes that can be involved. This section also investigates the influence and impact of school culture on curriculum change innovations.

The subsequent section addresses professional development and examines the literature surrounding the teacher as a professional. Within the literature, partnerships were continually offered as a means for promoting the professional change of teachers and as a means of implementing successful curricula changes and therefore was examined in more depth.

The final section explores the area of pedagogy and pedagogical change. It was observed from the exploratory phase one of the studies that the pedagogy of the Irish classroom still remained in the technical paradigm where pupils were blank slates and facts and dates were memorized. Due to the background of the researcher and the involvement in the European Comenius 2.1 project “GIMMS”; a special focus was given to the development of science education pedagogy. Science education has for some time being struggling with declining numbers and evoking interest among secondary pupils. This section begins by exploring the philosophies of science and examining the pedagogical trends for the contemporary classroom. This final section seeks to draw the previous parts of the literature together by exploring pedagogical change for the professional enhancement of teachers and the teaching community while enabling teachers to be change agents of their classroom pedagogy.

To conclude the author will draw the three sections together to help acknowledge how each change effort is reliant on the others.
3.0.2 Rationale for Literature Search

It is evident from chapter two that the nature and ideologies of the education system affect teaching and learning within Ireland. As a result, the researcher first began this study with an exploratory content analysis of Irish and European Policy documents “to explore the impact of policy on the teaching and learning of science”. The themes which emerged would then provide the milieu for the literature review. Themes were chosen due to their impact on teaching and learning as the project aimed to research and develop an innovative approach for the contemporary science classroom. It was critical for this study that the themes which emerged identified what the documents did not say, as much as what they did say (Krippendorff 2004 pg: 346, Bryman 2008, pg: 276). For the purposes of the study only three themes were picked, those the researcher believed were the ones which would have the most impact on teaching and learning in a 21st century classroom. The themes chosen were (Figure 3.1):

![Themes Which Emerged From the Research](image)

For the research project to be influential to the teaching and learning of science it was of upmost importance that matters surrounding curricula were included. The professionalism element was key to the study also, as research has indicated the importance of teacher quality for improving pupil outcomes and achievement (European Commission 2007).

Professional learning is increasingly focused on developing teachers’ professional skills and abilities to recognise and correct student learning problems and to enhance students’ learning

(Loucks-Horsley et al. 2010, pg: 159)

Nationally and internationally there has been an aspiration to develop a more professional and robust teaching community. Research has agreed that for this to be accomplished teachers need to engage in activities that promote professionalism, and
build confidence around being a professional, teachers must be allowed to develop and feel a sense of ownership about their work (OECD 2005). Ownership can only be gained by teachers from being involved in the policy decision-making and the elimination of top-down control, which is prevalent in the Irish context. The classroom of the 21st century requires a more democratic and relational approach to teaching. It requires teachers to be an equal partner of the curriculum development processes that impact upon them. Teachers also need confidence and ownership around curricular and professional matters in order to implement eclectic teaching and learning methodologies where needed. The prevalence of “teaching for the exam” must be eliminated and teaching for understanding embraced. Stolk et al (1932) recognises that the “involvement of teachers in curriculum change reforms requires professional development”, and further more innovations in science generally “require changes in pedagogy” (2011, pg: 370).

Therefore the researcher can conclude that each of the key areas must be supplementary and complementary to each other for the contemporary Irish classroom. Professional development cannot occur without the ownership of curricular matters and a sense of partnership, while teaching and learning methodologies cannot be revised until both curricular and professional matters are explored and renewed. When all three areas come together an innovative approach for the contemporary Irish science classroom can perhaps be developed (Figure 3.2).

**Figure: 3.2 Integrated themes for literature review**
3.1 Curriculum Change

Lortie (1975) outlines how change in education is inescapable. Curriculum change can be a low key and meaningless affair or it can be something quite significant that impacts pupil learning and teacher professional development. Irish policy-making around curriculum issues has been for a long time centralized, fragmented, secretive and *ad hoc* in character (Gleeson 2000, Gleeson 2009, pg: 57, 63, NCCA 2009). The section begins with a brief outline of what is meant by the word curriculum and once established, the review will identify and examine the common processes of curriculum change. By examining the literature the author will explore why so many of these curriculum changes, fail to “make it past the school room door” (Cuban 1988). Special attention is paid to the influence and impact of school culture on curriculum change/reform efforts. The chapter finishes with an example of curriculum change from the Irish context: the *Integrated Science Curriculum Innovation Project* (ISCIP), a science education curriculum development project in the 1970s.

Defining Curriculum

The process of defining curriculum has, for some time, been a process of contestation within education circles (Callan 1995, pg: 94). Defining curriculum is very important as “the function to which curriculum serves is related to what it is perceived to be” (Johnson 1974, pg: 9, Carl 2009, pg: 27/28). Research and time has produced many variations and definitions of the term (Clandinin and Connelly 1992, Trant 2007, Carl 2009, pg: 26, Gleeson 2009, pg: 92-94). Different definitions exist due to contradictory orientations and perspectives, which reflect the inconsistent historical, socio-political and economic context: “curriculum can be historical, political, racial, gendered, phenomenological, autobiographical, aesthetic, theological and international” (Helu Thaman 1993, pg: 249, Pinar *et al.* 1995, pg: 847). British researcher Lawrence Stenhouse cautions that “definitions of the word curriculum do not solve curricular problems; they suggest perspectives from which to view them” (Stenhouse 1975). Internationally and nationally, educational histories detail that there is no one distinct definition of curriculum. The research literature indicates how;
educational research has gradually sapped curriculum of its content meaning and injected in its place a “methods” and “forms” emphasis….metamorphosis that has been achieved by the persisting preoccupation with educational objectives, …and organisation of curricular materials

(Clandinin and Connelly 1992, pg: 364)

It can be viewed from the literature that curriculum can be seen in several ways, including as a thing, as a list of content, as a set of planned experiences and/or as a selection from culture. On an international and national level it was generally accepted that curriculum was the list of official lessons taught in a school, brought together and developed as the “timetable”, and it tended to give emphasis to “content” (Lawton 1973, pg: 11, Lawton 1975, pg: 6, Education Act 1998). The view of curriculum as a collection, or list of subjects was outlined and reinforced in Ireland through the Education Act 1998, where curriculum was defined as the “subjects to be offered, the syllabus of each subject and the amount of instruction time allotted, along with provision for Guidance and Counselling” (Education Act 1998). This view gained further approval with the publication of the official Rules and Programmes for Secondary Schools, where curriculum was described as a “list of those subjects in which instruction is given to the pupils of the school in courses approved by the Minister” (Gleeson 2009, pg: 92). Ireland has predominantly followed this concept of curriculum as a thing or object: the curriculum is viewed as a subject syllabus, a list of subjects for pupils to study, a table of contents, and even a course for teachers to follow (Department of Education 1980, Education Act 1998, Trant 1998, Department of Education and Science Ireland 2004b, Gleeson 2009, NCCA 2009, 2011a).

During the early 1970s a shift occurred, and curriculum was more likely to be defined in terms of the whole learning situation, incorporating content, pedagogy and assessment (Lawton 1973, pg: 11). Johnson (1968) defined curriculum as “the sum of the experiences of learners while they are under the auspices of the school”. While Tanner and Tanner (1975) distinguished the curriculum as the “planned and guided learning experiences, formulated through the reconstruction of knowledge and experiences under the auspices of the school” In Ireland, the 1980 Education White Paper offered a similar view, which was quite liberal for the time. It viewed the curriculum as the “totality of learning experiences”, embracing the whole experience of teaching and learning. Another variation was offered by Tunmer who identified the
curriculum as the “whole spectrum of compulsory and optional activities which are formally planned for pupils” (Carl 2009, pg: 27). The 1995 White Paper in Ireland developed in a similar way to this, suggesting curriculum was “concerned not only with the subjects taught but also with how and why they are taught and with the outcomes of this activity for the learner” (1995, pg: 18) This concept was embracing the notion of all key areas within teaching and learning: content, pedagogy and assessment. It was developing beyond the notion of a list of subjects or a list of content.

However, in Ireland, this view did not remain and later reversed back to the notion of “a range of subjects, with their individual syllabi, that are approved for study at a particular level”, reverting once again to the notion of curriculum as a thing (Department of Education 1980). Lawton put forward an additional alternative, that the core curriculum should be built through “cultural mapping”, as a selection from the culture of a society, which needs to be transmitted from one generation to the next (1973, pg: 32, 1975, pg: 6, Trant 2007, pg: 129). This notion of curriculum as a selection from society is quite pertinent as Helu Thaman (1993, 2003, pg:7) acknowledges that no curriculum is culture-free, instead it is embedded in the culture and shared beliefs that exist around it. As indicated by Pinar et al. (1995), the curriculum is a highly symbolic concept, it is what the older generation chooses to tell the younger generation. In Irish education circles Trant (1998) also put forward this idea when he spoke about “the story we tell our children”. According to Egan (1992) “unlike the Grand Canyon, curriculum is not a thing of nature, but of culture”. The impact of culture on the development of curriculum therefore is very important, as “curricula can only be understood as part of the society in which they originate” (Herbert and Hersom 1974, pg: 26).

To conclude, curriculum is a wide-ranging concept involving activities planned and unplanned, compulsory and optional, both within the normal school day and after school activities (Carl 2009, pg: 27). It is evident from the literature there appears to be no generally accepted view of the term “curriculum” (Carl 2009, pg: 26). It remains very much a contested issue within educational research. For the most part, however, “curriculum has been seen as an instrument of school reform and teachers as mediators between the curriculum and intended outcomes” (Clandinin and Connelly 1992, pg: 367). It is necessary therefore that the author refers back to Stenhouse and suggests a
perspective from which to view the concept of curriculum for the purposes of the research. Developing a perspective from which to view the curriculum will allow for impartial judgement when analysing the findings. The concept offered for curriculum for this research project is heavily influenced by the work of Lawton (1973, 1975) and Trant (1998, 2007), and their ideas about curriculum as a selection from society and the impact and need for culture within curriculum.

One of the principal tasks of the school is to help student to gain entry into a commonwealth of knowledge by handing on to them a selection of society’s intellectual, emotional moral aesthetic and technical traditions.

(Trant 2007, pg: 103)

3.1.1 What is Curriculum Change?

The Curriculum Change Process
Change is a socio-political process involving all kinds of individual, classroom, and school factors along with local, regional and national aspects (Owens 1974, pg: 65, Fullan 1991, pg: 5). It is a complex and challenging multi-layered process. There have been many innovations and developments within education curricula. The last twenty-five years have seen an assortment of approaches to curriculum planning and development (Owens 1974, pg: 55, Clandinin and Connelly 1992, Stoll and Fink 1996, Lawton 1998, Trant 2007, Gleeson 2009). The lengthier the time-scale, the more apparent the influences and trends which move curriculum development in particular directions become. In science education, for example, the 1980s saw a move towards making curricula more relevant to pupils and more active, while the 1990s saw developments around assessment of learning and practice (Bennett 2003). According to Drudy the 1990s in Ireland saw huge unprecedented change in education due to economic and knowledge-based industry changes (Drudy 2001, pg: 363). Warren-Little indicates that the changes envisioned in the 1980s and 1990s were not readily expressed in specific and transferable skills and practices (2001, pg: 23).

Originally the curriculum change process was deemed external to the classroom, and it was deemed to be “separate” from a teacher’s role and duties. The teacher was viewed as a “technician”, whose prime role it was to implement the research findings (Cochran-Smith and Lytle 1990, pg: 2, Clandinin and Connelly 1992, pg: 365, 366,
Currently, science educators and researchers acknowledge that for successful and deep change teachers need to be involved in the design and implementation phases (Keys and Bryan 2001, Stolk et al. 2011). More recently the view of the teacher as researcher and innovator, as a social learner has come to the fore and is encouraging teachers to engage with curriculum issues (Clandinin and Connelly 1992, pg: 11, Hargreaves 1994, NCCA 2011a). Emotions remain high during the change processes - imposed change can bring about anger and denial, while self-initiated change can bring excitement and relief. However, the most dominant emotion is anxiety, due to the uncertainties of the future which lies ahead (James and Connolly 2000, pg: 16).

The next section will identify and examine the three main processes of curriculum change that have been developed and found in the literature. “Each way of change has left a legacy – a mixture of strengths and weaknesses, good and bad” (Hargreaves and Shirley 2009, pg: 47).

It must be acknowledged that not all influences on curriculum change are visible (Owens 1974, Hopkins et al. 1994, pg: 18). The literature has revealed how a focus on structural change such as timetables, meetings, resources etc. will not guarantee success; it will only result in short lived and superficial educational change (Creemers 2002). For successful change, there is a need to engage with the cultural aspects of change. Helu Thaman (1993) reminds that no curriculum is culture free, and so the process of change must embrace all cultural aspects including relationships, beliefs, values etc. Other factors that impact change include when employer requirements alter, parental expectations change and finally the needs of the society revolutionise. The process is also influenced by individual philosophers and dominant ideologies, especially the ideologies of those who have some power or control within the system (Cuban 1990, Fullan 1991, Dalin 1993, Hargreaves 1994, Hopkins et al. 1994, Pinar et al. 1995, Morrison 1998, pg: 14, 15, Gleeson 2009). Trant (2007) recognises that “Education has always been influenced by ideologies and any consideration of the curriculum has to take this into account” (2007, pg: 15).
The Different Processes of Curriculum Change

Change may come about either because it is imposed or because we voluntarily participate in or initiate it, when we find dissatisfaction, inconsistency or intolerability in our current situation (Fullan 1991, pg: 31, James and Connolly 2000, pg:16). As a process it incorporates rules and relationships, practices and procedures, and the sociological and psychological mechanisms all which shape the destiny of a change (Hargreaves 1994, pg: 10). Curriculum change in secondary schools involves both internal and external pressures (Dalin 1993, pg: 6, Morrison 1998, pg:13). The three main processes for change will now be explored, with their strengths and weaknesses outlined.

The Top-down Change Process

The “top-down” process of change is understood to be centrally imposed or passed on in a “top-down” manner by those above and/or external to the main environment (Hopkins et al. 1994, pg: 17, 18, James and Connolly 2000, Goodson 2001, pg: 45, 48, Warren and Peel 2005, Darling Hammond 2009). The process developed due to a need for standardisation and public accountability. Inconsistencies and complexities had developed between schools, which in turn became an issue for education departments (Hargreaves and Shirley 2009, pg: 4-8). Darling Hammond (2009) refers to this process of change/reform as “The Bureaucratic Approach”, as decisions that travel through this process habitually have their roots in political and economic issues. Frequently a “crisis of personality” is faced as policy-makers, government agencies and corporate bodies battle over central issues (Sarason 1996, Goodson 2001, pg: 68). The history of some of these reforms is unpleasant, as most are not implemented into practice, and “planned change attempts rarely succeed as intended” (Fullan 1991, pg: 9). There is a sense of compliancy from teachers, who often feel their personal autonomy is being denied (James and Connolly 2000). The voice of the teacher is often quite limited as policy-makers assume teachers will do as they are told (Cuban 1993, pg: 183, Sarason 1996, pg: 50). Emotions run high as ownership is lost and a sense of uncertainty ensues (James and Connolly 2000, pg: 16). Centrally-produced initiatives leave teachers feeling “increasingly disempowered and professionally marginalized” (Wallace and Priestley 2011).
This pathway of curriculum change is often viewed as an event rather than a process, and once initiated and passed down the change is often deemed to proceed on autopilot. Changes are proposed and initiated without sure knowledge of the settings to which they are presumed to improve (Lortie 1975, pg: vii). These reforms are often developed around the concept of curriculum as a “thing”, promoting the notion that curriculum is something that is passed on, like a list or set of instructions. Detailed texts for teachers were written and passed down, developing the concept of “teacher as faithful implementer” (Atkin and Black 2003, pg: 37). Externally-mandated change like this is often referred to in the literature as a “reform”, as it often only serves as an improvement, or relative change on the surface of curriculum matters. These reforms often “do not strike at the heart of how children learn and how teachers teach” (Hargreaves 1994). Within this process of educational change the teacher becomes a responder, rather than an initiator of change (Goodson 2001). There are within this method several basic assumptions underpinning this form of change:

- Teachers will faithfully implement the prescriptions for practice
- Pupils will respond in identical and predictable ways
- Knowledge which is prescribed is generalisable to all educational settings
- Knowledge can be translated into standardised rules
- Rules can be operationalised through regulations

(Darling Hammond 2009, pg: 47)

Most often teachers carry out the prescribed changes to curriculum in a manner that does not reflect the ideals of the experts who mandated the change (Atkin and Black 2003, pg: 36, 37, Stolk et al. 2011). This process of change is often viewed as irrelevant by teachers as they do not see its purpose (Clandinin and Connelly 1992, NCCA 2009, pg: 16). The consequence of these externally-mandated reforms has been the general de-motivation and detachment of internal and personal missions of teachers (Goodson 2001, pg: 59).
The Bottom-up Change Process

The second process that was most common in the literature is where curriculum change is initiated from those on the ground i.e. the teacher. “Bottom-up” change begins “internally” with teachers who initiate and promote it (Goodson 2001). Lack of commitment to the government-led “top-down” process led to this new paradigm emerging in the 1980s (Stoll and Fink 1996, pg: 43). In this process, teachers identify a need within their teaching or pupils’ learning and strive to change, alter or satisfy this need. Change initiated in this manner from below is deemed to be deep change, as teachers are actively researching, developing and initiating what they feel is needed for their situation (Fullan 1991, 2001b). The belief and value for the change is there, as teachers enthusiastically want the change and so they believe in the change. Change that is developed in this manner tends to see the concept of curriculum as more than just content. This type of change was initiated to develop and/or enhance understanding, content, pedagogy and the beliefs and values etc. It examined the whole experience.

Educational change developed in the bottom-up approach is more likely to lead to deep and meaningful change as its leads to a change in beliefs and values, not an assimilated superficial trapping (Fullan 1991, pg: 35). Often there is a sense of excitement and anticipation felt by teachers towards the new change and even perhaps a relief that the old is left behind (James and Connolly 2000, pg: 16). In time there comes a change in all three key area’s outlined by Fullan (1991) and successful change is reached. The strength of this approach is that change is viewed as a process, in which the change is allowed to develop and progress accordingly. There is an acknowledgment of people’s beliefs and values, and an acknowledgment of teacher’s professional knowledge. Lord Bryon, Durant, Blue Mountain and Countesthorpe are examples of some schools in Canada, the United States and the United Kingdom which tried to implement this process of change. These schools were developed by teachers to be democratic schools, run with social equality and co-operation between staff and pupils (Gribble 1998). However, the weakness of this process soon caught up with its innovators and before long democracy and innovations were lost and replaced by external mandates (Gribble 1998, Goodson 2001, Hargreaves 2003).
The alien nature and unrelenting pace of standardized reform has undermined
the capacity of Durant to innovate and deliver its shared vision of what
constitutes effective schooling for the students it serves

(Giles and Hargreaves 2006)

In Ireland too, we have witnessed the impact of external pressures on bottom-up
change initiatives. Trant recalls how slowly the Curriculum Development Centres came
under extreme scrutiny from the government and the Department of Education, and
soon funding autonomy and staffing was decreased, “the Department had in fact
stopped just short of closing down the CDU” (1998, pg: 30, 31).

The Partnership Approach to Change

The third process to change is an inclusive approach incorporating educational change
and curriculum planning: it involves both policy-makers and teachers and is referred to
as the partnership approach. The partnership approach is a much more democratic
process than the previous two mentioned above.

It has become increasingly clear that both top-down and bottom-up strategies
for educational reform fail, neither schools nor universities find it easy to
solve improvements if they work alone.

(Fullan et al. 1995, pg: 188)

Giddens (1998) proposes that the partnership approach goes beyond the red tape of the
top-down process and beyond the aggressive competition that ensues with bottom-up
initiatives. Instead it establishes a combination of public, private and voluntary
solutions. In this approach to change, both internal and external change agents work
together to reinstate the balance between internal affairs and external relations
(Goodson 2001, pg: 54), “top-down measures are paralleled by and combined with
extensive bottom-up and lateral supports” (Hargreaves and Shirley 2009, pg: 17).
Research has shown that where teachers have the potential to experience a “happy fit”
between reform initiatives they tend to become noticeable reform enthusiasts (Warren
Little 2001, pg: 28). Darling Hammond (2009) refers to this process as the “democratic
approach”, where local ownership is instilled to increase accountability and suit local
needs. There is a re-negotiating of the balance of influence and an acknowledgment that
if success is to triumph both parties need to work together. The teacher is involved from
the very beginning, from consultation right through to delivery. Fullan (1991) identifies that deep change must involve a change in belief and value, not just content and practice, teachers and policymakers need to believe and value the incoming proposed changes and if not, they must be allowed to respond and put forward their own opinions. When teachers’ beliefs are in conflict with the philosophy of reform, then a gap develops between the proposed principles and the implemented principles, between the rhetoric and the reality, potentially limiting successful change (Levitt 2001, pg: 2, Gleeson 2009).

This process of change helps to acknowledge the concept of curriculum as a selection from the culture. Those involved need to embrace all cultures and make a selection which they feel suits their needs. Change is a learning process and those involved must be willing to learn as they progress (Dalín 1993). Trant (1998) suggested something similar to the concept of curriculum through partnership. In his idea of partnership no one person/group owns or controls the curriculum: it is a shared unit between teachers and key policymakers, “co-operation rather than confrontation” (ibid, 1998, pg: 7). Partnerships can, however, be adversely affected by pre-existing ideas on both sides, when forming partnerships therefore it is vital for all to be equal and start fresh (Peters 2002, Valadez and Snyder 2006) (see Figure 3.3).

![Figure 3.3 Partnership Approach Leads to Deep Change](image-url)
The Failure of Curricular Reforms

There are many reasons why curriculum change efforts fail to make it into the classroom permanently. Educational histories have demonstrated how standard solutions are often doomed to fail (Sarason 1990). The breakdown of reforms goes beyond structural problems such as lack of materials, ineffective planning and minimal support; they fail for a variety of reasons (Sarason 1971, Sarason 1990, Dalin 1993, Stoll and Fink 1996, Fullan 2001b). While it is unfair to say that all curriculum change efforts fail, failures may be related just as much to the fact that many innovations and reforms were never implemented into practice (i.e. real change was never accomplished), as to the fact that societal, political and economic forces inhibit change within the educational system (Fullan 1991, pg: 15, van Driel et al. 2001, pg: 137).

One of the challenges of educational change according to Fullan (1991, pg: 4) is that people do not have a clear, coherent sense of meaning, about what educational change is for, what it is and how it proceeds. Other reasons for failure include a lack of trust between both parties, a belief that the change is unnecessary, a belief that change is not feasible, a fear of failure, a loss of status and power, threats to values and ideals, high costs, economic threats and finally a resentment of interference (Morrison 1998, pg: 123, James and Connolly 2000, pg: 19, 20). It must be acknowledged that successful change does not come with just time either (Sarason 1990). It is imperative to understand that nearly all of these responses are natural and are understandable, because at the heart of all of these resistances is emotions and anxieties (James and Connolly 2000). Successful change requires a change in thinking, a change in practice and sometimes a change in culture. Reforms often fail when curriculum policymakers fail to take into account the teachers, the pupils and the culture in which the new change is going to be embedded into (van Driel et al. 2001, pg: 137).

Often described as a “self-defeating” process, the curriculum change process requires a great deal of understanding (Sarason 1990, pg: 99). More often than not this understanding however is either faulty or incomplete (Sarason 1971, pg: 9, Sarason 1990, pg: 99). The process of change, as shown earlier, is intricate work: it can often contradict old belief systems, challenging what is already known. It is a necessity for those wishing to change to unlearn the old and adapt to the new (Sarason 1990, pg: 100-105, Darling Hammond and McLaughlin 1995, pg: 597). Those who engage with
change (change agents) need to broaden their horizons so that alternative views and ways can be considered (Sarason 1990, pg: 110). Due to the nature and power of socialisation however, this can be difficult and can often be met with strong resistance (Sarason 1990, pg: 107, 110). Morrison (1998) reminds us that “resistance is a natural process and perhaps at times is unavoidable” (pg: 122). A change in thinking and practice requires high levels of commitment and understanding to appreciate and overcome this resistance. Science education requires a different way of thinking especially about the teaching and learning of science (Levitt, 2001, pg: 1). Dalin (1993, pg: 12, 13) identified four barriers that can lead to resistance:

- **Value barriers** – *challenges ones values, does not agree with proposed changes*
- **Power barriers** – *may resist if diminishes power status or may embrace where power will be greater*
- **Psychological barriers** – *resist change due to insecurity, uncertainty, emotions and confidence at play*
- **Practical barriers** – *threatens to deskill their work, machines taken over from mankind, if the proposed changes brings a need for new skills, this can be daunting*

These barriers are important as most social reforms neglect to notice how people are actually affected by change (Fullan 1991). They help eradicate the concept that the change process is to an extent independent of the teacher and the school setting. Instead they highlight how teachers and schools experience change, especially in comparison to how the change was intended to affect things (Fullan 1991).

**Conclusion**

Each country and individual has their own perspective from which to draw a concept for curriculum. Defining curriculum has been recognised as multifaceted, as the role of curriculum tends to be symbolic and representative within society. Contestation around curriculum has led to a variety of processes in which to develop and deliver change. The process of delivery can have huge consequences for its success at implementation level (Sarason 1990, Goodson 2001). The literature has shown that the implementation of change is very intricate and complex. Many studies have identified the need for greater understanding from both teachers and policy-makers for successful change (Sarason 1990, Fullan 1991, Pinar et al. 1995, Sarason 1996, Goodson 2001, Gleeson
2009). The process for development and delivery of change must become more democratic and relational, and allow a sense of ownership for each stake-holder to engage fully. The research has shown that teachers need to be engaged at development, as reforms fail when teachers deem them to be irrelevant and unnecessary, which happens when they feel disengaged (Fullan 1991, Clandinin and Connelly 1992, Gleeson 2009).

For too long curriculum in Ireland has been linked with the technical paradigm and technical issues. There is a need to broaden the horizons of those involved in curriculum change to move past the traditional ways and adapt to new, innovative ways, developing a professional approach to teaching and learning (Sarason 1990). Developing the process of partnership is one such way this could be achieved. The integration of both practitioner and researcher allows for successful partnerships to be formed, shared meaning to be developed and professional growth to be encouraged. However, before this can be achieved there needs to be understanding and appreciation of a school’s culture and the culture that surrounds change. The next section of the literature will look at school culture and the impact it has on successful implementation of change.

3.1.2 Impact of school culture

Defining School Culture
Culture is described as the ideas, customs and art of a particular society (Collins English Dictionary & Thesaurus 2007, pg: 190). The culture of a society is important as its represents the values that bind people together; it defines reality for those within a social organisation (Grimmett and Crehan 1992, pg: 60, Hargreaves 1994, Stoll and Fink 1996, pg: 83, Stoll 1999). Anthropologists and sociologists use culture to refer to characteristic ways of life, shared meaning, shared values (Helu Thaman 2003, pg: 6). In a logical sense, culture is a casual understanding of the “way we do things around here”, it is a constructed reality (Deal and Kennedy 1983, Grimmett and Crehan 1992, pg: 58).

School culture is a complex and challenging concept within education and school improvement (Prosser 1999a, pg: 13, Stoll 1999, pg: 33). Originating in the
1990s, it became a prominent way for expressing the character of a school, as it can represent a system of meanings that are shared among participants (van Houtte 2005, pg: 74). For example, “taken-for-granted assumptions, shared beliefs...and values that form a kind of backdrop” (van Houtte 2005, pg: 74). The origins of the term culture in connection to schools began with William Waller in 1932. Waller (1932) noted that schools had their own identity, with complex rituals of personal relationships and sets of folkways (Waller 1932, pg: 13, 103. 104, Lortie 1975, pg: ix, Maslowski 2006). There have been many definitions of school culture proposed and suggested by those involved in educational research (Hargreaves 1994, Deal and Peterson 1999, Helu Thaman 2003, Schoen and Teddlie 2008). Interpretations range from being quite broad, discussing difference between continents and countries, to narrowly focusing in on issues like gender and race (Schoen and Teddlie 2008, pg: 132). Most often within school research, the approach has been to investigate the dominant culture within the organisation, as this allows for differences between internal cultures to be examined (Deal and Kennedy 1983, Deal and Peterson 1999, Schoen and Teddlie 2008, pg: 132). Another philosophy around school culture is to see it as a holistic entity that permeates and influences everyone within a school (Prosser 1999a, pg: 14). The view, however, that this research project will follow is the notion of multiple subcultures. Resulting from multiple interactions, an attempt will be made to understand the relationships between co-existing sub cultures, identifying their beliefs and values and the impact that this may have on curriculum change and the development of partnerships (Prosser 1999a, pg: 14). It must be acknowledged that within this perspective there are many varying definitions of culture (Deal and Peterson 1999, Prosser 1999a, Schoen and Teddlie 2008).
The Challenge that is School Culture

The culture of a school is said to be influenced by teacher subcultures and framed by personal biographies, ontological perspectives and career experiences (Grimmett and Crehan 1992, pg: 59, Dalin 1993, Stoll and Fink 1996, Prosser 1999a, pg: 11). The way things are done around the school and the occupational culture of teaching, influence the school culture immensely. So too, does the written and unwritten rules, traditions, norms and expectations that permeate through a school (Lortie 1975, pg: 56, 57, Grimmett and Crehan 1992, Deal and Peterson 1999). The challenge however of school culture is that it does not only encompass the traditions of a school, but also involves relationships between its key players (Waller 1932, pg: 103, Schein 1985, Dalin 1993).

The characteristics that demonstrate the internal culture of a school are difficult to define. They are elusive because they are mostly implicit, and only surface aspects are seen (Stoll and Fink 1996, pg: 81, Schoen and Teddlie 2008, pg: 133, Tondeur et al. 2009, pg: 226). It is no surprise then that research shows that school culture can have serious implications on the success or failure of change (Hargreaves 1994, Stoll and Fink 1996, Gleeson 2009, McCormack 2010). The misunderstanding of the importance of school culture has led to a large number of failed reforms.

The literature surrounding curricular change, for example, has demonstrated how change can be approached differently in each school according to its own context, (Sarason 1990, Dalin 1993, Stoll and Fink 1996, pg: 43). Therefore, no blueprint can be proposed for all schools in all communities, as change is interpreted differently because in each school it meets different people, different circumstances and different conditions. Some teachers will take on board changes, while others will only pay scant attention to them (Stoll and Fink 1996, Trant 2007). As shown in the literature, schools are very influential; they are shaped by their history, context and the people within them. They are also impacted by external, socio-political and economic forces within them (Hargreaves 1994, Stoll and Fink 1996). Developing an understanding of school culture, therefore, is vital for implementing curricular change and for the promotion of professional development (Stoll and Fink 1996, pg: 80). When changing curricula, ignoring culture causes failure (Sarason 1971, Dalin 1993, Sarason 1996, Stoll and Fink 1996). An example of the impact of school culture of curricular change issues was demonstrated by Gleeson et al (2002). They documented the impact on school culture on the implementation of the Leaving Certificate Applied (LCA) programme in Ireland.
Using four schools, their analysis highlighted the significant impact school culture can have. Where the culture of the school was acknowledged and embraced into the process of change, the more successful was the implementation of the programme. However, where the school culture was ignored, resistance and failure were met by both teacher and pupils involved.

As a result the challenge that is school culture must be addressed openly in this research project. The researcher needs to be aware of possible implications caused by differing cultures at all times and stages of the project. The onus is on the researcher to develop positive and collaborative cultures, which can have a powerful impact on many features of a school (Deal and Peterson 1999, pg: 5, 7). Stoll and Fink acknowledge that “any attempt that does not address the underlying organisational conditions can be doomed to tinkering” (1996, pg: 80). Differing school cultures can bring much resistance, confusion and failure of change programs. Understanding a school’s culture is a necessary requirement for any internal or external change agent (Stoll 1999, pg: 44). Embracing school culture in change efforts can greatly enhance the following aspects of school:

- promote school effectiveness and productivity
- improve collegial and collaborative activities that foster better communication and problem solving practice
- develop successful change and improvement efforts
- Strengthen and build on commitment
- Increase energy and motivation of staff, and school community
- Increase the focus on daily behaviour and attention on what is important and valued

(Deal and Peterson 1999pg: 7, 8)
3.1.3 Curriculum Change an Irish Context:

The story of the Integrated Science Curriculum Innovation Project (ISCIP)
During the 1970s there was a move towards examination reform for the Intermediate and Group Certificate. Along with the increase in numbers and the development of the new primary school curriculum, three pilot curriculum projects were established in 1972. ISCIP was one of these projects and was originally launched in seven pilot schools. It was set up under the aegis of the Curriculum Development Centre (CDC) in Dublin and, from the outset, it recognised that curriculum development was “essentially based on the realities of classroom practice” (ISTA 1978). As a result, a fundamental concept of ISCIP was the notion of learning by doing, by experimenting and by observing (Bridges et al. 1972, Crooks and McKernan 1984).

ISCIP is a practical laboratory-based integrated science course with emphasis on pupil participation. The role of the teacher as a counsellor and guide instead of a lecturer in the classroom is a vital and basic ideal of this scheme.

(Crooks and McKernan 1984, pg: 7)

The aims for ISCIP were established by the teachers involved and they together decided that the project should incorporate the following:

- Teach science with the emphasis on enquiry and experimentation, on understanding and constructive thinking.
- Present physics, biology and chemistry in a naturally integrated fashion, showing the unity of approach
- Create among pupils an awareness of the aspects of science which play an important part in their everyday life.

(ISTA 1978)

From these general aims came the objectives of what was to be achieved through ISCIP: “the objectives of ISCIP were worked out in terms of behavioural skills, knowledge and awareness” (ISTA 1978, Crooks and McKernan 1984). As part of the development of ISCIP, pupil work cards, and teachers’ manuals were produced, which were subsequently revised using information from the teachers and pupils involved, year-on-year. While the first year of the ISCIP trial was being run in the schools, the classroom materials, ideas and content for second year were being developed. Eventually all ten units of the Intermediate and Group Certificate were completed.
ISCIP experienced some significant breakthroughs during its existence. A series of negotiations took place with the Department of Education, which allowed those taking part in ISCIP to receive an alternative examination within the national system. Reflective practice was developed into the weekly routine of the teacher: they were invited on a weekly basis to fill out a critical feedback form, so as to enable the curriculum writers to modify and adapt for subsequent years (Bridges et al. 1972, pg: 23). Continuous assessment was integrated into the state examinations, as over a third of all assessment for ISCIP was completed on a continuous basis, where the teacher of the pupils commented on the pupils’ work throughout the final year. Another significant feature of the ISCIP curriculum project was the development of resources and in-service courses available to teachers. In 1977 a booklet of resources and materials was published for those involved, with alternative lists of materials for pupils of different learning abilities. In 1984 there were over 30 schools and 7000 pupils participating in the project (Crooks and McKernan 1984, pg: 8).
3.1.4 Summary of Section

There are no hard and fast rules, rather a set of suggestions or implications

(Fullan 1991)

Defining the concept of curriculum can be varied, abstract and complex: it is much more than mere content; it also incorporates pedagogical, professional and cultural matters. Failure to recognise these connections in the change process can be detrimental to its outcome. Developing an understanding of curriculum as a selection from the culture, however, affords an understanding of the intellectual, moral, aesthetic and technical traditions associated with change. The process of developing and implementing change must therefore remodel and adapt to incorporate this concept of curriculum. Establishing an approach that is founded on partnership offers a more realistic chance of this, as this form of approach promotes democracy and cultural awareness. Organisational theorists have for some time now, testified to the importance of paying attention to culture (MacNeil et al. 2009).

There is a need to move away from the system of markets and targets and focus on the development of pupil understanding and the promotion of teacher professional development (Pinar et al. 1995). Teachers must be viewed as one of the key influential factors in educational change (van Driel et al. 2001, pg: 137).
3.2 Professional Change

Professional development programs are systematic efforts to bring about change in the classroom practices of teachers, in their attitudes and beliefs and in the learning outcomes of pupils.

(Guskey 2002)

Introduction

This section of the literature review explores professional change. Following on from the examination of curricular change, this section explores the notion of teachers as professionals, what is meant by professional change and explores partnerships as a model for change. There has been a growing body of evidence in the context of educational change and accountability that deep and sustainable change is only achieved when teachers are empowered to become leaders (Harris et al. 2003) According to the OECD report Teachers Matter (2005), most countries are falling short in updating teacher’s skills, and it has been acknowledged that there is little co-ordination between the different elements of teacher education (OECD 2005). This review will incorporate both international and national literature and will examine what professionalism means within the teaching community with particular focus on the science education teaching community. Models for professional development will also be explored along with different approaches for engaging teachers in professional development. Given that the research base on teacher professional development is so large and a wide variety of aspects can be examined in depth researching professional development can be a challenge (Loucks-Horsley and Matsumoto 1999). This study focuses on implementing a school-university partnership as a model for professional change, using a reflective paradigm.

Defining teacher professionalism

The story of teacher professionalism has been both lengthy and chequered. Defining what is meant by professionalism or the development of professionalisation has not always been universally agreed or understood (Goodson and Hargreaves 1996b, pg: 4). Redefining what it means to be professional and setting professional standards has been at the forefront of educational reform for some time (Goodson and Hargreaves 1996a, pg: vii). The Teaching Council in Ireland was established on a statutory basis in 2006. Its main purpose was to promote teaching as a profession and to establish and promote
its codes of practice, including its standards of teaching (Sexton 2007, pg: 79, The Teaching Council 2011). One of the motives for the development of teacher professionalism and the introduction of professional learning communities within schools, has been the link established between pedagogical and organisational change (Borko 2004, Harris and Muijs 2005, pg:49). The theory is that the more professional control the higher quality the service; professionals are compelled to do what is best of their clients, in this case pupils. Therefore the needs of the pupils will be met more specifically (Darling Hammond 2009). Increasingly, more and more studies are demonstrating the impact that professional learning communities within the teaching profession are having on the quality of instruction, pupil learning and teacher experience (Darling Hammond and McLaughlin 1995, Goodson and Hargreaves 1996a, Harris et al. 2003, Borko 2004, Day and Sachs 2004, Harris and Muijs 2005, Cochran-Smith and Lytle 2009, Darling Hammond 2009, Ostermeier et al. 2010, NCCA 2011a).

A further rationale is the final acknowledgement that teachers constitute a key group of professionals working and acting within the educational system and therefore need to be involved (Borko 2004, Ostermeier et al. 2010). The European Commission published “The Common European Principles for Teacher Competences and Qualifications” (2004). This document was written on the basis of teacher and teacher educator experiences and was validated by policymakers within education. The common principles identifying that teaching is a profession included:

- Well qualified profession
- It is a profession of lifelong learners
- It a profession based on partnership
- It is a mobile profession

(European Commission 2004, pg: 2, 3)
3.2.1 Teacher Professional Change

The current view of teaching as a profession requiring specialized knowledge is in sharp contrast with the outmoded perspective of teachers as skilled technicians.

(Loucks-Horsley et al. 2010)

Teaching as a Profession

The teaching profession is one that is inspired by values of inclusion, with the need to nurture the potential of all learners (European Commission 2004, pg: 1). It has a vital role within society as it shapes the future of generations to come. Teachers are responsible for meeting pupils’ spiritual, cultural, moral, mental and physical development needs, along with preparing them for the responsibilities and opportunities that come with adult life (Day 2000). However, teaching is becoming each day more and more complex, with greater demands being placed on teachers (Day 2000, Larrivee 2000, European Commission 2007). Alongside these demands are the ever-changing environments in which teachers work. These too are becoming more challenging, with a greater accountability on teachers to develop continuously (Commission of the European Communities 2007, pg: 2, 5). Critics view teachers as persons who base their judgements and views on personal feelings and limited subjective experience (Liston and Zeichner 1991, pg: 62). Therefore, as with any other modern profession in society at the moment, there is a strong responsibility on teachers to extend their professional knowledge and find new ways to develop authentic learning communities (Day 2000, Larrivee 2000, Commission of the European Communities 2007, pg: 5). Due to their direct involvement teachers have a major impact on the learning processes and outcomes of schools and so are a pivotal target group for improving the quality of schools, instruction, learning and understanding (Ostermeier et al. 2010). For some time, however, teaching has become about survival rather than the development of professionals (Day 2000). The conditions for teaching have been described as anti-professional by some (Howe and Stubbs 1996, pg: 167). This is not just the case internationally either, as if teacher professionalism is to become a central issue within education here in Ireland, then there is a need for teachers to become proactive around the issue (Sexton 2007, pg: 95, 96). Being a teacher into today’s classroom requires teachers to go beyond the fragmented techniques of the past and instead calls on them to be fluid and flexible in their manner and approach (Larrivee 2000). Ostermeier et al.
(2010), acknowledge how teacher’s learning is related to daily pedagogical changes in the classroom and therefore teachers should be central to professional development initiatives.

The history of “teachers as professionals” has been through somewhat of a struggle in the past. It was steadfastly resisted by cost-conscious, centrally-controlled governments for a long time (Goodson and Hargreaves 1996b, pg: 1). Government and policy-makers pursued policies to centralise conditions such as teacher’s pay, conditions of service and curriculum control, while at the same time decentralised areas such as school management and the control of governing bodies (Goodson and Hargreaves 1996b, pg: 2, Day 2000). Currently, however, things are very different with teacher professionalisation being sponsored with exceptional vigour by governments and policymakers (Goodson and Hargreaves 1996b, pg: 1, Sexton 1998). For example, the establishment of the Teaching Council in Ireland and the development of their codes of practice was encouraged and embraced by the Irish Government (Teaching Council Act 2001). It should be acknowledged, however, that the aspiration for teachers to have professional lives is very much a contested issue, and achieving the actuality of professional lives in teaching is not so easy (Goodson and Hargreaves 1996b, pg: 4, Sexton 2007). To engage with professional development, teachers need to be encouraged, motivated and given confidence (Sexton 2007). Motivation around professional development will not be achieved around tight, centralised control and so there is a need for policymakers to take a step back and allow teachers to develop (Day 2000, pg: 107). The Rocard Report (European Commission 2007) identified that teachers are key players when it comes to science education reform. However, to enable them to carry this out there is a strong recommendation for better support surrounding professional training, stimulating morale and developing motivation (European Commission 2007).
Professional Development in pursuit of school reform

Teacher professional development is a key aspect in improving classroom instruction and bridging the gap between theory and practice (Ostermeier et al. 2010, pg: 303). The success or failure of professional development commonly point to the contributions or shortcomings of formal staff development (Warren Little 2001, pg: 23). It involves more than just fixating on the improvements produced to pupil learning. It also includes an increase in knowledge (establishing lifelong learning), a change in practice, the development and integration of new programmes, a change to school culture and the development of teachers as leaders especially when partnerships are formed (Loucks-Horsley and Matsumoto 1999, Loucks-Horsley et al. 2010). Two crucial factors that need to be considered when pursuing professional development are 1) what motivates teachers to engage and 2) the process by which change in teachers typically occurs (Guskey 2002). Within science education, teachers are recognised as the central factor in the successful implementation of curriculum change and reform (Bell and Gilbert 1996, Levitt 2001). There are a variety of forms of professional development that teachers can take part in during their career. The literature identifies that there are two primary models which teacher professional development predominantly follows (see for example, Howe and Stubbs 1996, Sachs 1997, Borko 2004, Ostermeier et al. 2010)

Factors for successful professional development programmes include:

- Emphasising commitment over an extended period of time
- Leadership
- Mentoring
- Access to expertise
- Links between learning and curriculum renewal

(Tytler et al. 2011, pg: 872)

Models of Professional Development

Professional development can be developed and delivered specific to subject content e.g. science education, or it can be wide ranging, developing different aspects of teaching and pupil learning e.g. ICT, laboratory practical days etc. The most frequent approach to professional development is based on training in which teachers are presented with ideas and facts, and are then expected to return to the classroom and duplicate (Howe and Stubbs 1996, Brand and Moore 2011, pg: 891). The OECD refers
to this form of professional development as a “structured practice” (Shiel et al. 2009, pg:1). The most common form this usually takes is the traditional one-day seminar, usually at the local education centre, and often referred to as “in-service training” (Darling Hammond and McLaughlin 1995). According to Gilbert (1994) this is a process of training teachers in a clearly defined skill set, and learning outcomes are predetermined in this model for replication in schools. It is a pre-packaged traditional means of top-down training strategies for professional development (Ostermeier et al. 2010, pg: 305). Within science education this “in-service” approach is the most dominant, and many of them have been “teacher-proofed”, implying teachers may cause harm by adapting or changing to meet the needs of their pupils and classroom (Howe and Stubbs 1996, pg: 167, Atkin and Black 2003, pg: 37). In this model the teacher is viewed as implementing what has been formulated by external experts. This traditional conventional approach to professional development is often regarded as less effective, fragmented and intellectually superficial, as it does not take into consideration the daily aspects of a classroom (Borko 2004, pg: 3, Ostermeier et al. 2010, pg: 305).

The second approach to professional development is more social, personal and empowering. It looks at the process of professional development as a way of empowering teachers (Gilbert 1994, Bell and Gilbert 1996, Stolk et al. 2011, pg: 370). It often takes the form of courses or projects that teachers can take part in over a series of weeks or an academic year, at local third-level institutes or in their school (Darling Hammond and McLaughlin 1995, Loucks-Horsley and Matsumoto 1999). The social aspect to this form of professional development is gained when teachers work with other teachers to reconstruct knowledge about teaching (Bell and Gilbert 1996, pg: 34). This form of professional development allows teachers to take charge of their own growth, meaning that they are not dependent on others; they are independent and autonomous in dealing with their own development as teachers (Howe and Stubbs 1996, pg: 169). Teachers are actively developing their skills for lifelong learning in this model. In this model, teacher professional development is viewed as teachers learning rather than getting teachers to change (Bell and Gilbert 1996, pg: 33). This social and personal approach to teacher development is very important as we go forward in the twenty-first century. Research shows that teacher professional development needs to take teachers beyond the uncritical and unreflective implementation of practice, as defined by others, and offer opportunities to give “support for classroom pedagogy that
goes far beyond the mechanics of teaching” (Goodson 1997, pg: 29, Day 2000). It is important that approaches to professional development allow teachers to understand the complex realities of their classrooms (Darling Hammond and McLaughlin 1995, pg: 597). Professional development programmes that are linked to educational reform or pedagogical change aim to relate teacher learning to the daily routine of their classroom and are therefore more effective, as they are designed from a perspective of situated learning (Borko 2004, Ostermeier et al. 2010, pg: 305). Teachers are encouraged to reflect critically on their practice and create new knowledge and beliefs about content, pedagogy and learners (Darling Hammond and McLaughlin 1995, pg: 597).

**Tools for promoting Professional Change**

Loucks-Horsley et al. (2010, pg: 157-279) identified 15 different strategies for professional development within science education, that fall into 4 different categories. The categories include:

- Immersion (in content, standards and research)
- Curriculum (aligning and implementing)
- Examining practice (teaching and learning)
- Collaborative work (professional structures, workshops, professional networks).

Each of the four categories listed may be combined to develop professional development programmes for science education. For this research project there has been a focus to involve the following strategies: inquiry by teachers, thinking and examining pupil work, mentoring, curriculum implementation, workshops and finally professional networks. Some of these strategies are implemented as tools into the project, so teachers can use and adopt them to promote professional learning. This section will focus on the tools implemented. A more in-depth analysis will be given to the exploration of professional networks in the section under school-university partnerships.
Reflection

Possibly the most common tool for the professional development of teachers is the tool of reflection. Reflective practice now forms a huge part of initial teacher education in Ireland and across the globe. The concept of reflection and reflective teaching was developed by John Dewey (1933). It was developed around the notion that teachers recognise teaching as a process that is open to scrutiny and that they can stand outside themselves and come to a clearer understanding of what and who they are (Schön 1983, Brookfield 1995, pg: 214, Marcos et al. 2011, pg: 21). It is a necessary condition for teachers learning and an essential step in the process of lifelong learning (Zeichner and Liston 1996, Watson and Wilcox 2000, pg: 57, Day 2003). It is employed by teachers to examine past and current practice with an aim to informing future practice (Loucks-Horsley et al. 2010, pg: 62). According to Dewey (1933) reflection involves engaging in self-appraisal and development (Pollard 2008, pg: 14). The theorists of reflective practice believe that practitioners, including teachers, must research their own work sites (Brookfield 1995, pg: 215). The practice of reflection has been widely used to promote teacher understanding around practice and pupil learning. Naturally it is a cyclical process that engages teachers to problem solve and raise awareness about issues of teaching and learning within their classrooms, while at the same time construct professional knowledge (Liston and Zeichner 1991, Brookfield 1995, Zeichner and Liston 1996, Marcos et al. 2011, pg: 21). This is done through gathering evidence and solving problems. The process of reflection supports the growth and continuation of professional expertise for teachers (Brookfield 1995, Pollard 2008, pg: 5). When teachers develop skills to become reflective practitioners they develop professionally as they develop a set of skills to integrate and modify to suit the changing contexts in front of them (Larrivee 2000, pg: 293). The literature has shown that successful leadership is connected to the commitment to engage in reflective practice (Day 2000). It must be acknowledged that becoming a reflective practitioner cannot be prescribed by others: it is a process of self-discovery. Liston and Zeichner (1991) outline two common models of reflective inquiry: Fenstermacher’s model (1986) and Schon’s model (1983). Schon’s model is possibly the most common within the professional development of teachers as it’s reflection on “knowing in action”.

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Larrivee (2009) acknowledges how “keeping a reflective journal is one vehicle for ensuring time is set aside for daily reflection...it allows teachers to chart their development and become more aware of their contribution” (2009, pg: 296). The incorporation of reflective journals into a teacher’s daily routine can serve many important purposes in a teacher’s professional development. They can become a “dumping ground” for frustrations, can help work through conflicts, record incidents, trace patterns and themes in their teaching and learning, and help identify relationships. It can also make teachers more aware of personal biases and prejudices (Larrivee 2000, pg: 297). The fundamental goal of reflective practice is to enable teachers to reconstruct knowledge while working in professional learning communities (Cochran-Smith and Lytle 2009).

**Mentoring**

The term mentoring has been subjected in the last two decades to various uses and adaptations (Roberts 2000, pg: 148). It is quite an “elusive” concept and often the process person and activities are all mistakenly combined when trying to define it. Internationally mentoring within education has for the most part been used to retain and support new teachers when they enter the profession first, with some cases reporting an 85% retention rate as a result of mentoring (Loucks-Horsley et al. 2010, pg: 231). In Ireland a similar programme for mentoring newly qualified teachers does exist, however, it remains at a pilot basis and as of yet is not nationally rolled out. Mentoring can be viewed as “a form of integration” (Long 1997), “a relationship that encourages learning” (Parsloe 1995), “a process whereby skills change” (Fletcher 2000). According to Loucks-Horsley et al. (2010), mentoring is a “teacher-to-teacher professional development strategy that sustains a system of long term ongoing professional learning embedded within the school culture” (Loucks-Horsley et al. 2010, pg: 230). The process of mentoring allows for teachers to create new knowledge as they interact together, which in essence leads to change. Mentoring has been implemented as a tool for the professional development of teachers within this study, as it creates a collegial structure through which teachers can develop their expertise and clear the ways to change (Bransford et al. 1999, Fletcher 2000). In professional development settings, the primary purpose of mentoring is to provide support and enhance leadership. It allows teachers to engage in pedagogical discourse and reflective thinking (Hudson 2007, pg: 201). The incorporation of mentoring into the study provides the opportunity
to promote open communication in areas such as pedagogical and content knowledge, which are not often discussed in the Irish context (OECD 1991, 2005, Shiel et al. 2009). Selected positive outcomes from mentoring include the discovery of hidden abilities, personal growth, a performance improvement, a growth in confidence, and an increased effectiveness within the school/organisation (Fletcher 2000, Roberts 2000, pg: 160). According to Roberts (2000) there are eight essential attributes to the mentoring concept, each of which this research project will aim to encompass, these are:

- Of a process form
- An active relationship
- A helping process
- A teaching-learning process
- Reflective practice
- A career and personal development process
- A formalised process-a role constructed by or for a mentor

There are, however, areas for concern when using mentoring as a tool for the professional enhancement of teachers. It has been recognised in the literature that the mentoring experience of teachers involved in any project may vary greatly and so there is a responsibility to ensure democracy is maintained, by making sure mentoring is not left to chance (Fletcher 2000, Hudson 2007). It is a process whereby both people and skills change and smooth transitions must be ensured (Fletcher 2000).

**Partnerships, Collaboration and Learning Communities**

Another approach gaining much support is the development of professional learning communities as a means of professional development (Brookfield 1995, Wenger 1998, Cochran-Smith and Lytle 2009). The support for these learning community-based models as a new method of delivery for professional development for teachers is witnessed in the new term “teacher professional learning”, which is now the preferred term used in the writing around this area (Tytler et al. 2011, pg: 872). The new term allows for a distinction to be made with the supply of pre-packaged knowledge to teachers, which is underpinned in the traditional methods, and the new version of sharing insights about teaching and learning in order to gain a sense of professional control and ownership.
This new approach is very similar to an approach put forward by Cochran-Smith and Lytle (2009) called “inquiry as stance”. This approach allows “closer understanding of knowledge-practice relationships as well as how inquiry produces knowledge, how inquiry relates to practice and what teachers learn from inquiry within communities” (Cochran-Smith and Lytle 2001, pg: 48, Cochran-Smith and Lytle 2009). From a professional development viewpoint, this approach by Cochran-Smith and Lytle allows for teachers to engage with new knowledge, develop more understanding around new pedagogies, while also developing them as learners. In this approach, teachers engage as members of communities of practice (Cochran-Smith and Lytle 2001, Groundwater-Smith and Dadds 2004, pg: 239). Communities of practice are characterized by Wenger (1998) as the natural structures for the ownership of knowledge. “Inquiry as stance” disregards the notion of expert and novice teacher, as both new and experienced teachers engage in the search for significant questions and problems to solve; they count on each other for alternative viewpoints; and they view themselves as lifelong learners and inquirers (Cochran-Smith and Lytle 2001). Together teachers engage in the construction of knowledge through conversations, collaboration and interpretation.

Through talk and writing, they make their tacit knowledge more visible, call into questions assumptions about common practices, and generate data that make possible the consideration of alternative.

(Cochran-Smith and Lytle 2001, pg: 53)

The incorporation and development of professional development tools into a teacher’s daily life is extremely important, both for the sustainability of the profession but also for the teacher. Engaging with professional development allows teachers to explore new ways of teaching and learning, while also developing an understanding for the context in which they work. The world of teaching is no longer trouble-free, and each day it becomes more challenging and complex, as also does the lives of the pupils who attend it. Teachers that engage with professional development can offer a whole new concept of learning to pupils as they are more open and willing themselves.

The literature has identified two main models of professional development, one of which has a strong association with Ireland. There is a need to develop professional development more like the second model identified above here in Ireland, where
teachers are encouraged to take a more social but personal approach to professional development. Reflective practice can play a huge part in developing and promoting this aspect of professional development and when integrated into teacher communities the results can be large. The next section seeks to address the establishment of partnerships as an approach to promoting professional development.

### 3.2.2 Establishing Partnerships for Professional Development

This section examines what is meant by partnership and explores different types of partnership that can exist. In particular the section focuses on the establishment of school-university partnerships, and their role in promoting professional development. This section concentrates on identifying what is necessary for school-university partnerships to become effective and successful. To finish, the researcher examines the *Teaching and Learning for the 21st Century* (TL21) project which was co-ordinated from NUI Maynooth: this is an Irish exemplar of a partnership for promoting professional development in Ireland.

**What is meant by partnership?**

A partnership is described as a joint venture between two companies or bodies, who share ideas for the betterment of a common good or goal (Collins English Dictionary & Thesaurus 2007). Partnerships can be developed for many reasons in education, and these include: educational research, mentoring, professional development, enhancement of pedagogical practices etc. Numerous partnerships are developed and created in schools: between teachers, among teachers and pupils, between teachers and principals, and among schools and universities etc. There has been an emphasis on collaboration and collaborative inquiry between schools and higher education institutions for some time (Hargreaves, 2003 cited in, McLaughlin and Black-Hawkins 2007, pg: 347, Moss 2008). Some partnerships between schools and universities are often viewed as “professional collaborations” or “professional learning communities”, as their purpose is often to develop further the professional practice of those involved. “Collaboration has been described by a number of authors as a positive strategy to initiate school improvement”, “increase quality, (and) bridge the gap between theory and practice, (Warren and Peel 2005, pg: 346). Most often partnerships that are established between
schools and universities are research and development (R&D) partnerships that are externally funded, but beneficial to both. The European Commission funds such R&D projects in secondary education under its Comenius Programme.

**School-university Partnerships**

This section aims to examine what is meant by a school-university partnership and explore why they are developed. School-university partnerships (SUPs) are partnerships where both the academic researcher and the teacher work collaboratively to learn and create new knowledge (Rönnerman *et al.* 2008). They are unique organisations, where practitioners who share mutual concerns and interests about education are connected (Miller 2001). Partnerships between schools and universities play a “cornerstone” role, in both educational restructuring and the professional development, between second-level teachers, university academics and university researchers (McIntyre and McIntyre 1999, pg: 59/60, Grundy *et al.* 2001, pg: 204, Lefever-Davis *et al.* 2007, pg: 204). SUPs create fundamental links that can be used to strengthen teacher education reform, school performance and further professional development (Burton and Greher 2007). Traditionally schools and university education departments have been associated through a number of activities: initial teacher education, continuous professional development (CPD), consultancy and research (Baumfield and Butterworth 2007). Over the past two decades, however, school-university partnerships have been prompted to develop due to various concerns such as improving classroom instruction (Warren and Peel 2005, McLaughlin and Black-Hawkins 2007, Borrero 2010, pg: 47)

The last decade has seen mounting pressure in North America, Europe and Australia for teacher educators to work collaboratively with school colleagues for the dual purposes of reciprocal professional development and improved education for pupils.

(Peters 2002, pg: 229)

The potential role of school-university partnerships as a stimulus for professional practice and educational reform has been established. Areas such as: bridging the divide between theory and practice, the raising of standards within teaching and learning, and the creation and dissemination of useable knowledge, can all be developed from a professional partnership between a school and a university (Hargreaves 1996,
School-university partnerships develop for many reasons, as already explored. Their reason for development can often influence the form they take. In their research, Furlong et al (2000) identified two “ideal” models of partnership that are pertinent to the creation of school-university partnerships. They describe these partnerships as a continuum with both models at either end of the spectrum. The position of school-university partnership on this spectrum is strongly influenced by the levels of involvements of each partner (ibid, 2000, pg: 77). While both models identified are quite idealistic, partnerships can be created embodying different aspects of each model.

Model 1 –The Complementary Partnership: in these partnerships, schools and universities are viewed as having separate but complementary responsibilities (Furlong et al. 2000, pg:78). There is no systematic attempt to bring the two dimensions into dialogue, and while both parties agree to partnership, there is no integration between them, and no shared meaning. This is similar to traditional school-university partnerships, where relationships are structured according to the needs of the university.
The role of the school was a passive one that filled the need of the university, and there was no intention of an equal relationship between the two (Lefever Davis, 2007, pg: 205). Planning within the complementary partnership is kept to quite a broad structure, with agreed areas of responsibility. The higher education authorities do not visit schools unless issues arise and need the attention of university staff. The relationship between both parties in this partnership is finance-led and legalistic. Partnerships of this form can often emerge as a pragmatic response to limited resources. The complementary partnership is dependent on the school making a strong and independent contribution (Furlong et al. 2000, pg: 88).

By contrast, the collaborative model (Model 2) has the commitment to develop different forms of educational knowledge, some of which come from school, and some of which come from higher education (Furlong et al. 2000, pg: 80). The concept of collaborative implies there is no hierarchy and that decision-making is democratic (Hord 1986). The organisational structure of the partnership is flat, unlike the traditional partnerships. There is no top-down order among the participants, and decision-making is self-governing (Dallmer 2004, pg: 31). The collaboration provides both personal and professional development on both sides of the partnership (Dallmer 2004, pg: 43). Borrero (2010) comments, that it was the commitment and joint effort between the teachers and faculty members that entailed the K-8 school-university partnership to be successful.

Creating effective school-university partnerships
Reviews of the literature have identified key criteria for successful and effective partnerships. This section explores two main conditions that must exist for success, while also identifying some conditions that can impact on this success. Partnerships between schools and universities, create their own norms, values, expectations, rules and roles that support reciprocity, equality and open conversation (Miller 2001, pg: 102). In many ways, they create a unique third culture. There is growing recognition however that partnerships can be adversely affected by conditions that pre-exist on both sides of the partnership (Peters 2002, pg: 229, Valadez and Snyder 2006, pg: 32). Hargreaves (1994) and Goodson (1992) document how the structural, cultural and personal relationships within a partnership can affect collaboration and its success. Effective school university partnerships, involve:
• A Balance of Power
• Developing a shared meaning

(Furlong et al. 2000, Lefever-Davis et al. 2007, pg: 204)

**Balance of Power**

Effective partnerships are based on reciprocity, where both parties meet on equal
grounds, with the desire to improve matters (Day and Sachs 2004, Lefever-Davis et al.
2007, pg: 204). University culture values scholarship for promotion, tenure,
publications, and research grants, while for teachers their identity is grounded in their
daily work of learning, teaching and knowing (Dallmer 2004, pg: 32). In the past the
university would be recognised as a place of knowledge and the school as a place of
action, thus separating both worlds. Issues of power and differing cultures often
dominate, and “partnerships are coloured by partners” perceptions of each other’s”
status and power” (Sarason 1990, Valadez and Snyder 2006). The divide between the
two worlds militates against the development of professional partnerships, as success is
inhibited by the clash of cultures or “turf protection” (Grundy et al. 2001, pg: 205,
Burton and Greher 2007). Partnerships where cultural differences are not
acknowledged face communication problems, encounter conflicting values and demand
reminds us of the effects of power relations on relationships involving strategies, and
the onslaught of domination by those who assume more power and control.

Traditionally universities have had a dominant role, and the needs of the
university were served over the needs of the school (Burton and Greher 2007). An
attitude of distain was held towards teachers, as university staff considered themselves
superior, particularly in terms of understanding educational issues such as curriculum
and pedagogy (Sarason 1990, Clandinin and Connelly 1992, Valadez and Snyder 2006,
pg: 32). They often regarded research carried out by teachers as “trivial, atheoretical
questioned the motives of university academics, dismissing research conducted by them
as overly theoretical with little practical value and therefore irrelevant to their practice
(Valadez and Snyder 2006, pg: 32). Tensions occur when there is indifference or
distrust, and prior interactions and experiences can affect the nature of the relationship,
and the way that partnerships are structured (Lefever-Davis et al. 2007, pg: 209).
From the literature it is clear that quality, structural relationships and conditions must exist within relationships (Hargreaves 1994). Relationships established between the university and school, must be both open and democratic, where trust is established from the start (Grundy et al. 2001, pg: 205, Rönnerman et al. 2008, pg: 32). For example, some university participants involved in the Innovative Links project in Australia saw the “lack of credibility as an initial barrier to winning some form of acceptance from school participants” (Peters 2002, pg: 231). Differences must be offset with flexibility, patience and the ability to break down pre-existing stereotypes. Roles and responsibilities must be negotiated and accommodated to all needs of the participants (Grundy et al. 2001, pg: 205, Peters 2002, Lefever-Davis et al. 2007, pg: 204). Teachers, for example, do not like to have their time compromised, especially if they wished to be actively involved (Noffke et al. 1996, pg; 170). Differences in culture, faculties, pupil population and communities must be recognised (Dallmer 2004, pg: 204). The relationship between both parties must be genuine, collegial and egalitarian if it is to be truly effective (Grundy et al. 2001, pg; 205, Lefever-Davis et al. 2007, pg; 204). Teachers like to be treated as equal within the collaboration, especially when it comes to their voice being heard (Noffke et al. 1996, pg; 171).

**Developing a shared meaning**

Collaborative and effective school-university partnerships are dependent on both parties to have an emphasis toward planning. Once the relationship between both participants is established and trust is mutual between both parties, developing a plan must begin. By identifying the problem or issue together, the partnership becomes relevant to both, and both parties are now empowered to discuss their issues in a manner that is mutually beneficial. When a clear view of the purpose of the partnership is established, it results in a more effective and successful partnership, that meets the needs of stakeholders (Duffy 1994, pg: 600). Baumfield and Butterworth (2007) suggest it is the enquiry that drives the process, and so when problems are posed together, solutions are sought using expertise located on either side of the partnership.

Implementing school-university partnerships requires time and dedication by those involved (Noffke et al. 1996, Dallmer 2004, pg: 43). When the emphasis on planning is low difficulties arise, for example, the SUPER project (School-university
partnership for Educational Research) in the United Kingdom spent the first 18 months of their partnership trapped in the planning stages. There was difficulty in creating and developing a shared agenda and putting meaning to the partnership. The partnership was “formed spontaneously”, and had no driven agenda (McLaughlin et al. 2006, pg: 148). It is clear that there is a definite need within partnerships to establish a clear understanding of the project and the role played by both members from the very beginning (Peters 2002). Developing the partnership around a genuine issue or problem provides focus and adds purpose to the partnership. It allows the participants to “grow into” their roles within the partnership (Duffy 1994, pg: 599).

Research acknowledges that within school-university partnerships there is a “recurring problem of setting unrealistic expectations for participants” (Peters 2001, pg: 15). It is important when setting agendas and developing plans to develop both realistic plans but also plans with relevant outcomes for educational reform and professional practice. Care must be taken that decision-making and agenda-making take place at all levels of the partnership (Burton and Greher 2007). Goodlad (1991) warns how the preoccupation with sustaining partnership for its own sake cannot be allowed to overrun the agendas of the partnership. In order to redress the notion of expert and creator of knowledge, academic associates often seek teachers at partnership schools to develop projects which are important to their needs and the needs of their school and to develop and take ownership for their plans (Grundy et al. 2001, pg: 208). Much of the research recognises “boundary crossers” and the roles academics need to play when trying to develop a plan. “Boundary crossers” are individuals who are comfortable in the realms of both participant institutions, and they appreciate the realities of both institutions (Valadez and Snyder pg: 31).

**Conclusion**

It can be concluded from the literature that school-university partnerships are not easy and are often messy in their development. A balance of power and a shared agenda, which are beneficial to both parties, needs to be agreed from the outset. Partnerships such as school-university partnerships draw out different commitments and working worlds. Miller uses the analogy of an amoeba to describe school-university partnerships, which is quite apt; she describes where a nucleus of core values integrates an “organism” in such a way that it can only survive by having sufficient fluidity and
flexibility to respond to change in the environment, while retaining its identity at all time (Miller 2001). Similarly school-university partnerships can only survive when there is a shared agenda, a balance of power and where independence is recognised.

### 3.2.3 Professional Development an Irish Context

#### The story of the TL21 Project

Partnerships that have taken place in the past in Ireland were very much around the implementation of curricula, and not so much about the development of teaching and learning or professional practice of teachers. Gleeson (2000, pg: 18) identifies how the adoption of the partnership approach within Irish education has only occurred in recent times and mainly at policy and/or curricula implementation levels. Implementation of the partnership approach within the system was first seen through the representational NCCA. The NCCA was established on a statutory basis in 2001, to advise the Minister of Education around matters concerning curricula and assessment (www.ncca.ie). The council sought to represent all parties within the education system in the design and implementation of curricula. This partnership included parents, university academics, teacher unions and the business community. The council however has mainly been effective “in the legitimation of top-down curriculum reform” (Gleeson 2000, pg: 19). While many policy documents and research refer to those directly involved in education as “the partners”, the reality is that these “partners” are “social partners”, and all they succeed at is helping to “cloak the influence of those in power” (Department of Education Ireland 1995, Sugrue 2004, pg: 78). Inevitably with social partners, some are more powerful than others, and so the partnership approach becomes fragmented and broken, with each sector out for its own “sectoral agendas”. The partnership approach in Ireland is very much in theory and not in reality.

However, one research and development project has tried to alter this. The TL21 project (Teaching and Learning for the 21st Century 2003/2007) from NUI Maynooth is possibly the most recent and most valid attempt at creating a school-university partnership within an Irish context. The project was a research and development project developed within NUI Maynooth across 15 post-primary schools in Dublin, Maynooth and the Midlands’s area (Hogan et al. 2007, pg: 1, Malone and
Smith 2010, pg: 106). The focus of this school-university partnership was the development of a new approach to continuing professional development of teachers in Ireland (Malone and Smith 2010, pg: 108). The project was developed around the following aims:

- To strengthen teacher ownership,
- To encourage pupils to become active participants of their own learning and
- To develop and promote the notion of a learning society within schools

(Hogan et al. 2007, pg: 5-9)

The third aim was developed when the project was in motion, as there was a growing awareness “that the workplace cultures of teachers and those of policymaking and implementation are largely unacquainted....sometimes even worlds apart” (Hogan et al. 2007, pg: 8). A distinctive component of this partnership was the opportunity for teacher accreditation. Teachers involved in the project were accredited with a M. Ed from NUI Maynooth on completion of assignments and submission of a 30,000 word thesis. While only 20% of the teacher cohort availed of this opportunity, the opportunity might have appealed to participation and placed merit on involvement. Participation and sustainability was vital for the researchers, as relapse was always a possibility (Hogan et al. 2007, pg: 14). The final report outlines eight “suggestions” for furthering CPD and developing teaching and learning practices in Ireland. Although the researchers acknowledge the influence of “purse strings” on such projects, they also identify how many of the implications of change can be overcome with a small change in mindset and practice (Hogan et al. 2007, pg: 75).
3.2.4 Summary of Section

There are no policies that can improve schools if the people in them are not armed with the knowledge and skills they need.

(Darling Hammond 2009, pg: 63)

Professional development is a central component for improving education (Guskey 2002). Increasingly policy makers are acknowledging that schools can be no better than the teachers that work within them and therefore if policymakers are interested in reforming the education system they must invest from initial teacher education right through the career of practising teachers. Successful professional development, however, needs to be meaningful, and piecemeal efforts are not sustainable. The professional development of teachers in Ireland is of utmost importance as we try and drive the professionalisation of teaching in Ireland. As Sexton (2007) indicates, however, the professionalisation of teachers is very much a contested issue in Ireland. As a result, there is a need that the process of engaging teachers in professional development is done as effectively as possible, keeping in mind at all times the final goal. The research has showed that “structured” professional development (in-service) does not have sustainability within the classroom. Nor does it offer teachers the opportunity to engage fully with their practice of the changing contexts in which they teach (Stoll and Fink 1996, Loucks-Horsley and Matsumoto 1999, Day and Sachs 2004, OECD 2005). Teaching is becoming more and more complex and challenging, as the world and society changes around it. There is more pressure than ever on teachers to engage with their practice and develop new ways of teaching and learning.

The literature on school-university partnerships has shown that the establishment of such partnerships can lead to positive results. School-university partnerships develop learning communities both in the schools and the universities that engage within them. They are developed around shared meaning and so offer teachers the opportunities to engage with their work. School-university partnerships that encourage mentoring and reflection help to break down barriers around professional dialogue and assist teachers to improve the link between content and pedagogical knowledge. However, implementing successful partnerships cannot be done overnight; it takes time and commitment by all those involved.
3.3 Pedagogical Change

Introduction

Science education is failing. There has been worldwide concern as numerous projects costing thousands of dollars try to fight the declining enrolment figures in science and science-based subjects (Rowlands 2008, Hampden-Thompson and Bennett 2011, pg: 1). The failure of science curricula to attract and inspire learners is having massive consequences in many developed countries, including the United States, Australia, the United Kingdom and Ireland (Department of Education and Science Ireland 2002c, Peters 2002, Osborne et al. 2003, Matthews 2007, Rowlands 2008). The need for science has never been so significant; today’s world consists of a more technological society, where arguably science is needed for full citizenship. Science promotes critical thinking and a concern for evidence. The contemporary Irish classroom requires “more than a knowledge of basic concepts”; it requires an understanding and appreciation for the “how” and “why” of science (Osborne 2007, pg: 174). This vision for science education is often referred to as developing “scientific literacy”.

This section of the literature review investigates the main ways in which science pedagogy has developed in the past few years and the pedagogical trends that have influenced science education, in the hope of developing the “scientific literacy” of society. The section begins with an examination of the term pedagogy and an exploration of the main philosophies of learning.

Defining Pedagogy

Similarly to the concept of curriculum, pedagogy is very much a contested issue that can be viewed from many different perspectives. In the past the most common view was the notion of pedagogy as a science: a complex skill that could be learned or developed as an art (Hopkins et al. 1994). Best (1988, pg: 154) identifies pedagogy as the science of education, because the substance of pedagogy lies much less in the processes that it brings into play than in the theoretical reasoning through which it discovers, evaluates and co-ordinates these processes. Another perspective is put forward by Davies (1994), who indicates that pedagogy involves a vision (a theory, a set of beliefs) about society, human nature, knowledge and production, in relation to educational ends, with terms and rules inserted as to the practical and mundane means
of their realisation (cited in, Daniels 2001). An alternative notion present in the literature is the notion of pedagogy as craft. This is offered by those who recognise the limits of predictability and uncertainty (McDonald 1992, Marland 1993 cited in, Mortimore and Watkins 1999, pg: 2). Another form in which pedagogy can be viewed is similar to the concept of “curriculum as a selection from the culture”: the notion that pedagogy can be guided by a person’s beliefs or values. For this research project the view of pedagogy follows the work of Petty (2009), where pedagogy refers to the theory or science of teaching, encompassing all activities around the creation and transfer of knowledge within a classroom, including teaching, learning and assessment. Sociologists have long shown that schooling is anything but a passive and neutral activity; what counts as “appropriate” or “acceptable” pedagogy is always conditioned by choices about what skill pupils need to know (Kaiser 2005, pg: 1, 2). Pedagogy is a concept where the “intellectual rubber meets the politico-cultural road” (Kaiser 2005, pg: 1, 2). Watkins & Mortimore (1999), highlighted four main phases through which the concept of pedagogy has gone. These stages are listed as:

- Focus on teachers
- Focus on the context of teaching
- Focus on teaching and learning.
- Focus on integration

According to Osborne (2007, pg: 173), science education at present rests on a set of arcane cultural norms; one of the most fundamental of these cultural norms is the tension between “training” and “educating” the future scientist. This tension exists due to the needs of the minority who will continue the study of science and the needs of the majority who will not. The current needs of the future scientist, according to Osborne, are met by an education essentially of a foundationalist approach, which “attempts to educate the neophyte pupil in all basic concepts of the discipline”, however, an infinite time and cumulative generations deem this quite difficult (2007, pg: 174). The pupil of the future requires more than the just basic concepts of science but also needs a vision of how they relate to other events, why this is important and how this view of the world came to be (Osborne 2007, pg: 174). Osborne identifies that our primary aim for science education in the twenty-first century should be to develop “scientific literacy” (2007, pg: 173, 174).
Learning Science

“Learning can be considered as the process by which knowledge, concepts, skills and attitudes are acquired, understood, applied and extended” (Pollard et al. 2008, pg:170). It is an amalgamation of cognitive, affective and social basics, a process by which learners construct knowledge by “modifying and revisiting existing ideas” (Driver et al. 1994, Bransford et al. 1999, Loucks-Horsley and Matsumoto 1999). Bransford et al. (1999) outline the following points in relation to learning and learners:

- New knowledge is built on learners’ prior knowledge
- Learning is an active process
- Knowledge is constructed through a process of change
- New knowledge comes from experiences and interaction with ideas and phenomena
- Learning needs to be situated in meaningful and relevant contexts
- Learning is supported through interaction

Teaching and learning science is, in its own right, an investigative and constructive process, some forms of teaching can reinforce this process while others can inhibit it (Hawkins 1994, pg: 9). In its simplest and uncomplicated form, learning can be viewed as the product of interaction between development and experience through life (Blyth 1984, cited in Pollard 2008, pg: 172). A feature within research around learning science, that has developed over the last twenty or thirty years, has been the rejection of science as a list of facts, and instead put forth the notion that science is a system of ideas (Driver 1983, Driver and Bell 1986, Atkin and Black 2003, Trumbell et al. 2005). Unfortunately, however, learning in science has traditionally been taught didactically, with pupils’ often describing school science as the transmission of content from expert to passive novice (Lyons 2006, pg: 595, Prince and Felder 2006, pg: 22, Watters and Watters 2007, 2008). The concept of repetition and “recitation” still dominate the field of school science (Atkin and Black 2003). Often the only motivation behind learning material in science for pupils beyond grades obtained, has been the usefulness of its content later on in the curriculum or in their career (Prince and Felder 2006). Millar (1989) acknowledged that school science can carry somewhat a “limited value” as it can come to look like a transmission of knowledge that cannot be challenged by pupils (1989, pg: 590). “Several scholars have argued that learning has both individual and
sociocultural features, and have characterized the learning process as one of enculturation and construction” (Driver et al. 1994, Borko 2004, pg: 4). For centuries, psychologists and philosophers have laboured to investigate learning, with an aim to try and outline how learning takes place, and as a result there have been many alternative theories of learning put forward (Pollard 2008, pg: 172). Research findings have supported this by demonstrating that pupils do not enter science instruction without any pre-conceived ideas (Duit and Treagust 2003). The next section of the literature will examine the main philosophies of learning in relation to science.

3.3.1 Philosophies of Learning Science

The teaching and learning of the secondary school science classroom has seen unprecedented changes in the last twenty years; research activity around science and technology has seriously influenced and affected school science and its provision. A key area of the research has been the development of different models of learning (Piaget and Inhelder 1958, Osborne and Freyberg 1985, Daniels 2001). Early work focused on the personalised Piagetian notion of the epistemic entity, while now more recent work adopts the Vygotskian social agenda (Scaife 2000, Alsop and Watts 2003, pg: 1044). Such models can be incorporated and merged into many areas of education: curriculum change packages, teaching and learning resources, assessment methodologies and/or developed into strategies to make teaching and learning more effective and real (Kennedy 2004, pg: 24). This section of the literature seeks to examine these philosophies of learning associated with science and examines science education from the traditional and constructivist perspective. Research within science education has had a long-standing cognitive tradition (Alsop and Watts 2003).

The Traditional Approach

Traditional paradigms in education have purposefully focused on the learning with little regard for the social and the cultural factors of learners (Atwater 1996, pg: 821). Often referred to as the transmission view of teaching, this is primarily what we now in the twenty-first century aim to move away from. The “transmission of knowledge” classroom is didactic, with a very high percentage of “chalk and talk”, and low levels of
teacher-pupil interaction. While a certain percentage of this type of teaching and learning may be required, it has major limitations (Bennett 2003, pg: 23).

Science has traditionally been taught through the deductive and didactic positivist paradigm of teaching and learning, where science has been presented as a rigid body of facts (Levitt 2001, Stolk et al. 2009). This traditional approach stems from the behaviourist theory of learning from the early 1960s and the work of psychologist B. F. Skinner (Prince and Felder 2007, Pollard 2008). The behaviourist theory of learning, casts the learner in a passive role, leaving the selection, pace and evaluation of learning activities to the teacher (Skinner 1985, pg: 291). Teaching in this manner attempts to transmit to learners concepts which are precise and unambiguous; it is transferring ideas from expert to novice (Carr et al. 1994, pg: 147). Frequent use of transmissive pedagogy in science leaves pupils with the impression that science is a body of knowledge to be memorized (Lyons 2006, pg: 95, Stolk et al. 2009). Textbooks become sources of facts and theories about a concrete world, which pupils learn off and recite, and learning becomes superficial and fragmented (Carr et al. 1994pg: 147, 148, Pollard 2008, pg: 174). The pupil is identified as a “blank slate” with no prior knowledge or conceptions of their own (Scaife 2000, Bennett 2003, pg: 23). This has led to the widespread notion that one learns to pass examinations, rather than to become more knowledgeable (von Glasersfeld 1995, pg: 177). This model of teaching and learning has been reinforced substantially in Ireland through the current state examinations process and entry to third-level. Subsequent research on this model has shown, that pupils taught in the “transmission / traditional” manner become quite passive and as a result become quite disengaged and alienated from the classroom environment and what is being taught (Driver and Bell 1986, pg: 443, Carr et al. 1994, pg: 148). Research has managed to dispel the notion that “students are empty vessels waiting to be filled with new ideas”; what we know now is that pupils carry their own prior knowledge, along with beliefs and values, all which influence how and what they learn in the classroom (Loucks-Horsley et al. 2010).

This approach to teaching is not conducive for the teacher’s professional development either, as it encourages a technical culture, with a fragmented and mechanistic pedagogy (van Driel et al. 1998, pg: 674). Research has shown that teachers who teach in this manner are more likely to be unsure about their own
knowledge and prefer transmissive teaching, as it avoids discussion and possible revelations of a teacher’s uncertainty (Carr et al. 1994, pg: 148). Driver identified that “teaching science cannot be viewed as the transmission of knowledge from teacher to pupil, as pupils may not interpret teaching in the ways expected by their teachers” (Leach 1998, pg: 4). While Lortie (1975), remind us that the purpose of teaching to “facilitate” learning opposed to “delivering content” (pg: 61).

**The Constructivist Perspective**

Research in science education has seen rapid growth and dominance of the philosophy known as “constructivism”: “constructivism provides the philosophical foundation for reform in science education” (Levitt 2001, Palmer 2008, Heywood and Parker 2010). It stands out against the traditional method and overrides the long-established technical transmission of knowledge paradigm (Hawkins 1994). The constructivist theory suggests that people learn through an interaction of personal and social experiences (Scaife 2000, Palmer 2008, Pollard 2008, pg: 175). While the name is modern and relatively new, the theory can be traced back to Plato and Socrates, or in more contemporary times Kant, Toulmin, Dewey and Freire (Hawkins 1994, pg: 9, 10, Nola 1997, pg:58, Freire 2009). Constructivism is a theory of learning with its origin in the cognitive sciences; it is learning that “is influenced by prior experiences and ideas” (Bennett 2003, Ferguson 2007). Ausubel (1968) noted that “the most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly”. The core commitment of a constructivist position is that knowledge is not transmitted directly but rather actively built up by the learner (Driver et al. 1994, Pollard 2008, pg:175, Heywood and Parker 2010). A move towards constructivist teaching practices requires, however, a new vision of teaching and learning, “a paradigm shift for those in the educational community” (Levitt 2001). The concept of learning science in this way is that knowledge is formed by pupils constructing their own meaning from their experiences, rather than acquiring knowledge from alternative sources (Brooks and Brooks 1999, Bennett 2003, pg: 25). Research carried out on constructivism has overwhelmingly shown that children arrive into science lessons with ideas already formed, in order to help make them sense of the world around them (Osborne and Freyberg 1985, Loucks-Horsley et al. 2010). There are many different research traditions relating to the theory of constructivism. Within constructivism there
have primarily been two main strands of learning theory from which science education has drawn upon (Leach and Scott 2003).

There is, however, disagreement within the literature regarding the precise manner in which the learning process occurs (Palmer 2008). As a result there are many “forms”, “brands”, “versions” and “types” of constructivism. Epistemologies were questioned due to the socio-cognitive ways pupils learn, limitations were realised in the late 1980s and early 1990s, which led to the merger of constructivism with social constructs, resulting in “multi-perspective epistemological frameworks in order to adequately address the complex process of learning” (Duit and Treagust 2003). These versions of constructivism have led to the suggestion of a continuum (Atwater 1996, Palinscar 1998, pg: 347, Staver 1998, pg: 503, Ferguson 2007, pg: 29). One end stresses the individual as knowledge constructor, often referred to as “personal constructivism”, while the opposite rejects this notion of objective knowledge and argues instead that knowledge is co-constructed through a community of learners in dialogue with each other, which became known as “social constructivism” (Piaget and Inhelder 1958, Driver et al. 1994, von Glasersfeld 1995, Palinscar 1998, pg: 347, Daniels 2001, Lemke 2001, Palmer 2008) (see Figure 3.4). The next section of the literature will explore these two areas of constructivism in more detail.
Phases of the Constructivism movement - Personal Constructivism

The first strand of learning theory within constructivism has its origins in Piaget’s genetic epistemology (Leach and Scott 2003). Socrates gains credit for being the first to articulate the concept of the learner as a builder of knowledge (Nola 1997). However, it is the work of Piaget in the 1960s and 1970s that gained considerable interest. He developed the stage theory of cognitive development (Piaget and Inhelder 1958, Snowman and Biehler 2006, Pollard et al. 2008). The concept of Piaget’s cognitive development theory was that children inherit two basic tendencies: 1) the tendency to organize and 2) the tendency to adapt. Knowledge they develop or create is systemized and combined into coherent general systems. When new knowledge is received it is either assimilated into pre-existing schemes, or else the scheme is accommodated to fit the new experience (von Glasersfeld 1995, pg: 62-66, Pollard et al. 2008, pg: 175). Meaningful learning occurs when children create new ideas of knowledge from their existing information. The learner is actively engages in the process and utilises previous knowledge to construct new knowledge. It needs to be acknowledged that the learner actively engaged in the learning as an individual (Leach and Scott 2003, pg: 43). This process of creating knowledge is referred to as “personal” constructivism by psychologists and educationalists. Its origins are rooted in the work of American psychologist George Kelly (1971) and his work on “personal construct theory”.

Personal constructs are described as the dimensions we use every day to conceptualise new aspects of life. Kelly’s work influenced thinking about constructive alternativism, leading to more modern techniques when dealing with behavioural issues (Hallam and Ireson 1999, pg: 74). According to Ferguson (2007), personal constructivism focuses on “the sense making or meaning making that occurs as individuals try to understand their experiences with the world in which they live”. Learning in science classrooms, from this perspective, requires well-designed and presented practical activities that challenge children’s prior conceptions and encourage learners to re-organise personal theories (Driver et al. 1994, pg: 5). Piaget “viewed constructivism as a way of explaining how people came to know about their world” (Brooks and Brooks 1999, pg: 29). By the late 1980s however, “personal constructivism” had reached its pinnacle, and limitations were beginning to surface. One concern at the time was that the process of “the constructivist model of learning has
become associated with a particular model of instruction” and was “beginning to plateau” (Millar 1989, pg: 588).

**Phases of the Constructivist Movement - Social Constructivism**

The second strand of learning theory within constructivism saw the development of “social constructivism” and “radical constructivism”, developed around the work of Vygotskian and non-Vygotskian psychology (Leach and Scott 2003). Both are very similar and arose in the late 1980s, when there was an emergence of critical writing and an increase in theoretical debate on the nature of constructivism and its development. Social constructivism was proposed as an alternative to personal constructivism by Solomon (1987) and O’Loughlin (1992) (cited in Ferguson 2007), where learning is described as being embedded in social and cultural experiences and factors. “Learning and meaning-making are portrayed as originating in social interaction between individuals” (Leach and Scott 2003, pg: 92, 93). The early cognitive approaches of constructivism tended to exclude the societal and cultural factors from its context (Daniels 2001, pg: 69). Within this broader view of learning there is more emphasis on the context in which learning occurs, and it also places more emphasis on the “socio-cultural aspects” (Bennett 2003, pg: 33, Palmer 2008).

Social constructivism draws on the work of Vygotsky, who “emphasised the importance of culture and language in the development of knowledge and understanding” (Solomon 1998, pg: 42, Bennett 2003, pg: 47). Vygotsky distinguished two types of learning: those that occur from the bottom-up (spontaneous concepts) and those that result from adult-generated or top-down activities (scientific concepts) (Palincsar 1998, pg: 351-354, Solomon 1998, pg: 42). He suggests that learning takes place when the two concepts meet in the zone of proximal development (ZPD). Social constructivism focuses on the interdependence of social and individual processes in the co-construction of knowledge (Driver et al. 1994, pg: 5, Palincsar 1998, pg: 345, Bennett 2003, pg: 47). Social constructivism places less importance on the individual and more on the learning community and context in which learning takes place. The role of the teacher is one of support, helping pupils to make sense of ideas and practices of the scientific community.
3.3.2 Science Education for the contemporary classroom

Science education is important because it offers:

- A way of thinking about the world that has application in everyday life, and
- Well-founded explanations of the world

(Newton 2008, pg: 6)

The research literature on science education has shown a variety of changes in science pedagogy, in an effort to stop the decline of science (Osborne and Freyberg 1985, Driver et al. 1994, Levitt 2001, Borko 2004, Tytler et al. 2011). Pedagogy has been a major concern for recent reforms both in the United States and in Europe (Kaiser 2005, pg: 1). The decline in the uptake of science has for many years overwhelmed policymakers, education researchers and teachers, along with many other education stakeholders (Department of Education and Science Ireland 2002c, European Commission 2007, Asay and Orgill 2010, Stolk et al. 2011). One of the common threads in this debate is a pupil’s ability to learn and understand science, as “many children find it difficult to understand ideas put forward in science lessons” (Osborne and Freyberg 1985, pg: 5). Much of the research surrounding pedagogy and pedagogical practice in science has only taken place since the 1980s and since then has produced many studies of how pupils learn, where the difficulties lie, and what makes learning science easier (Driver 1983, Driver et al. 1994, Monk and Osborne 2000, Bennett 2003, Kaiser 2005, Lyons 2006, Rowlands 2008, Heywood and Parker 2010).

Science education, therefore, has not remained unscathed from the challenges of the twenty-first century. Today’s society calls for a more demanding and active curriculum, and a more scientific and technologically-advanced population is needed to meet the demands of the economy (European Commission 2007). Gilbert (2006, 2011) acknowledged five main challenges to science education, which were supported by others in the same field (Laugksch 2000, Bennett 2003, pg: 102, Gilbert 2006, Gilbert et al. 2011). The five challenges are:
1. Lack of clear purpose
   o Confusion over why science should be learned
2. Widespread curriculum content overload,
   o Isolated facts and concepts of varying significant (Millar and Osborne 1998)
3. Incoherent learning by students
   o content of the curriculum is fragmented and does not allow for a “mental map” to be achieved
4. Lack of relevance to students
   o Irrelevant to everyday lives, especially where the goal is the development of scientific literacy (Gilbert et al. 2011)
5. Lack of transfer of learning to new contexts
   o Struggle to transfer knowledge to situations other than the one in which it is learned (Gilbert et al 2006)
   (Gilbert et al 2006, Gilbert et al 2011)

As a result learning in science has had to change down through the years to encompass these challenges and develop learning into a more socio-cultural process. The literature has shown that the quality of learning that a pupil undergoes is shaped by their learning experience, interests and aspirations (Pollard et al. 2008, pg: 171). An OECD study (2006) highlighted how the traditional science pedagogical approach could stifle a child’s natural curiosity towards science and therefore have a negative influence on the development of attitudes toward learning science. Science pedagogy for the contemporary classroom requires pupils to think critically, make judgements, solve complex problems, communicate and collaborate (‘Partnership for 21st Century Skills' 2004, Loucks-Horsley et al. 2010, pg: 66). Embracing new pedagogical methods is not just beneficial for the pupil; it also promotes and extends the professional knowledge of the teacher. The next two sub-sections address the concepts of pedagogical content knowledge (PCK) and scientific literacy, both of which, according to the research literature, are the new way forward for science education in the twenty-first century.
Pedagogical Content Knowledge (PCK)

PCK incorporates:

An understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons.

(Shulman 1986, pg: 9)

The knowledge construct that is PCK has become very important in the area of science education and science teacher research, due to the issues associated with the interpretation and representation of science in teaching (Heywood and Parker 2010). The literature has shown that the development of PCK is an “important aspect of teachers’ professional knowledge” (Berry et al. 2008) and therefore essential for any innovation in classroom learning in the twenty-first century. PCK has proved very influential in science education research (Heywood and Parker 2010). This section of the literature will explore the origins of PCK and the necessity for PCK in the contemporary classroom.

Origins of PCK

Pedagogical content knowledge (PCK) was devised by Lee Shulman in the 1980s, and has subsequently become a way of describing the “professional knowledge” of a teacher (Shulman 1986, van Driel et al. 1998, van Driel et al. 2001, Berry et al. 2008, Kind 2009). Shulman claimed that to be the best possible teacher, a strong PCK was needed, (Berry et al. 2008) as it “identifies the distinctive bodies of knowledge for teaching”, “blending content and pedagogy” (Shulman 1987, pg: 8), transforming and interpreting “subject matter knowledge in the context of facilitating student learning” (van Driel et al. 1998, pg: 673). The pedagogical content knowledge (PCK) of teachers combines both subject matter knowledge (SMK) and a teacher’s pedagogical knowledge (PK) (Shulman 1986). According to Shulman, in the literature and teacher education programmes at the time, there was only a focus on the skill of teaching, and questions regarding content knowledge and subject matter were missing (Shulman 1986). The absence of a focus on subject matter was referred to as the “missing paradigm” by Shulman and his colleagues (Shulman 1986, pg: 7-9, Berry et al. 2008, Kind 2009, pg:172). Without this, Shulman argued that a teacher could not fully understand or appreciate how to make knowledge and ideas relevant to pupils or understand how
subject matter could be made into instruction (Shulman 1987, Kind 2009, pg: 172). It was impossible to understand how pupils interpreted lesson knowledge and what impact their prior knowledge would have (Kind 2009, pg: 172). To fill this “gap” that existed in teacher knowledge, Shulman proposed “the knowledge base for teaching” (Shulman 1987, van Driel et al. 1998). The knowledge base consisted of seven categories, three of which were content related, while the other four referred to general pedagogy, learners and their characteristics, educational contexts, and educational purposes (Shulman 1987). The three categories of content knowledge for teachers were

- Subject Matter Content Knowledge (SMK)
- Subject Matter Pedagogical Knowledge (PCK)
- Curricular Knowledge

(Shulman 1986, pg: 9-10, Kind 2009, pg: 172)

The notion of pedagogical content knowledge was to bring together the knowledge of subject matter and the skill and knowledge of teaching (e.g. pedagogy). The foundation of PCK was thought to be influential in the way teachers taught so as to engender pupils’ learning for understanding (Berry et al. 2008). To be truly professional, both aspects had to be equally developed (Shulman 1986, pg: 7-9, Shulman 1987, Berry et al. 2008, Kind 2009, pg:172).

There have been many varying definitions of what “PCK” actually means. However, they all form around Shulman’s notion of transforming knowledge for the purpose of teaching/pedagogy. These differences in the portrayal of the relationship between the sub-domains of teacher knowledge have, however, four commonalities which researchers agree influence PCK. Fig 3.5 shows the influences on the development of PCK.
The need for PCK in the contemporary classroom

Much research and literature has explored how to close the gap between the theory and practice of teaching and learning, breaking down the rhetorics of the classroom while developing the professional status of the teacher (Berry et al. 2008, Gleeson 2009). This has been exceptionally difficult as the knowledge and theories that influence a teacher’s practice often remain tacit (Schön 1983). School teachers have little expectation for developing links between theory and practice due to the great demands of time, curricula and pupil achievement in the classroom. As a result, the focus for school teachers tends to be on “doing” teaching. However, if science teaching and teaching generally are to be better appreciated then this link between theory and practice is not only needed but should be expected (Berry et al. 2008, Gleeson 2009). One way of reducing the gap between the theory and practice of teaching science in the twenty-first century, is through the development of PCK (Berry et al. 2008).

PCK brings the value of specialist subject matter knowledge into teaching, it highlights how good teaching needs more than a set of generic skills, and most importantly it opposes the technical culture of teaching (Loughran 2007). PCK is a theoretical construct that develops knowledge and expands a teacher’s professional experience (Loughran et al. 2008). It develops both the internal and external constructs of teaching (Gess-Newsome and Lederman 1999). It has been described as the knowledge used to transform subject matter content into forms more accessible for pupils (Park and Oliver 2008). PCK involves a dramatic shift in teachers’
understanding. This shift in teacher understanding is what transforms the teacher into an expert, according to Shulman (1986); their ability and capacity to turn the content knowledge he/she possesses into different forms for pupils of varying ability and background makes them an expert.

Research on PCK has found it to be useful in exploring aspects of teachers’ professional knowledge (Loughran et al. 2008). PCK facilitates the development of “craft knowledge”, which acknowledges the complexity of teaching and therefore promotes teacher empowerment and enhances the professional status of teachers (van Driel et al. 1998, pg: 674). Craft knowledge according to van Driel et al. (1998) guides teachers’ actions, while also encompassing their beliefs and values around pedagogy, subject matter, curriculum and pupils. It is underpinned by prior education and ongoing schooling, but ultimately it is teacher’s personal background and the context in which they work that shapes the development of teachers craft knowledge. In some instances PCK has been put forward as a way of “aiding experienced teachers in developing more reflective practices” or helping “novices adjust to teaching” (Park and Oliver 2008, Kind 2009, pg: 169). As a result, for some the development of PCK within teacher education is considered a primary goal (Borko and Putnam 1996).

The Concept of Scientific Literacy
Scientific literacy is the new axiom in the world of science education pedagogy. The 1990s saw huge debate about scientific literacy, as concerns for the educational challenges of the twenty-first century drew closer (DeBoer 2000, Duit and Treagust 2003). The literature has shown that scientific literacy is valued and recognised as a desirable outcome of pupil learning within science (Lang et al. 2006, Smith et al. 2011). It has become increasingly common in debates about aims, objectives and purposes of school science education (Millar 2006, pg: 1499). In 1990 at the UNESCO World Conference on Education for All, it was maintained that science education should promote a world community of scientifically and technologically literate citizens and so along came the concept of “scientific literacy” (Miller 2001, pg: 145, Millar 2007). The impact that scientific literacy has had on curriculum reviews and developments has been worldwide, with strong contribution to curriculum development in the United Kingdom, United States and Australia (Laugksch 2000, Miller 2001, Lang et al. 2006, Millar 2006, pg: 1500, Smith et al. 2011). It needs to be acknowledged that while referred to
as scientific literacy in America, in Britain the phrase “public understanding of science” is more commonly used (Laugksch 2000, pg: 71). Conceivably the greatest indication of the impact of “scientific literacy” in current thinking comes from the Organisation for Economic Co-operation and Development (OECD) in their decision to replace “level of understanding of school science” with scientific literacy in their Programme for International Pupil Assessment (PISA) (Miller 2001, Millar 2006, pg: 1500). Incorporation of scientific literacy into the Third International Mathematics and Science Studies (TIMSS) identified the huge deficiencies in scientific literacy around the globe. While the term “scientific literacy” seems straight-forward, its implications for the pedagogy of science can be quite confusing at times (Smith et al. 2011).

Scientific literacy has been around for some time, even though its only in the last few years that a major move towards a pedagogy that can support and increase it has been seen (Millar 2006, pg: 1501, Osborne 2007). Scientific literacy was first coined in the 1950s in a publication by Paul Hurd (1958), after an impetus interest was raised in the post-sputnik America about developing the scientific ability of society (DeBoer 2000, Laugksch 2000, Osborne 2007). It has since then been an elusive term and has resisted precise definition (DeBoer 2000, pg: 582). Similar to the concept of curriculum change and professionalism, scientific literacy has been difficult to define. The term is very much contested and debated within the literature (Laugksch 2000, Duit and Treagust 2003, Lang et al. 2006). The differences in relation to defining or unpacking the term are mainly due to the varying definitions and expectations that are associated with the word (Laugksch 2000, Smith et al. 2011).

In its simplest form “scientific literacy” is shorthand for “what the general public ought to know about science” (Osborne 2007, pg: 176). DeBoer (2000), in an extensive review of the use of the term, noted nine different meanings, while Norris and Phillips (2003) recognised ten different ways (2003, pg: 225). DeBoer argued against a confined or exact definition, and instead offered “to speak of scientific literacy is simply to speak of science education itself” (DeBoer 2000, pg: 582). Norris and Phillips (2003) offer the argument that “scientific literacy” must be grounded in the fundamental sense of literacy as the ability to interpret and analyse text. They contend that science could not exist as an oral tradition; scientific texts are essential and not optional. (Norris and Phillips 2003, Millar 2006, pg: 1502, Osborne 2007, pg: 177). (Lang et al. 2006)
acknowledged that scientific literacy constitutes “a literacy that crosses disciplinary boundaries and puts human values at the centre of educational practice”. This is similar to the concept explored in PISA, where “cross curricular competencies and science processes are given particular emphasis” (Duit and Treagust 2003). It is essential that a definition is agreed upon before trying to implement any types of reform, as without a clear idea it can at best become a vague notion (DeBoer 2000, pg: 582).

At the core of scientific literacy is the need to understand and appreciate science, that is, the “cultural argument” of literacy (Millar 2006, pg: 1503). There is a need to move away from proficient specialist areas of science and its intellectual products; the learning of facts and the memorizing of numbers, and instead move towards the critical consumer of broad general science, leaving specialization to those who wish to acquire it. Driver and Osborne (1998) identified four arguments for scientific literacy; the economic argument, the utility argument, the cultural argument and the democratic argument. From these arguments it can be viewed that the traditional view of learning key concepts is far too narrow for developing scientific literacy; there is a need instead to encompass the social aspects also (Lang 2006). New approaches to develop scientific literacy, however, do not come without challenges. According to Lang (2006) the challenge is “to see the subject in a new light”, and to accompany this many different pedagogical trends have been developed in science education (pg: 178). The next section of the literature review will explore some of the common trends that have affected science education, in the hope of developing and supporting the scientific literacy of pupils.
3.3.3 Pedagogical Trends for the contemporary Classroom

The Rocard Report (2007) acknowledged that “improvements in science education should be brought about through new forms of pedagogy” (European Commission 2007). The research literature has acknowledged the challenges facing science education and in order to combat this within most if not all of the literature, the promotion of scientific literacy and the enhancement of PCK has been offered, reinforced by a deep understanding of the socio-cultural constructivist approach to learning (Bell and Gilbert 1996, Bennett 2003, pg: 102, Gilbert 2006, Millar 2006, Osborne 2007, Gilbert et al. 2011). This constructivist view brings information about pupils’ learning to the fore, and incorporates and identifies pathways that pupils’ learning can take. The next section of the literature review will explore the two predominant concepts currently being developed and explored within science education in the hope of meeting these challenges. The new approaches include: 1) the context-based approach and 2) the inquiry-based approach. These new approaches not only help to develop the PCK of the teacher but also the establishment and formation of scientific literacy for his/her pupils.

Context-Based Learning in Science

Context-based approaches are increasingly being implemented to address the challenges within science education, and are considered an important development in curriculum design and approach to classroom teaching (Gilbert 2006, Gilbert et al. 2011). The last twenty years have seen an increased emphasis in the use of context and applications as starting points within science education lessons. This is often what differentiates context-based approach from other approaches: the links/connections are made at the beginning of the topic and used as an opening or starting point to introduce and develop scientific ideas. Research has shown that the context-based approach to learning has the following affects on teachers and pupils:

- Increases pupils’ interest and enjoyment
- Helps pupils to build an appreciation for the subject
- Develops links between science and everyday life
- Pupils learn as effectively as they do in conventional courses
- It is a model that involves the teacher more and so if more effective in changing practice and in their professional growth
- Alleviates teacher anxiety when faced with innovation

(Bennett 2003, pg: 114, Gilbert 2006, pg: 114)

The initial idea of the “context-based” approach within science education was to engage both the context in which concepts were used and the interaction between concepts in a more open manner. This would in turn make learning science more relevant and interesting for pupils. There is a “desire to show young people links between the science they study in school and their everyday life” (Bennett 2003, pg: 101, 102, Stolk et al. 2009). The traditional view of science has led to science becoming isolated from society and so context-based approaches offer a way to address the problem (Stolk et al. 2009). To be effective, however, context-based designs must be embedded within a clear assumption of how learning takes place, and most often in science this is within the constructivist philosophy of learning (Gilbert et al. 2011, pg: 821).

There are many different meanings and models of “context-based learning”. A narrow view would be the application of a theory in the lesson, which is often the view most expressed in developing curricular material (Bennett 2003pg: 105). Whitelegg and Parry (1999) in relation to physics learning, broadly suggest that context-based learning means the “social and cultural environment in which the pupil, teacher and institution are situated”. While within chemistry education, (Gilbert 2006) outlined four different models for a context-based approach to learning. These included;

1. Drawn from presumed personal / social aspects of a student’s everyday life,
2. Concept is formed by the juxtaposition of the concept and application
3. Context is provided by personal mental activity
4. Context as a social aspect, is situated as a cultural entity

(Gilbert 2006)

Bennett (2003, pg: 106) acknowledges that meanings drawn from the literature alone are not sufficient for applying meaning to a context-based approach. True to their purpose many context-based approaches are better defined and illustrated through the materials/resources they involve. From the literature there are four broad groups into which material for context-based teaching and learning can be divided:
- Specifically developed courses that contexts form the frameworks in a coherent and systematic way e.g. Salter’s programme in the UK
- Materials are whole courses where scientific contexts and applications are the focus of the instruction, course is driven by contexts and applications e.g. ChemCom in the United States.
- Units of material developed about particular contexts and applications, generally used to replace more conventional topics
- Very short units used within conventional lessons (1-2 lessons only) e.g. Science and Technology in Society (SATIS) units in England.

(Bennett 2003, pg: 104)

Context-based teaching and learning has been strongly mentioned in the debate about scientific literacy (Bennett 2003, pg: 104), as its purpose is to provide a “coherent, structural meaning for something new” where pupils are able to provide meaning and experience the learning as relevant to some aspect of their lives (Gilbert 2006, pg: 960). From which, in turn, a mental map may be drawn of the subject and its topics, for the pupil to develop an appreciation and understanding of the topic and therefore enhance their scientific literacy. The context-based approach to learning also offers the potential for teachers to develop their PCK, as it helps to lessen the gap between theory and practice, but also enables the teacher to explore differing aspects of their professional and pedagogical knowledge.

**Inquiry-Based Science Education (IBSE)**

Inquiry-based science education is another concept that has seen significant development within science education research (Crawford 2000, Deters 2004, Crawford et al. 2005, Trumbell et al. 2005, Asay and Orgill 2010). Inquiry provides an environment in which meaningful learning can take place, and offers pupils a way in which they can learn about the nature of science and develop their own scientific thinking (Asay and Orgill 2010, pg: 57). Similar to context-based learning, inquiry-based learning can be generally defined two ways: the first in the professional sense, using non-linear, messy pathways similar to the professional scientist, while the second way is used to describe an active learning process (Asay and Orgill 2010, pg: 58). Inquiry as an active learning process engages pupils; it is a process by which pupils
learn and participate. Some would argue that “process” is the incorrect term and that in fact inquiry is instead a “vehicle” for learning (National Research Council 1996). Inquiry-based learning offers an alternative approach to conventional teaching and learning and incorporates several characteristics including:

- Usually starts with question or scenario
- Student-centred
- Encourages pupils to ask questions
- Promotes dialogues
- Promotes critical thinking
- Develops transferable life skills
- Encourages collaborative learning
- Supports the role of teacher as facilitator

(Broggy 2010)

Learning outcomes that have been associated with the approach within science have included the ability to develop hypotheses, establish a plan for generating and collecting data, and most importantly it has given pupils a voice and the ability to construct arguments based on evidence (Trumbell et al. 2005, pg: 880). Inquiry-based learning has proved to be successful in developing pupil attainment, increasing levels of interest and stimulating teacher motivation (European Commission 2007, pg: 2).

Similar to all curricula design changes, implementing the inquiry-based approach brings changes to teacher practice and these are not achieved without barriers. Research has identified that teachers face challenges when implementing inquiry (Crawford 2000); challenges include worrying about not having enough control over the classroom activity (Deters 2004), safety within the laboratories (Deters 2004), mixed-ability setting and pupils perhaps not capable of carrying out the tasks (Asay and Orgill 2010), while others simply think that there is not enough time to cover the mandated curriculum through an inquiry-based approach (Deters 2004).
3.3.4 Pedagogical Change: An Irish Context

The most radical pedagogical change to take place within an Irish context in the last decade has been the change in structure of assessment within lower secondary science. 2003 saw the introduction of a revised science syllabus; this was a revised version of the 1989 syllabus and was devised by the NCCA course committees and approved by the Minister of Education and Science. The 2003 syllabus differed in many ways from the previous syllabus and for the first time dealt with assessment procedures, in the hope of adjusting the traditional didactic teaching methods, reported by the OECD to still exist in Ireland (OECD 1991, Shiel et al. 2009). The revised syllabus was significantly different to the assessment applied in the 1989 syllabus (SEC 2006, pg: 3). There was a move away from one written terminal examination, worth a hundred percent, to a three tier component assessment model. It was envisaged that the revised syllabus would help deal with the decline in the uptake of science. The new course was activity-based in its design and emphasised the practical element of science (Department of Education and Science Ireland 2003, pg: 3). The main areas to be changed within the syllabus included:

- An increased emphasis on scientific investigation
- Reduced content
- Simplified structure (divided into the 3 to represent biology, chemistry and physics)
- Learning outcomes were introduced
- An investigative approach was embodied

(NCCA 2003c)

The integration of learning outcomes de-emphasised the method of approach taken by teachers, and allowed for flexibility in designing experiences that suit all level of pupil ability, achievement and interest (NCCA 2003a, pg: 6). It also allowed the pupil to gain 35% of their grade before sitting the terminal examination. The revised syllabus of 2003 was a turning point in the history of science education in Ireland, with the inclusion of coursework and practical elements, and abolishement of the 100% terminal examination. There was clearly a more marked effort toward the practical side of science (Department of Education and Science 2003, pg: 6, 7).
The introduction of coursework A and coursework B replicated this major new emphasis being placed on the active participation by the pupil and the embodiment of the investigative approach. The concept behind the integration of these two new coursework sections was for the pupils to personify the work of a scientist and to be enthusiastically involved in their own learning. The written terminal examination of the new revised syllabus took the form of a “completion-style booklet” (SEC 2006, pg: 4), divided into three sections, one representing each of biology, chemistry and physics, and three questions in each section per topic. Noteworthy is that this new form of assessment does not allow any choice; pupils must answer all questions on the paper.

Coursework A is developed around prescribed experiments and laboratory activities. Pupils are involved in completing and reporting ten prescribed experiments per topic (biology, chemistry and physics), and are encouraged to keep a laboratory book detailing the experiments. The completion of the experiments is “signed off” by the school (SEC 2006, pg: 3).

Coursework B aims more towards an inquiry-based approach to learning. Pupils are required to complete two prescribed investigations, and to submit a pro forma report for assessment. These prescribed titles are given out by the State Examinations Commission (SEC). The titles of these investigations change each year but three options are offered, one for each branch of science studied. Alternatively, pupils can opt to do one larger investigation of their own choice that meets the criteria, instead of the two prescribed ones (SEC 2006). The optional programme in coursework B was seen to promote new pedagogical approaches by allowing pupils to take on the role of scientists independently in the classroom. However, in correspondence with the Junior Science Support Services (JSSS), it would seem that not many schools are opting for this alternative. The promotion and foundation of innovative competitions such as the BT Young Scientist (BTYS) and SciFest are all seen in aiding pupils’ initiative to get involved and have an interest in science, and so it is envisaged that participation in these competitions will lead to a higher rate of uptake in the alternate coursework B.
3.3.5 Summary of Section

“Changing pedagogy requires appropriate implementation”

(Stolk et al. 2009, pg: 166)

This section of the literature has explored what is meant by pedagogy and learning with an in-depth exploration of some pedagogical trends relevant to science education. Two main philosophies of learning have been explored in the hope of guiding the reader through the continuum that is learning. It is clear from the literature that learning is a social process that involves prior knowledge and the freedom to assimilate and generate one’s own ideas. In-depth learning does not occur when facts and dates alone are memorized, learning requires understanding. In terms of science education the literature has highlighted the need for change in how students learn science, in order to help increase numbers and fight the decline in science uptake at secondary education. This section of the literature review has also sought to highlight the strong impact that an emphasis on PCK and scientific literacy can have on the development of science education for the twenty-first century.
3.4 Conclusion of Chapter

To support the emerging themes selected for review from the exploratory first phase of the study, it is envisaged that the conclusion will help demonstrate the connectedness of the three themes (see Figure: 3.0.6).

Curriculum is much more than mere content; viewing the concept of curriculum as a selection from the culture brings with it ideas of pedagogy and professionalism. Failure to understand and appreciate each of these facets will result in curriculum failure and a teaching community that feels no ownership, and old, traditional didactic pedagogies that remain uninteresting to pupils. In Ireland there has been a strong tradition of the “top-down” approach to curriculum matters, where curriculum has been viewed as a “thing” involving only content. This approach to curriculum matters has left Irish teachers isolated and in the dark professionally. It has developed a culture where dialogue surrounding teaching and learning is uncommon and pedagogical innovation sporadic.

If there is to be a move forward into the twenty-first century, there is a strong need to recognise the negative culture that this view of curriculum brings forth. There is a necessity to empower teachers with the sense of ownership, where they can be lifelong learners as well as leaders of pedagogical innovations. Perceiving the curriculum as a thing, leaves behind concepts such as scientific literacy, and the impact this can have on pupils and society; it leaves behind the notion of PCK, and the professional development of the teacher. A new view of curriculum should be established, with all aspects of it involving pedagogy and professionalism of the teacher. Curriculum change for contemporary Ireland requires a much more democratic and relational approach, where both teachers and policymakers work together in the professional development of education. Establishing an approach that is built on partnership and recognising
individual differences gives a much more realistic chance of success. School-university partnerships offer one such partnership that could aid this rejuvenation of curriculum, professionalism and pedagogy.

Science education is suffering at the cost of the decline in pupil uptake. There is a need to revive the place of science and a key place to begin is in the classroom of lower secondary pupils. It is in this phase of their education that pupils get a real sense and flavour for science at upper secondary and tertiary levels. It is vital that this phase of their education system “sells” the concepts of science for those wishing to study further but also offers a knowledge base of scientific literacy for those who do not. The literature shows that to engage teachers in any new curricular changes, that there is a need to give ownership and empower teachers to overcome barriers and believe in themselves as pedagogical innovators. However, as seen from the literature, this cannot be done where the culture of the school is not recognised. Here again implementing school-university partnerships can help identify and work within the existent cultures of a school.

Therefore, it can be concluded from the exploratory phase one of the study and the literature review, that a thorough understanding of what has been done in the past, helps indicate what is needed for the future. Teachers need to be engaged in curricular matters as key change agents, which in turn will help them to gain ownership and grow professionally, empowering them to become pedagogical innovators for the contemporary classroom. One approach to support this could be school-university partnerships, where school cultures are acknowledged and recognised and where teachers and researcher work together in a mutually beneficial relationship, sharing meaning and supporting one another.
4.0 The Emerging Theoretical Framework
4.0.1 Introduction
The purpose of this chapter is to set out the theoretical framework that has guided the research. The theoretical framework links together the literature and methodology while taking into consideration the personal perspective that the researcher brings to the project.

To help the reader gain a thorough understanding of the development of the theoretical frame, the author returns to the strategy of inquiry mentioned previously, reaffirming the research aim and research questions before examining the theoretical frame designed, developed, and implemented. Following on from this, an understanding of what is a theoretical framework is then examined, along with an exploration of the considerations made before developing the framework. A summary of frameworks and models found in the literature that influenced the study follows, with each framework individually summarized. It is from the amalgamation of these frameworks, that the theoretical frame for this research is developed. The purpose of developing a framework unique to this research was to help serve as a useful tool for referencing and identifying changes within the research.
4.1 Review of Inquiry

The aim of this research project is to empower teachers professionally to develop curriculum ownership and pedagogical innovation in the teaching and learning of science in the contemporary Irish school and classroom.

4.1.1 Research Questions

- To explore the impact of policy on the teaching and learning of science through content analysis of International and Irish Government documents from the 1960s
- To investigate the attitudes and beliefs of lower secondary science teachers in Ireland to curriculum development, teaching and learning methodologies and assessment
- To determine the effectiveness of a school-university partnership as a means for implementing curricular change and developing teachers as professionals in the Mid-West of Ireland

4.1.2 “Layering it all up”, developing the theoretical frame

The primary aim of the research as mentioned above was to develop an innovative approach for the teaching and learning of science in lower secondary education in Ireland. Such a task is by no means a simplistic one. Developing innovation in the classroom is a complex process that involves a democratic and relational approach, along with a thorough understanding of context. Therefore, the research questions were developed and designed in a specific manner to inform the research by gradually building on each successive stage.

The starting point for the research was a policy text analysis of official government documents to help contextualise the impact of policy on teaching and learning at lower secondary level in Ireland. Following this, it was clear that the next step was to gain an appreciation of what practising in-service teachers nationally believed about the emergent themes. Once an understanding and appreciation achieved, the third phase, developing an innovative approach could begin. This phase and the
theoretical framework for the project were strongly influenced and impacted by the findings from phase one and phase two, along with the research literature.

4.2 Development of a Theoretical Framework

In this section, the author will explore what a theoretical framework means. Also examined are the overarching concerns and considerations within the project in the hope of bringing together the researcher’s personal position, the research literature and the aim of the study.

4.2.1 What is a theoretical framework?

A theoretical framework is a structure that ascertains and depicts the major elements, variables or interpretations that organise a research project (Ennis 1999, pg: 129). It is a system of ideas and theories about knowledge, about how research should be conducted and how research should be reported (Bodner and Orgill 2007). According to Ennis (1999) theoretical frameworks help to understand what is already known about the topic and identifies what needs to be learned or discovered (pg: 133). A theoretical framework grows out of the research focus, adds structure to the research plan and guides the research design (Ennis 1999, pg: 129). It has great affect on the design, data collection, and data analysis of qualitative studies. According to Crotty (1998), a theoretical framework is the “philosophical stance informing the methodology and thus providing a context for the process and grounding its logic and criteria” (pg, 3). Each researcher is responsible for making explicit the framework he or she has chosen or developed, as is the case in this study. It needs to be acknowledged that a theoretical framework is very subjective and is heavily influenced by the researcher’s own ontological and epistemological position. The next section outlines the considerations that were assessed before developing the framework in light of the research but also the researcher’s own personal context.
4.2.2 Considerations for developing a theoretical framework

Prior to developing the framework, it is necessary to take into account some considerations that arose from the literature and the researcher’s personal context (see Figure 4.1). These considerations included:

- Researcher’s epistemological beliefs
- Key stakeholders
- Partnership
- Philosophies of learning
- Promoting learning
- Awareness of context

![Figure 4.1 Considerations for Developing the Theoretical Framework](image)

The considerations above developed from both the literature research but also from the researchers own ontological and epistemological beliefs. It is important for any research that the researcher is fully aware of the personal construct they bring to the research.

The research project set out to create an innovative approach for the contemporary Irish science classroom. To accomplish this it was vital to outline from the very beginning who were the key stakeholders within the research. From the first
phase of the research project it was evident that teachers did not feature much in policymaking within Ireland, nor did there seem to be any guarantee of a significant role for them into the future at policy level (OECD 1991, Trant 1998, NCCA 2003b, 2007, Trant 2007, Gleeson 2009, NCCA 2009, Shiel et al. 2009). Based on this knowledge it was established that the teacher was to be the key stakeholder within the project. The research project was about developing an innovative approach, which encompassed change in curriculum, pedagogy, and professionalism. As the literature has shown all three elements are needed for innovation to be developed (Stolk et al. 2009, Stolk et al. 2011). While studying “teaching as a profession” in final year at the University of Limerick, it was clear that for teachers to become professionals they needed to be empowered and to be able to take ownership of their work. This was also evident in the literature research from the work of Bell and Gilbert (1996). The central system currently in place goes against this in every way (Trant 2007, Gleeson 2009).

As the current project is part of a European Comenius 2.1 Project, it is understandable that university researchers and academics would also play some part as stakeholders. However it was important that this role was equivalent to that of the teacher, and that the university researcher did not come across as “expert” as has been the case so many times before in educational change and professional development programmes (Stenhouse 1980, Cochran-Smith and Lytle 1990, Clandinin and Connelly 1992, Cochran-Smith and Lytle 2009, Loucks-Horsley et al. 2010). The key stakeholder within the research was therefore to be the science teacher in lower secondary education in Ireland working in partnership with the University researcher. Partnership cuts any red tape and allows both parties to move beyond competition (Giddens 1998, Hargreaves and Shirley 2009). The partnership has to be innovative in its approach: it has to mentor teachers to empower them within their work, help them to gain ownership and support them in developing innovative pedagogical approaches to science. Each stakeholder working together for the same shared meaning (Warren and Peel 2005, Burton and Greher 2007).

Quintessentially the partnership is about both parties learning: schoolteachers and teacher education researchers learning how to develop innovative approaches for the contemporary classroom; learning how to work mutually together; learning how to share a vision; learning how to work in partnership; learning how to trust; learning how
to share amongst peers; learning how to take ownership; and learning how to reflect and mentor each other. **Promoting learning** is therefore a key consideration within the research project. A conscious effort by the researcher is necessary to ensure teachers that the author too is learning and is in no way an expert. For teachers to be open to learning and for learning to begin, it is vital that they feel safe and comfortable, that the environment they are in is not only trusted but relational and democratic (Day 2000, Day *et al.* 2000, Day and Sachs 2004, Loucks-Horsley *et al.* 2010). It is important that space is developed and created where teachers can talk freely about their own personal experiences and not worry about what others think. From the literature, there is a long history of teachers, within the Irish context, not engaging in professional dialogue around teaching and learning (OECD 1991, Shiel *et al.* 2009). It is therefore a key consideration of the project to promote a learning environment, which would cater for this and allow teachers to discuss freely what happens in their classroom. As Guskey (2002) acknowledges “what motivates teachers to engage” and “the process by which change in teachers typically occur” needs to be fully understood and nurtured into bloom. The rhetoric and reality need to become one for the sake of innovation and change (Levitt 2001, Ostermeier *et al.* 2010).

The literature surrounding the three key areas has described the important role that **context** plays within each, especially around the aspect of “change” and bringing about change. The research literature on school culture and curriculum change acknowledged the importance of context and cultural understanding. Curriculum change fails when policy makers develop uniform changes for all without any awareness of the differing contexts between classrooms and schools (Sarason 1990, Dalin 1993, Stoll and Fink 1996, Prosser 1999b, Fullan 2001a, 2010). A lack of contextual awareness around student learning will only help to disengage students from learning, as each student is individual and each student learns differently. Professional change cannot occur either where an appreciation of the context in which teachers work is not understood. For professional change to be effective it must be relevant and appropriate to the teacher who partakes in it, it must be relevant to their schools and stage within their career. Any project that hopes to bring about change in any of these three areas: curriculum, pedagogy, or professionalism, needs to have full awareness and understanding of context or else they are destined to fail.
The next section will demonstrate how these considerations were put into place through the development of a unique theoretical frame. Drawing from a variety of frameworks within the literature, the researcher will develop a unique framework that will take all these considerations into being.

4.3 Summary of Theoretical Frameworks from the Literature

This section will explore the frameworks found in the literature that discuss factors that influence an innovative classroom approach. Relevant elements from each framework are drawn and used in the construction of a specific and unique framework for this research project. This approach for the development of the theoretical frame has been adapted from the work of Declan Kennedy in his PhD Thesis “An investigation of student teachers teaching of difficult ideas in Chemistry” (Kennedy 2004). In his thesis Kennedy, focused on six frameworks and identified seven common themes that were threaded throughout each framework, which he used to analyse his data. The framework for this study has been adapted to include five frameworks and instead of common threads each framework will play a significant role developing the overall theoretical framework for the study.

The framework has been heavily influenced by and built upon the work of Bransford, Brown and Cocking’s (2001), How People Learn (HPL) and Darling Hammonds and Branford’s (2000) Preparing Teachers for a Changing World. When developing an innovative approach for the contemporary classroom it is necessary that an appreciation of “how people learn” and an “understanding of teaching and learning” exists. Each of the frameworks plays an individual role and is significant in its own right. The framework builds on the work of Darling Hammond and Bransford (2005), and brings together: knowledge, the learner, assessment, and the community. Before exploring the individual frameworks, the author feels it necessary to outline the foundational framework from which the project was designed and developed.
4.3.1 Framework for Understanding Teaching and Learning

“Preparing Teachers for a changing world: what teachers should learn and be able to do” Darling-Hammond and Bransford (2005)

The framework developed by Darling Hammond and Bransford (2005) was an expansion of the How People Learn (HPL) framework developed by Bransford, Brown and Cocking (2000). The HPL framework (see below Figure 4.0.2) identifies four key perspectives to consider within learning. It acknowledges that these four principles are necessary for learning to take place and while each principle is capable of being dealt with independently, conceptually all can be interconnected, reciprocally supporting one another (see Figure 4.2). This support is what the authors referred to as “alignment”. This framework offers a significant guide for implementing change, as “effective change requires a simultaneous consideration of all these factors” (Moss 2008, pg: 152). Therefore, an innovative approach for the contemporary will not occur without embracing all key four elements of learning.

![Diagram](image)

Figure: 4.2 HPL Framework Developed by Bransford, Brown and Cocking (2000)

Darling Hammond and Bransford (2005) then further adapted the HPL framework into a framework for “understanding teaching and learning” and examining the interactions between learners, teachers and content. Two key conditions of practice, which impact and influence what teachers need to know and are able to do, encase their framework.

- Teaching is a profession
- Education must serve the purposes of a democracy
This framework offers a solid foundation for this research project as it provides a set of lenses to examine any teaching and learning situation through reflection and from which practice can be improved upon. Figure 4.3 below is a graphic representation of the framework which they developed.

![Diagram](image)

**Figure: 4.3 Framework Developed by Darling Hammond and Bransford (2005) for Understanding Teaching and Learning**

It is clear from the work of Moss (2008) and Darling Hammond (2009) that for effective change, a deep understanding and appreciation for teaching and learning is necessary first. Merging both their work it is clear that the following is true:

- Learner-centred, in turn becomes knowledge of learners, and their development
- Knowledge-centred, in turn becomes knowledge of subject matter and curriculum goals
- Assessment-centred, in turn becomes knowledge of teaching and content
- Community, encompasses teaching as a profession, learning in a democracy
In the development of the framework for this research, the author has lifted these four key areas to represent the following broad representations:

- **Curriculum**: knowledge of curriculum goals, knowledge of subject matter
- **Pedagogy**: knowledge of teaching, content knowledge of assessment
- **Professional development**: knowledge of learning, context of learning
- **Awareness of Context**: democratic and relational approach to teaching, learning and change

The following diagram in Figure 4.4 represents the underlying foundation for the framework:

![Diagram](image)

**Figure: 4.4 The Underlying Foundation for Theoretical Framework**

Table 4.1 summarizes each framework, with the influential factor to “an innovative classroom for the contemporary Irish classroom” outlined. From here, the author will merge the frameworks and develop a unique framework for this study and for future work.
Table 4.1 Summary of Theoretical Frameworks

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Type of Article</th>
<th>Title of Article</th>
<th>Focus of Work</th>
<th>Theoretical frameworks for factors that influence an innovative classroom in Ireland</th>
</tr>
</thead>
</table>
Preparing teachers for a changing world  
Teaching as a profession  
Learning in a democracy |
Collaborative model  
School/university partnership | Fundamental principles for partnership |
4 strategies for professional development  
5 elements for teacher based curriculum design  
Teacher Knowledge  
Teacher learning theory  
Professional development  
Context based learning | |
Change in beliefs and attitudes can only come after a change in classroom practices when student improvement is viewed. |
4.3.2 Framework for Partnership

“Collaborative Model for Schools Reform Through a rural School/University Partnership” Warren and Peel (2005)

The framework offered by Warren and Peel (2005) offers a “blueprint for other schools and universities as they engage in collaborative initiatives” (pg 348), and was developed when a principal felt that “outside assistance with an inside mentality” was needed (pg 347) This framework for partnership is about democratic collaboration and shared goals. The framework developed in teachers “a greater sense of unity, a greater sense of empowerment, and higher sense of responsibility for the schools destiny and an increased level of pride” (pg: 351). Figure 4.5 below outlines the four characteristics that, when implemented, increase success for school reform through collaborative inquiry.

Figure 4.5 Framework for Partnership adapted from Warren and Peel (2005) for school reform

For the purpose of this research project, the framework offered by Warren and Peel (2005), bring:

- Importance of understanding the context
- Importance of communication, working together for the same goal
- Regular contact with teachers and schools involved at all times
- Importance of building confidence and self-belief, creating a support network internally dependent on the university mentors
- Researchers must make an active role and contribution and listen
4.3.3 Framework for Professional Development


Increasingly professional development frameworks are being used to help in the design of activities that promote the professional development of teachers (Stolk et al. 2011, pg: 369). This framework brings to the study an approach to accomplish the task of teacher empowerment (Stolk et al. 2009, pg: 164). The framework developed by the authors was a “synthesis of goals, strategies, events and learning theory” (Stolk et al. 2009, pg: 172).

The most important aspect for this research project was the inclusion of a learning theory to support the professional development of teachers. Too often in professional development there was a lack of attention to the learning process and how people learn (Stolk et al. 2009, pg: 168). As a result, Glaperin’s theory for internationalization of actions was incorporated by Stolk et al (Glaperin 1992). Glaperin’s theory is a further development of the work of Vygotsky and the “socio-cultural perspective on learning” (Glaperin 1992). Incorporation of this learning theory led to the integration of the following systematic sequence into the framework:

- Building motivation
- Orientating on action
- Providing the practice within actions
- Checking and evaluation the learning process and results

The framework also incorporated four general strategies for professional development (Stolk et al. 2009, pg: 154, Stolk et al. 2011, pg: 371). The four strategies include:

- Providing access to innovative units
- Organising reflection on practical experience
- Stimulating collaboration with peers
Organizing teachers designing new units

These two sets of steps in the framework offer to the research project one possible approach to engaging with the schools and helping to empower the teachers.

4.3.4 Framework for Teacher Change


This framework by Guskey (2002) examines the links between teacher change and professional development. It outlines two important considerations for working with teachers and initiating change.

- What motivates teachers and
- Process by which change in teachers occurs

Teacher are motivated around professional development because they feel it will contribute to their knowledge and skill, contribute to their growth and enhance their effectiveness with students (Guskey 2002, pg: 382). This model developed by Guskey (1986) offers a framework for this approach. It recognizes that changes in classroom practices (curricular), improved student learning outcomes (pedagogy), and changes in teachers’ attitudes and beliefs (professional) are all goals of professional development. The model outlined proposes that when these are put in a specific sequence, teacher change through professional development can be accomplished. Figure 4.6 below displays the sequence of events from a professional development experience to produce change in teacher attitudes and perceptions (Guskey 2002, pg: 381).

Figure: 4.6 Framework for Teacher Change adapted from Guskey (2002)
The central point is however that the change in attitude and belief does not necessarily come through the professional development aspect per se but more through the successful implementation of new pedagogy practices (Guskey 2002, pg: 383). The framework highlights how it is not until a change in seen in student learning, that a change of teacher beliefs and attitudes can really take place.

4.3.5 Framework for Reflective Practice

“Transforming Teaching Practice: Becoming the critically reflective teacher” Larrivee (2000)

The process of reflective practice has been strongly associated with the professional development of teachers. The framework outlined by Larrivee (2000), is an acknowledgment that reflection is not a linear or step-by-step process; instead it offers actions and practices that support the teacher to become critically reflective. The framework offers three aspects to consider in the development of critically reflective teachers, see Figure 4.7.

![Diagram of the Framework for Reflective Practice]

Figure 4.7 Framework for Becoming a Reflective Practitioner Adapted from Larrivee (2000)

Integrating these three aspects supports the development of learning communities. If teaching is to be recognised as a profession there is a need to develop such communities, and not only discourse communities but authentic learning communities (Larrivee 2000, Tytler et al. 2011). By creating “learning communities” Larrivee identifies that these in turn adjust “the power dynamics to turn power over into power
with learners”, thus developing the teacher as a “social mediator, learning facilitator and reflective practitioner” (Larrivee 2000, pg: 293).

### 4.4 Theoretical Framework for the Contemporary Irish Science Classroom

The concluding result of the research into theoretical frameworks was the amalgam of the frameworks from the literature into the development of a theoretical framework (see Figure 4.8) that integrates:

- Purposes of curriculum
- Professional reflection *and*
- Development of eclectic pedagogy

We must keep in mind the intricacies associated with these three concepts that consider them successful, notably the existence and awareness of issues such as:

- Partnership and community
- Cultural and contextual awareness
- Teaching as a profession *and*
- Importance of democratic and a relational approach

As explored in the literature section, all three concepts are inextricably linked if change and innovation is to be implemented successfully in the contemporary Irish classroom (see Figure 4.8).
4.5 Chapter Summary

This chapter has united the review of the research literature with the methodology of the research project. It brings together an awareness of the intricacies of curriculum change, professional change and pedagogical change, while also giving recognition to the main elements of each of these three aspects for successful change. The frameworks have been drawn from the international literature and gather together considerations that arose within the literature and from the researcher’s personal context. It seeks to address the epistemological, ontological and theoretical aspects of research and practice for educational innovation and change in the contemporary Irish classroom and school. Ultimately it seeks to bridge the gap between the rhetoric and the realities of policy and practice in the Irish school and classroom.

Without tying teaching and management decisions to personal beliefs about teaching, learning, and development, a teacher will have only the bricks. The real “stuff” of teaching is the mortar – what holds the bricks in place and provides a foundation.

(Larrivee 2000, pg: 293)
5.0 Research Methodology
5.0.1 Introduction

This chapter seeks to justify the methodological choices made in the research project. The chapter begins by outlining the strategy of inquiry within the study, incorporating the aim of the research project and the research questions, which underpinned its design and development. This is followed by an outline of the methods of data collection. Each phase of data collection is dealt with independently, differentiating research instrument, instrument design, study cohort, ethical considerations and research analysis taken. The chapter concludes with the limitations of the methodological approach.

5.0.2 Link to the Literature

The literature review identified three key areas: curriculum change, pedagogy and the professional development of teachers. It recognised Ireland as having an extremely centralised bureaucratic education system, whereby curriculum, teaching and learning methodologies and assessment are administered by a central body (OECD 1991, pg: 36; see all, Sect. 4.1.3). Although changes have been introduced to help alleviate this problem in the past, the grip of a centralised system cannot be avoided too easily. The literature surrounding professional development brought the singular aspects of the project together, as it has shown that teachers cannot affect curriculum change if they do not become more engaged and take the stance of a profession, nor can teachers increase pupil learning and change the didactics of their classroom if they do not see themselves as professionals and feel a sense of ownership over their work.

The target audience for the research was lower secondary science teachers, as both international and national literature has shown a downturn in the uptake of physical sciences in upper secondary education, which is affecting colleges and universities, and in turn influencing our industry and economy (Smyth and Hannan 2002, OECD 2004, European Commission 2007, OECD 2007, Perkins et al. 2010, Stolk et al. 2011). Research has shown that this downturn in numbers choosing science has been linked to various elements: its non-compulsory status, the teaching methodologies employed, and learning environments created or not created as is the case here in Ireland (Smyth and Hannan 2002).
5.1 Strategy of Inquiry

This section sets out the aim of the research followed by the research questions that have driven the study. This section also explores the paradigms of research and outlines the approach taken within the project.

5.1.1 Aim of Research

The aim of this research project is to empower teachers professionally to develop curriculum ownership and pedagogical innovation in the teaching and learning of science in the contemporary Irish school and classroom.

5.1.2 Research Questions

- To explore the impact of policy on the teaching and learning of science through content analysis of International and Irish Government documents from the 1960s.
- To investigate the attitudes and beliefs of lower secondary science teachers in Ireland to curriculum development, teaching and learning methodologies and assessment.
- To determine the effectiveness of a school-university partnership as a means for implementing curricular change and developing teachers as professionals in the Mid-West of Ireland.

Table 5.1 offers a timeline of the research project.
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5.1.3 Paradigms of Research

There is no single way to investigate report or acquire knowledge. In the past philosophers developed “paradigms” to specify different ways that best suited certain investigations and reports (Kane and O’Reilly-de Brún 2001, pg: 14, Bryman 2008, pg: 605, Trifonas 2009, pg: 297, 298). A paradigm is a set of beliefs or assumptions that guide action within a research project: they impact the nature of phenomena, the way things are studied and also the design and methods employed (Guba 1990, pg: 17, Kane and O'Reilly-de Brún 2001, pg: 14, Parahoo 2006, pg: 38). Paradigms of research are distinguished by the view of social reality that they follow (Cohen et al. 2000, Patton 2002, Burrell and Morgan 2005, Coady 2010). The two views of social reality are: objective and subjective. Burrell and Morgan (2005) indicate that there are four assumptions which underpin these views: the ontological, the epistemological, the methodological and human nature.

The two main paradigms within educational research are 1) the traditional paradigm also referred to as the positivism paradigm and 2) the post-positivism or anti-positivist paradigms (Guba 1990, pg:17, Cohen et al. 2000, Kane and O' Reilly-de Brún 2001, pg:14, Coady 2010). They are also differentiated by the generic perspectives as “normative” and / or “interpretive” (Cohen et al. 2000, pg: 22). The normative or traditional paradigm believes that human behaviour is essentially rule-orientated and should be investigated by the methods of natural science. While the interpretive or anti-positivist paradigm is characterised by the “concern for the individual” (Cohen et al. 2000, Patton 2002, pg: 546). The researcher will now explore the main characteristics of each.
Positivist Paradigm

Research that is underpinned by the positivist paradigm is regular and orderly, stable, constant, and most importantly objective. It examines society collectively, analysing relationships between variables or separate aspects of reality (Bassey 1999, Kane and O’Reilly-de Brún 2001, pg: 15, Burrell and Morgan 2005, pg: 42, Castro et al. 2010). The role of the researcher is as analyst of the subject matter (Cohen et al. 2000, pg: 9). Research methods employed are done through empirical measurement, and much time and effort goes into designing and developing the research instrument (Denzin and Lincoln 1998, pg: xii, Kane and O’ Reilly-de Brún 2001, pg: 15, Parahoo 2006, pg: 40, 41). The methodology is often described as “quantitative”, as it involves quantity measurements that are subjected to statistics, e.g. questionnaires, surveys (Bassey 1999, pg: 42, Kane and O’ Reilly-de Brún 2001, pg: 16). It has been recognised that positivism is less successful in its application to human behaviour, and as a result it does not suit social science research in schools or classrooms, as the complexity of human nature, contrasts with the paradigms views of order and regularity (Cohen et al. 2000, pg: 9, 10, Castro et al. 2010, pg: 343).

Post-Positivist Paradigm

The other main strand of research followed within educational research is underpinned by the post-positivist or interpretive paradigm. This is viewed as an alternative to the positivistic paradigm. This strategy requires that respect is shown for the differences between people and the objects of the natural sciences. The exploration of a particular case is essentially interpretive; the researcher is required to grasp the subjective meaning of social action (Bassey 1999, pg: 44, Cohen et al. 2000, pg: 181, Bryman 2004, pg: 13). Research methods employed in this paradigm are of a qualitative nature, trying to examine the whole person (Krippendorff 2004, pg: 17, Castro et al. 2010). In rejecting the objective view of social reality, an individual’s behaviour can only be understood by the researcher sharing the same frame of reference (Guba 1990, pg: 20-27). The onus is on the researcher to construct subjective meaning from the in-depth analysis of a population.

On consideration of both paradigms and incorporating the aim of the research, it was decided to incorporate a mixed methods approach to the research design. This approach to the research would also offer “a more rigorous and integrative analysis of
qualitative textual evidence and quantitative numeric data” (Castro et al. 2010, pg: 344). An approach like this is often referred to as “integrative mixed methods design”. Increasingly mixed methods research is being recognised as a major third research paradigm or research approach (Johnson et al. 2007, pg: 112, Castro et al. 2010, Harrits 2011). “Methods usually associated with different paradigms are increasingly being used in the same study” (Parahoo 2006, pg: 100). A research paradigm is also known as a “methodological paradigm”, expanding the notion that a paradigm can be developed around how research is conducted and how it is undertaken (Johnson et al. 2007, pg: 130). The mixed methods approach of the study will be explored in more depth in the next section.

5.2 Approach to the Study

The approach to the study was exploratory in design. The first phase of data collection was carried out prior to the literature review. The themes that emerged from this phase would in turn drive the literature review and the subsequent research design. The purpose of this approach was to allow the researcher to address the aim of the research by beginning with the first research question “to explore the impact of policy on the teaching and learning of science”. It was recognised by the researcher that in order to develop an innovative classroom, a good foundation and understanding of the past needed to come first.

The investigation is planned over three phases, which will create a “collective case study” around the main themes of curriculum, pedagogy and professional development. A “collective case study” is where the researcher wishes to study a number of cases jointly in order to inquire into phenomenon, population or general condition (Stake 1995, pg: 3, 4, Stake 1998, pg: 88). Encompassing a mixed methods approach offers a more in-depth and reliable way of gathering findings, that attempts to collect multiple viewpoints, perspectives and attitudes (Johnson et al. 2007, pg: 113). The three phases for data collection are:
5.2.1 Mixed Methods Approach

Mixed methods research is quickly becoming a third paradigm within social science research (Harrits 2011, pg: 151). A significant amount of the literature identifies different grounds for the inclusion and exclusion of such an approach in research investigations (Denzin and Lincoln 1998, Kane and O’Reilly-de Brún 2001, Bryman 2004, Onwuegbuzie and Leech 2005, Johnson et al. 2007, Bryman 2008, Castro et al. 2010, Tashakkori and Teddlie 2010, Harrits 2011, Kington et al. 2011). Mixed methods attempts to respect the viewpoints of both paradigms, while seeking a workable middle ground (Johnson et al. 2007, pg: 113). Mixed methods is a concept of sharing similar characteristics as opposed to being dichotomous to each other (Parahoo 2006, pg: 87, Harrits 2011). Two main arguments surrounding mixed methods are: the notion that research methods carry epistemological and ontological commitments; while the second argument centres around the paradigm debate (Bryman 2008, pg: 604, 605, Castro et al. 2010, pg: 342). However, as acknowledged by Bryman (2008) there are “areas of overlap and commonality”, therefore making the fixed epistemologies and ontology’s difficult to sustain within social science research (2008, pg: 604, 605).

Within the research project, the two paradigms are viewed as complementary, with each phase of data collection offering successively more valid and reliable knowledge. The mixed methods approach offers the project a different way of viewing society and therefore a more exclusive and in-depth perspective, as Parahoo (2006) remarks, “every method has its weaknesses” (Burrell and Morgan 2005, pg: 25, Parahoo 2006, pg: 89). The incorporation of qualitative and quantitative methods authorises the researcher to explore relationships further and in more depth (Berg 2001, pg: 2, Bryman 2004, pg: 460). As Bassey (1999, pg: 44) recounts, “the public world is positivist; the private world is interpretive”. By combining both methods the researcher becomes pragmatic, adding supplementary value to the research. It opens an opportunity to unite both the macro and micro levels of the research subject, which feed into the
investigation findings and conclusions (Onwuegbuzie and Leech 2005, pg: 383). Results from the different methodological strategies are “mutually reinforcing” (Bryman 2004, pg: 455). “Qualitative data can be used to supplement, validate, explain, illuminate, or reinterpret”, while “quantitative data can be gathered from the same subjects or site” (Miles and Huberman cited in Bogdan and Biklen 2006, pg: 41) The most common approach of combining both qualitative and quantitative research methods is done through the implementation of a triangulation research design (Bryman 2008, pg: 608).

5.2.2 Triangulation
The concept of triangulation is employed in a research design when trying to combine qualitative and quantitative research methods, sometimes it is referred to as “mixed methods” or “multi-methods” (Parahoo 2006, Bryman 2008). Triangulation can also be implemented when a “more holistic view of educational outcomes is sought” (Cohen et al. 2000, pg: 115). Using only one source of information can lead to a linear study, whereas, the incorporation of more than one source offers a more robust piece of research (Berg 2001, pg: 4, 5, Bogdan and Biklen 2006, pg: 115). Triangulation also reduces significantly the chance of bias and misinterpretation within in a study and therefore increases the validity of a study (Cohen et al. 2000, pg: 112, Patton 2002, pg: 93, Bell 2005, pg: 116, 167, Bryman 2008, pg: 608). Patton (2002) identifies four types of triangulation within social science research, these include:

- Triangulation of data sources (data triangulation)
- Triangulation among different evaluators (investigator triangulation)
- Triangulation of perspectives to the same data set (theory triangulation)
- Triangulation of methods (methodological triangulation)

(Patton 2002, pg: 245)

Generally “methodological triangulation” is the most implemented: this involves “the use of two or more methods of data collection in the study of some aspect of human behaviour” (Cohen et al. 2000, pg: 112, Parahoo 2006, pg: 99, Bryman 2008, pg: 379). Triangulation is evident in various parts of the research project. On the whole the “collective case study” encompasses the approach of “data triangulation” or “combined
levels” approach to triangulation”, whereby the three phases of data collection are feeding into the same question or theory. The “combined levels of triangulation” incorporate cultural and group analysis. Where possible combining several levels of analysis is the preferred approach (Cohen et al. 2000, pg: 114). The cultural analysis explores the values, practices, traditions and ideologies of teaching and learning in Ireland in phase one and two. Within phase one, this is done from a political viewpoint, through the content analysis of policy documents, while within phase two this is explored through the findings of a national questionnaire sent to teachers. The group analysis is examined through phase three, where interaction patterns are examined between individuals and groups through the school-university partnership.

The second form of triangulation within the research is methodological or data triangulation. This is used in phase three within the case study schools, and the collection of data from teachers, pupils and researchers. Data triangulation involves collecting data from more than one source and is aimed at “corroborating the same fact or phenomenon” (Yin 2003, pg: 99). The use of multiple sources of data allows the researcher to investigate a broader range of historical and behavioural issues. An advantage of multiple source or data triangulation in case study research, such as this project, is the development of converging lines of inquiry: the findings and conclusions are more accurate, convincing and credible (Yin 2003, pg: 98, Bryman 2004, 2008). This multi-method research approach is best when studying human behaviour and relationships as single source data provides “only a limited view of the complexity of human behaviour” (Cohen et al. 2000, pg: 112). Another advantage they examine is that of “method boundedness” which is a limitation associated with research when only one method of data collection has been used. As shown by Figure 5.1, there are three data collection points in this research, each phase complementing each other.
5.2.3 Research Design

The term “research design” refers to the plan that describes how, when and where data will be collected and analysed (Parahoo 2006, pg: 183). The rationale behind the three stages of the research design was to scaffold the research and findings from one phase to the next. The third and final phase will be informed by both the content analysis and from the national survey. This allows a more robust understanding of the current situation before engagement with teachers and schools. Figure 5.1 is a graphic representation of the research design of the study.
Figure 5.1 Graphical Representations of Research Design
5.2.4 Validity and Reliability

There are many forms and functions of validity and many types of reliability (Cohen et al. 2000, pg: 105-120, Bryman 2008, pg: 149-152). Validity is much more complex than reliability and in many ways a lot more important as a criterion of research. Validity cannot exist if a source or method is not reliable, as “reliability is a necessary precondition of validity” (Cohen et al. 2000, pg: 105, Bryman 2004, pg: 74, Bell 2005, Parahoo 2006, Bryman 2008). “The concept of validity reflects the accuracy with which the findings reflect the phenomenon being studied” (Parahoo 2006, pg: 80), and it is described as the “quality of research results that leads us to accept them as true” (Krippendorff 2004, pg: 313). In essence, “validity is concerned with the integrity of the conclusions that are generated from a piece of research” (Bryman 2004, pg: 28). Validity is significant to both quantitative and qualitative research (Cohen et al. 2000, pg: 105, Bryman 2004, pg: 28, Bell 2005, pg: 117). The main tests available for validity testing include; content validity, construct validity, and internal/external validity (Cohen et al. 2000, Yin 2003, Parahoo 2006, Bryman 2008). Each of these tests will be explored as the researcher progresses through the three stages of data collection. Reliability relates to how stable a set of results are, how repeatable a set of findings are under similar constraints (de Vaus 1996, pg: 54, de Vaus 2002, pg: 52, Field and Hole 2003, pg: 47, Bryman 2004, pg: 28, Bell 2005, pg: 117, Parahoo 2006, pg: 36, Bryman 2008, pg:149-150).

5.2.5 Research Ethics

Ethical concerns should be at the forefront of any research project and should continue through to the write up and dissemination stages. (Wellington 2000)

Ethics are a set of moral principles or code of behaviour that govern an individual (Collins English Dictionary & Thesaurus 2007, pg: 282). Ethical issues in social science research are issues that morally protect the researcher and participant. A variety of ethical issues can arise at the different stages in social research, interviews, observation, findings, dissemination (Bryman 2004 pg: 305, Bell 2005 pg: 46). In recent times there has been a growing appreciation of the moral issues involved in the work of social researchers and of the need to fully respect those involved in, or affected
by, the investigations (Cohen et al. 2000, pg: 49, Bell 2005, pg: 45). Ethical approval was not necessary for phase one of the data collection. An application was made to the University of Limerick Research Ethics committee (ULREC) for ethical consent on the 30th March 2007 for the second phase of the project. Full ethical consent was granted for the research to proceed at the end of April 2007. The ethics application granted both confidentiality and anonymity to all research participants’ in the second phase of data collection. Please note, the third phase of the research project, had a separate ethics application to the University of Limerick, as it was part of a larger research project called Gender, Innovation and Mentoring in Mathematics and Science (GIMMS). A comprehensive examination of the ethical considerations made in phase two and phase three are explored and examined in the individual sections below.
5.3 Phase One - Content Analysis

This section of the methodology will outline phase one of the research project incorporating the sample used and format implemented. This phase of the project was developed around the process of content analysis, and was done prior to a literature view to explore themes that have shaped the teaching and learning of science at lower secondary level in Ireland. Content analysis is an approach to classifying textual material. It is indispensable for researchers who must make sense of historical documents or official publications (Weber 1990, pg: 5).

5.3.1 Defining Content Analysis

There are varying definitions available for the practice of content analysis. Bryman (2008) offers the broad definition that:

> Content analysis is an approach to the analysis of documents and texts (which may be printed or visual) that seeks to quantify content in terms of predetermined categories and in a systemic and replicable manner.

(2008, pg: 247)

While Holsti (1969) offers perhaps the most widely referred to definition that “content analysis is any technique for making inferences by objectively and systematically identifying specified characteristics of messages” (1969, pg: 14). Content analysis to a degree is the analysis of the content of communication, and it can take many different forms (McDiarmid and Pratt 1971, pg: 121). Researchers who use content analysis are interested in analysing a text to determine what it doesn’t say as much as what it says (Krippendorff 2004 pg: 346, Bryman 2008, pg: 276). According to Krippendorff “content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use” (Krippendorff 1980, pg: 18, Krippendorff 2004, pg: 21).

As a methodology, content analysis can be both qualitative and quantitative; many current studies use qualitative content analysis, which address weaknesses of the quantitative approach (McDiarmid and Pratt 1971, pg: 122, Zhang and Wildemuth 2009, pg: 1). The quantitative approach was not considered for this project as it restricts content to what is common to everyone, there is no room for individuality and self-
reflection of the researcher, which was believed to be essential to this study (Krippendorff 2004, pg: 19-20). Furthermore the qualitative approach uncovers patterns and themes and not statistically significant information. Content analysis carried out in a qualitative design can be “systematic, reliable and valid” (Krippendorff 2004, pg: 10). Patton (2002) defines qualitative content analysis as “any qualitative data reduction and sense making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings” (2002, pg: 453). Qualitative content analysis is often referred to as “ethnographic content analysis”, as the role of the researcher involves the creation of meanings of and in texts (Krippendorff 2004, Bryman 2008). An ethnographic approach allows for the contributions of the reading of a text to be recognised. Approaches to qualitative analysis include: discourse analysis and rhetorical analysis. Another reason for inclusion of content analysis within this study is the approach to sampling. Quantitative content analysis requires texts to be selected randomly, whereas within qualitative texts can be purposely selected (Zhang and Wildemuth 2009, pg: 2). The format of the content analysis conducted will now be explored.

5.3.2 Content Analysis Design

The design and format of a content analysis study can begin from different starting points: question orientated, text driven, method driven etc. The starting point for this research project was “problem driven analysis”, and followed the “belief that systematic reading of potentially available texts could provide answers” (Krippendorff 2004, pg: 342, 343). The question that drove the research was “to explore the impact of policy on the teaching and learning of science”. The approach to the design was qualitative in nature, as the concept of the project sought to produce descriptions of how the social world is viewed (Zhang and Wildemuth 2009, pg: 2). The perspectives of those who produced each text can be understood better as a result of qualitative analysis (Berg 2001, pg: 242). This qualitative approach to content analysis shares the following characteristics;

- Close reading of relatively small amounts of textual matter
- Involve the re-articulation of given texts into new narratives that are accepted
- Acknowledgement of working within hermeneutic circles

(Krippendorff 2004, pg: 17, 87-89).
Below in Figure 5.2 is a graphic representation of the qualitative content analysis approach suggested by Krippendorff (2004, pg: 89).

**Figure: 5.2 Krippendorff’s Qualitative Content Analysis Framework**

### 5.3.3 Sample

Sampling refers to the selection process of a group, cohort or sample for investigation and/or study. There are two main strategies within sampling: 1) probability sampling or random sampling and 2) non-probability sampling, also known as purposive sampling, and both occur within this research project. The difference between both is described as:

In a probability sample the chances of members of the wider population being selected for the sample are known, whereas in a non-probability sample the chances of members of the wider population being selected for the sample are unknown.

(Cohen et al. 2000, pg: 99)

According to Bryman (2004, pg: 87) a sample is “the segment of population that is selected for investigation. It is a subset of the population”. “Samples can reflect the populations from which they are drawn with varying degrees of accuracy” (de Vaus 1996, pg: 60). The sample population for phase one, was policy documents from 1960s to present, which demonstrated the impact on teaching and learning of science at lower secondary level in Ireland (see Appendix C).
Berg (2001) identifies that the level on which to sample for content analysis documents can occur at any or all of the following levels: words, phrases, sentences, paragraphs, sections, chapters, books etc. Relevance or purposive sampling was employed for gathering a sample of texts, allowing the researcher to select texts that were specifically aimed at answering the research question. The researcher identified Irish government documents from the 1960s and the international OECD reports as the main units of analysis for the project (see Appendix C). The sample documents picked were those relevant to the teaching and learning of science at lower secondary level in Ireland. The justification for the selection in the research project of these two areas of documentation was:

- The 1960s saw the first real significant changes within the Irish education system and hence its selection. The researcher could have started from the foundation of the state (1921) however it was felt that 1) the volume of documentation would have been quite large, unnecessary and time consuming and 2) that the material would have been somewhat irrelevant to the research questions. The 1960s also saw the “Report of the Council of Education on the Curriculum of the Secondary School”, which was deemed pertinent to this study.

- The OECD reports were included for their relevancy and impact within the Irish Education system. OECD reports incorporate the report Teachers Matters (2005) along with the Programme for International Student Assessment (PISA) (2003, 2006, and 2009) studies as well as the recent Teaching and Learning International Survey (TALIS) (2008) report. Both of which offer significant insight into lower secondary education in Ireland.
5.3.4 Coding

Within content analysis research there is a need to make durable, valid and reliable records so that phenomena can be recorded and analysed over time, again and again. Recording and coding, “bridges the gap” between texts and “someone’s reading of them” (Krippendorff 2004, pg: 84). Coding is a technique used in organising and interpreting findings (Bell 2005). It involves assigning tags or labels as “units of meaning to descriptive or inferential information”, “codes are usually attached to “chunks” of varying sizes - words, phrases, sentences or whole paragraphs” (Miles and Huberman cited in Bell 2005, pg: 214). According to Bell (2005, pg: 214) “coding allows you to “cluster” key issues in your data”. The coding within this phase of the project relies on both verbal designations and constructs for closure. The latter aims to examine what has been omitted, known as the “latent meaning” (Holsti 1969, Krippendorff 2004). To ensure consistency the software programme NVivo has been used to code themes throughout all the documents. The coding technique used within the NVivo package was influenced by Bazeley and Richards (2000), who outlined that a pragmatic approach to coding is often more useful when working with large documents. This approach allows for passages of text to be “tagged” or coded, it outlines three steps for generating useful codes:

- What’s interesting (highlight passage)?
- Why is it interesting?
- Why am I interested in that?

(Bazeley and Richards 2000, pg: 54, 55)

Krippendorff (2004, pg: 33) outlines that it is important to note when setting the context that the researcher identify what was done with the text, how the texts came to be, what they mean and what they can do or tell. Coding of data can raise issues around reliability, what Bryman refers to as inter-observer consistency (2004, pg: 71).
5.3.5 Validity and Reliability

Content analysis involves “identifying, coding, categorising, classifying and labelling primary patterns in data” (Patton 2002, pg: 463). Qualitative content analysis resists “being forced into a particular sequence of analytical steps” and focuses more on hermeneutic circles and multiple interpretations. As a result ensuring researcher bias and subjectivity means that researchers must employ more than the criteria of validity and reliability. Alternative criteria recommended include trustworthiness, credibility, transferability, accountability, and reflexivity (Patton 2002, pg: 542-548, Denzin and Lincoln 2005, pg: 24).

Validity

For validity, content analysts need to justify their selection as much as possible. It must be demonstrated explicitly “that the information that they need for their analysis is represented in the collection of units” (Krippendorff 2004, pg: 83). The approach relies on “content validity”. This is also called *face validity*, due to the nature of data collection (Parahoo 2006, pg: 305). Findings from this form of research are accepted because they “make sense”, and “reflect the content of the concept in question” (Holsti 1969, pg: 143, Krippendorff 2004, pg: 313, Bryman 2008, pg: 152). Content validity is established through the investigator, and to display content validity within the research, the researcher is required to show that the instrument “comprehensively covers the domain or items that it purports to cover” (Holsti 1969, pg: 143, Cohen et al. 2000, pg: 109). It is necessary also that the sampling of texts is done carefully to insure representativeness. To ensure further validity, the literature suggests getting others to “act as judges” to help determine whether the measures reflect the concept (Bryman 2008, pg: 152). In the case of this research project, this strategy was also employed and it was the research supervisor who acted as judge of the material being sampled and collected.
Reliability

“Reliability is fundamentally concerned with issues of consistency of measure” (Bryman 2008, pg: 149). If participants answer the same question in the same way over a number of occasions then it is deemed reliable (Fowler 1988, pg: 91, de Vaus 2002, pg: 52). “The goal of reliability is to minimize the errors and biases in a study” (Yin 2003, pg: 37). According to Bryman (2008, pg: 149-151) there are three important factors involved in considering whether a measure is reliable: a) stability, b) inter-observer consistency and c) internal reliability. These factors are also referred to as sources of unreliability (de Vaus 2002, pg: 52). Unreliability can occur within the area of coding data, and this impacts data collection in phase one. The reliability of the coding technique can be undermined when different researchers code answers differently, especially to open questions (de Vaus 1996, pg: 52). Within phase one, decisions around categories for the content analysis can raise issues of reliability. Dependability discussed below is a parallel for reliability in quantitative research, and this will be examined in more depth.

Trustworthiness

Alternative criteria for the interpretive paradigm are offered by Lincoln and Guba (1985) for evaluating interpretive research work, as this differs from the conventional positivist research paradigm. The two primary criteria for assessing qualitative studies are trustworthiness and authenticity. This study focuses on “trustworthiness”, which itself includes credibility, transferability, dependability and conformability. Each of these will now be explored in relation to the current study.

Credibility refers to “adequate representation”, as there can be several accounts of data interpreted (Bryman 2008, pg: 377). Incorporating credibility ensures that research is carried out according to good practice. Peer briefing is one such activity for ensuring credibility. For this research project all material will be passed to the research supervisor to peer brief. For the incorporation of transferability, the onus falls on the researcher to provide data sets and descriptions rich enough so that other researchers can transfer it (Bryman 2008, pg: 378, Zhang and Wildemuth 2009, pg: 6). Employing the software package NVivo will allow for in-depth descriptions and data sets to be developed ensuring transferability. Dependability is the qualitative version of reliability, and adopting an “auditing” approach is recommended for ensuring this
criteria (Guba and Lincoln 1985, Bryman 2008, Zhang and Wildemuth 2009). Dependability ensures that all phases of the process are recorded in an assessable and reliable manner. This criterion is once again maintained by the inclusion of a peer as auditor. Similarly the criterion of conformability is maintained by the peer auditor. Conformability is concerned with objectivity and the notion that the researcher acknowledges his/her influence and that this influence is not overtly allowed. Due to the nature of the research, conformability was very important, and the researcher was conscious of one’s own perspective when carrying out the data collection. The analysis of this phase of data collection will conclude with the researcher’s interpretations. The involvement of one’s own perspective involves self-questioning and self-understanding (Patton 2002, pg: 64).

5.3.6 Research Analysis
Research analysis was carried out using the software programme NVivo. NVivo allowed the researcher to compile all the data and helped in the formation of themes. The data is categorised chronologically and a synopsis drawn on its impact on teaching and learning. The emerging themes are then identified and discussed. “The Qualitative Inquiry Reader” (2002) was used to offer the researcher some information on how best to assess and interpret text (Denzin and Lincoln 2002, pg: 229-376). When reporting findings from content analysis the researcher must strive to balance between description and interpretation (Zhang and Wildemuth 2009, pg: 5). Description will give readers background and context, while interpretation will allow the reader to understand description (Denzin 1989, Patton 2002, pg: 503, 504). Quotes from the text and literature will be interwoven to support the researcher’s interpretations and conclusions (Krippendorff 2004, pg: 88).
5.4 Phase 2 - National Survey

This section of the methodology seeks to explore the design and format of data collection in phase two of the research project. A central concern for the researcher at this stage was to achieve a representative sample of the whole population. This could have been achieved in two main ways: a self-completion questionnaire or a one-to-one structured interview (Cohen et al. 2000, Bryman 2004). The first subsection will explore why the questionnaire was preferred over the interview. The remaining subsection will examine questionnaire format, study cohort, ethical considerations, validity and relatability and research analysis. The demographic breakdown of the study cohort is given in the research findings chapter.

5.4.1 Postal Questionnaire

The questionnaire is a social survey method, and is defined as a set of questions, usually on a form, used to obtain useful data, that is mainly statistical in nature (Fowler 1988, Bryman 2004, pg: 86, Trochim 2006, Collins English Dictionary & Thesaurus 2007). It is “a highly structured technique where each respondent is asked much the same set of questions” (de Vaus 1996, pg: 80). Questionnaires can be administered in a variety of ways: postal, telephone, electronically (Cohen et al. 2000, pg: 248-266, Bell 2005, pg: 137-139). The postal questionnaire was seen to be more advantageous in convenience, cost, and accessibility for the research project, as the purpose was to get a national, representative sample. This approach was deemed convenient, and a great deal faster and cheaper than the administration of interviews or questionnaires in person, over the telephone or electronically (de Vaus 2002, pg: 123, Bryman 2004, pg: 86).

The postal questionnaire was also more convenient than via telephone or email for numerous reasons. Electronic mail systems could not be guaranteed to be an integral part of each school and locating email address for possible participants would have been quite difficult. Problems were also envisaged with the internet and its provision in schools. Along with this problems were foreseen with levels of access to computers and different levels of IT skills. Administration via telephone was deemed just as awkward, and expensive (de Vaus 2002, pg: 127). As one would have to telephone schools, not individual teachers, problems were expected with the numbers involved, the complexity involved in locating teachers, the risk involved in leaving
messages etc. Administrating the questionnaire in person was excluded due to the high costs of travel and time spent administrating it around the country. Overall it was decided that the postal administration would create the best advantage of creating a representative sample.

The way a researcher plans to draw a sample is related to the best way to collect data. Certain kinds of sampling approaches make it easy or difficult to use one or another data collection strategy.

(Fowler 1988, pg: 162)

5.4.2 Questionnaire Design

Due to the well-known problems associated with low response rates and postal questionnaires, a lot of time and effort went into the design of the instrument to maximise response rates (Cohen and Manion 1989, Cohen et al. 2000, de Vaus 2002, Bryman 2004, Bell 2005). Essential to the design process and format were matters such as choice/type of questions, inclusion of sections, incorporation of headings and subheadings, layout/appearance and length of questionnaire, and clarity of the research instrument (Cohen et al. 2000, pg: 258-259, 261). There is a need to concentrate on clarity and simplicity when working with self-completed questionnaires (de Vaus 1996, pg: 81). The research instrument was fourteen pages in length, so it was vital that appearance was of a high standard, as an attractive layout is likely to enhance response rates (Dillman 2000). While the length of the questionnaire does not indicate any clear evidence of hampering response rate, it is common sense and good practice to keep the length reasonable and ensure participation is “made as pleasant and rewarding as possible” (Cohen et al. 2000, pg: 262, de Vaus 2002, pg: 112-113). As a result of these considerations the research instrument layout was quite specific and divided into five sections for completion (see Appendix D). The final three sections were subdivided to incorporate questions under the subset heading, “your views on ….” It was envisaged that categorising the questions into sections, would lead to ease of use for the participant and it was hoped that the integration of categories would also encourage the participant to respond (Bryman 2004, pg: 137, Bell 2005, pg: 144). The design was guided by the three main themes that emerged from the content analysis. The research instrument was exploratory in its design, and in addition aimed to establish information surrounding the type of school, and the profile of teachers, and their personal views were also sought.
using an additional comments box on all three key areas, curriculum development, teaching and learning methodologies and assessment. Each of the sections is outlined below:

- General school information
  - This first section of the survey was exploratory in design and aimed to gather information about the type of school, pupil numbers, number of science teachers present in the school. It also incorporated a section on fee paying or public schooling.

- Teacher general information
  - This section gathered data on the gender of the research participant, number of years teaching and type of qualification. It also examined the main degree subject and if any post graduate courses was undertaken by the participant.

- Curriculum Development
  - This was a key area for the research. The first subsection here identified a list of statements asking teachers to respond in terms of a Likert scale. The statements were developed by the researcher and envisage gathering teacher’s attitudes to the new syllabus. The second subsection within curriculum development aimed to explore teachers’ views to curriculum development it examined satisfaction with level of input currently by teachers and additional changes they may like to make and where.

- Teaching and learning methodologies
  - This middle section examined the methodologies used by the participant. Within this section some questions were included to subliminally investigate matters around professional development. It was felt that if a section specifically focused on professional development was included that teachers may tick the alleged “right answers” to look good and therefore incorporate bias. The first subsection addressed professional membership, types of in service completed. While the second subsection examined common methodologies used in the classroom and their frequency in classes.
This final section was incorporated to gain an insight into teachers’ attitudes to methods of assessment. The year of distribution was the first year of examination for the new revised syllabus. It was envisaged that this section would help the researcher to gain an insight into what teachers felt about this new procedure and assessment in general.

“Considerable attention must be given to developing clear, ambiguous and useful questions” (de Vaus 2002, pg: 97). Questionnaire design can incorporate scale, ranking, category, and/or closed or open question type and format (Fowler 1988, pg: 86, Bryman 2004, pg: 145). The research instrument consisted of a broad range of question type: open, category, scale and grid-type questions. Open questions were avoided as they present problems in relation to time; they are consuming in development, administration and analysis. They require a lot more from the respondent, so while they were included they were kept to a minimum (Bryman 2004, pg: 145-147). It was felt that the more structured the questions, the easier it would be to complete and the easier it would be to carry out analysis (Cohen et al. 2000, pg: 261, Bell 2005, pg: 137). The majority of the closed questions used were of the scale type, with most devised around the Likert Scale (originally devised by R. Likert, 1932). Likert scales are used to learn about strength of feeling or attitude (Bell 2005, pg: 142). Grid-type questions were made use of where it was necessary, to get a response to two or more questions (Bell 2005, pg: 138).

5.4.3 Study Cohort
The purpose of this phase of data collection was to seek a response from Junior Certificate science teachers as a whole population, in relation to the themes emerging from the content analysis of the first phase. To achieve a whole population account, the literature indicates that a representative sample, which accurately reflects its population must be obtained (de Vaus 1996, pg: 60, Bell 2005, pg: 146). The benefit of creating a representative sample is the ability to generalise findings to the overall population (Bryman 2004, pg: 87, Bell 2005, pg: 145). Creating a representative sample depends heavily on the number within the whole population and also the type of sampling technique that is used. Cohen et al (2000, pg: 92) indicate that the quality of a piece of
research can “stand or fall” depending on the sample suitability. Due to the disparity of junior science teacher numbers per lower secondary education provider, it was foreseen that the sample would be generated on school numbers and not on number of junior science teachers, with one teacher representing each school. The sampling frame used was the database of lower secondary education providers for the academic year 2005/06, posted on the Department of Education and Science (DES) website (www.education.ie) (Department of Education and Science 2007). A “sampling frame” is a “listing of all units in the population from which the sample will be selected” (Fowler 1988, pg: 20-22, Bryman 2004, pg: 87). The database generated a list of 733 education providers, and was inclusive of all post-primary education providers, including all types of schools (Secondary, Vocational, Community/Comprehensive, Gaelscoileanna and Colleges of Further Education).

From the sampling frame, a simple random sample was drawn. In this type of sample, each unit of population has an equal opportunity to be included in the sample (de Vaus 1996, pg: 61, Cohen et al. 2000, pg: 100, Bryman 2004, pg: 91, Bell 2005, pg:146). Simple random sampling involves the selecting of participants randomly from a list, where each participant is independent to the next (Fowler 1988, pg: 22, Cohen et al. 2000, pg:100). One of the main reasons for the incorporation of this type of sampling is that it does not allow any human bias to manifest (Bryman 2004, pg: 91). Cohen et al. (2000, pg:100) identify only one difficulty with this type of sampling technique, “that a complete list of the population is needed and that this is not always readily available”. Fortunately this was not the case with this investigation.

The questionnaires were administered in a “pack format”, whereby each pack contained an information sheet, a questionnaire and stamped addressed envelope for return (de Vaus 2002, pg: 134, 135) (see Appendix E). In consultation with Dr. Jean Saunders at the Statistical Consulting Unit (SCU) in the University of Limerick it was determined that 500 packs would be sent out to schools selected from the sampling frame in April 2007. Each school that was selected was assigned a code, as per the technique of coding. Each coded school that did not return a questionnaire within two weeks was issued a follow-up questionnaire pack in May 2007. Follow-ups are recommended to maximise response rate (Cohen et al. 2000, pg: 263, de Vaus 2002, pg:
123). This time a new information sheet was distributed (see Appendix F), highlighting the importance of the research (Cohen et al. 2000, pg: 263, de Vaus 2002, pg: 136).

5.4.4 Validity and Reliability

When using questionnaires there are two key points that need to be taken into consideration: a) whether participants answered accurately, honestly and correctly and b) whether those who failed to return questionnaires, would have completed the same responses as those already returned (Cohen et al. 2000, pg: 128). This subsection surrounding phase two data collection outlines the strategies and techniques that were employed to maximise validity and reliability. Validity according to Gronlund (1971) should be seen as a matter of degree, not as an absolute state, and hence one should aim to minimise invalidity and maximise validity (cited in Cohen et al. 2000, pg: 104). As a result the second phase “national survey” incorporated various strategies that helped to reduce invalidity. Two strategies were incorporated to ensure reliability: these were piloting and testing for internal reliability. Even though there are disadvantages to questionnaires, they do increase reliability as they tend to be anonymous which encourages greater integrity of response (2000, pg: 73).

Validity

Several strategies that were incorporated to reduce invalidity included: the enclosure of a stamped address envelope; inclusion of helpful information stressing the importance and benefits of the questionnaire findings which outlined risks and benefits, and a return envelope (see Appendix E, F). Different features of the questionnaire, already discussed in the design of this research instrument, also helped to maximise validity, e.g. ease of completion, length of questionnaire, completion time etc. Within questionnaire research content validity and construct validity are the main tests undertaken to ensure validity. The results from this phase are automatically deemed externally valid due to the methods of collection. External validity is concerned with whether the results from a study can be generalised beyond its specific context (Cohen et al. 2000, pg: 109, Yin 2003, pg: 37, Bryman 2004, pg: 29). The results from this
phase of data collection can be generalised to all science teachers, as a random representative sample was achieved, and it is therefore externally valid.

Content validity, which has already been discussed above in relation to phase one, is tested within the questionnaire design, by submitting the questionnaire to others with experience “to judge” whether it reflects the phenomena being studied (Parahoo 2006, pg: 305, Bryman 2008, pg: 152). The questionnaire used within this phase of the research was submitted to academics and postgraduates within the Education and Professional Studies Department for feedback in March 2007. From the responses, amendments and recommendations were incorporated. However, since the research instrument was to be used by practising teachers, the researcher felt it was important to gain feedback from teachers on the final draft before distribution. Lower secondary science teachers from St. Declan’s Community College, Kilmacthomas, Co. Waterford kindly analysed and gave feedback on the questionnaire in April 2007.

Construct Validity, also called measurement validity, measures if a construct is unstable. This form of validity is most difficult for a questionnaire to achieve, as it “refers to the extent to which the questionnaire or scale reflects the construct which is being assessed or measured” (Parahoo 2006, pg: 306, 466). The most common test for construct validity is through correlation co-efficient. Correlation co-efficient tell us about the relationships between two variables, and “the strength of the relationship” (Cohen et al. 2000, pg: 198, 199, 201). Correlation analysis was carried out with a sample of statements from the “curriculum development section” of the national questionnaire that was distributed to teachers around Ireland to test for strength of construct validity (see Table 5.1). The correlation table below shows that whole group predictions for phase two can be made accurately, as Cohen et al, acknowledge that correlations ranging from 0.65 to 0.85 “make possible group predications that are accurate enough for most purposes” (2000, pg: 202). This high level of correlation allows the researcher to conclude that this phase is valid.
Table: 5.1 Correlation coefficient of lower secondary school science teacher’s attitudes towards the new programme of study for science at lower level

<table>
<thead>
<tr>
<th></th>
<th>pupil participation and input in the programme is too little</th>
<th>the junior science programme is not a substantial basis for future study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>1</td>
<td>.704**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>207</td>
<td>207</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).

Reliability

The questionnaire incorporates two strategies surrounding reliability: stability and internal reliability. *Stability* refers to the level of consistency within a measure, for example, a question may be unreliable if the wording is inadequate or poorly phrased, i.e. if a person can elicit different meanings from the same question at different junctures, the question is deemed unreliable or unstable (de Vaus 2002, pg: 52). To sustain stability within this phase the questionnaire was piloted with different groups involved in education. These included academics in the University, fellow colleagues in educational postgraduate research and most importantly practising teachers (Bell 2005, pg: 145). All groups were asked to comment on the appropriate use of language and any difficulties foreseen with the wording. Researchers and academics with experience of conducting postal questionnaires made some recommendations at the initial stages, regarding leading questions and ambiguity within the design, which helped alleviate any future problems.

*Internal reliability* needs to be tested to ensure there is coherence within answers. It is especially important where scales are being used as a means of data collection, as in phase two for this research project. “A reliable scale is one on which individuals obtain much the same scale score on two different occasions” (de Vaus 2002, pg: 184). Cronbach’s alpha is a test for internal reliability: it calculates the average of all possible split-half reliability coefficients. The alpha coefficient that is computed will be between 1 and 0; 1, signifying perfect internal reliability, and 0
signifying no internal reliability (Bryman 2004, pg: 72). 0.8 as a rule of thumb, is deemed an acceptable level of internal reliability according to Bryman, however de Vaus (2002, pg: 184) indicates that 0.70 is also deemed to have acceptable reliability. The value of Cronbach’s alpha for this investigation scored 0.843.

5.4.5 Ethical Considerations

Ethical considerations are quite critical in the design and administration of questionnaires. It is imperative that a respondent is not coerced into completing a questionnaire and that he/she is not seen as a passive data provider but rather as a subject (Cohen et al. 2000, pg: 245). There were two key areas for ethical consideration in this phase of the research project: a) confidentiality and anonymity and b) informed consent. Each of these will now be examined below. Bell defines:

“Confidentiality is a promise that you will not be identified or presented in identifiable form, while anonymity is a promise that even the researcher will not be able to tell which responses came from which respondent”.

(2005, pg :49)

To ensure confidentiality within the research project, each school, which was randomly, selected was assigned a numerical code. Included in the distribution of each questionnaire was an information sheet clearly outlining that both confidentiality and anonymity were to be ensured, while also outlining to each participant that participation was voluntary and that they could withdraw at any stage from the research. Once the completed questionnaire was returned, the address corresponding to each numerical code was deleted; but a record was kept so as to facilitate a second round distribution. The full list of addresses and corresponding numerical codes was destroyed after the return date of the second round distribution. At no point on the questionnaire was the name of the participant requested, clearly identifying to the participant that all measures were being taken to ensure anonymity.

An additional ethical consideration that was taken into account was the area of informed consent. Informed consent implies that future research participants are given as much information as possible, which will allow them to make an informed decision about whether or not they wish to partake in the study (Bryman 2004, pg: 540).
Another preferential purpose for involving the practice of informed consent is outlined by Bowling (cited in Bell 2005, pg: 45) who suggests that the process of informed consent also gives some legal protection as it “reduces the legal liability of the researcher”, which is very important in our new found “litigious days”. To protect the vulnerability of each participant involved and a typed information sheet accompanied all postal questionnaires, on first and second distributions [see Appendix E, F]. The information sheet outlined what the purpose of the research was, who was involved and the benefits of the data to current research. It also indicated that participation was voluntary and that participants could withdraw at any stage. The letter also summarised what would occur to data when collected, and how it would be disseminated. Due to the format of this phase of collection, informed consent of the participant was seen as the return of the completed questionnaire. The researcher did not send individual consent forms to be signed as this would identify the participant and go against the confidentiality and anonymity agreed to participants.

5.4.6 Data Analysis

Research analysis for phase three was carried out using the software package Statistical Package for the Social Sciences (SPSS). In total, 212 questionnaires were returned, with 206 fully completed; 6 questionnaires were returned not filled in but with a reason attached. Each was coded prior to entry into the statistical package. Initial frequency checks were carried out in order to detect coding errors in the data. Errors were rectified and initial descriptive statistics were carried out, so that frequency distributions and generally trends could be established. This involved presenting much of the data using graphical representations such as pie charts and bar charts. Inferential statistics such the Mann Whitney and Chi square tests were also employed. The data tested negatively for normal distribution so non-parametric tests were employed for further statistical analysis. The qualitative data within the questionnaire was coded and employed to add depth of insight into participant’s responses.
5.5 Phase 3 – Case Study

The research methodology used in phase three was case study research. “Case studies may be carried out to follow up and to put flesh on the bones of a survey” (Bell 2005, pg: 10). This phase consisted of three individual case studies in schools in the mid-west region of Ireland. Each individual case study school was guided by the outcomes of the literature research and the final two research questions.

5.5.1 Case Study

The case study was selected as a means of data collection as it enables “many situations to contribute to our knowledge of individual, group or organisational, social, political, and related phenomena” (Yin 2003, pg: 1). Case studies investigate and report dynamic interactions of events, human relationships and other factors in unique instances. A “case study is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances” (Stake 1995, pg: xi). The case study approach is often used in the “study of an instance in action”. Examples include a child or teacher, a school, group or organisation, a classroom, a community etc. (Cohen et al. 2000, pg:181, Yin 2003, pg: 1). In essence a case study provides an example of real people in real situations, and most importantly they can penetrate situations that are not always susceptible to numerical analysis (Cohen et al. 2000, pg: 181). Case studies within education are about “people and programs” and so we conduct case study research as these enable us to hear their stories (Stake 1995, pg: 1). The involvement of case studies for research purposes is identified as one of the most challenging within social science (Yin 2003, pg: 1). Hitchcock and Hughes (1989) identify several hallmarks relating to case study research:

- Concerned with a rich and vivid description of events
- Provide a chronological narrative of events
- Blends description with analysis
- Focuses on individuals or groups
- Highlights specific events
- Researcher is integrally involved
Due to the wholeness and integrity of research generated through case study research, case studies can often be used to complement other kinds of large-scale research. In this sense, material produced through case study research can provide powerful human scale data on decision making and thus fuse theory and practice (Cohen et al. 2000, pg: 183). Case study is most appropriate for this third phase, as this phase aims to examine what has been learnt in phase one and phase two and is dealing with the views and attitudes of various teachers from different schools, coming from differing social and political standings. There are several types of case studies offered by a variety of researchers in the field of educational research and social science research, such as Yin (2003), Stenhouse (1980), Stake (1995) etc. Yin (2003, pg: 3) identifies three types of case studies in terms of their outcomes:

- Exploratory (as a pilot to other studies)
- Descriptive (providing narrative accounts)
- Explanatory (testing theories)

Yin’s identification of case study types also collaborates and supports the work of Merriam (1998) and Stake (1985). The case studies within this research phase are ethnographic and descriptive in nature, as they follow and describe, teachers within three schools in a school-university partnership. The design primarily involved teachers, but the student voice was also drawn upon. A variety of instruments was used to collect the data within each case study for phase three; these included reflective journals, reflection seminars, semi-structured interviews and pre-and post- surveys.

5.5.2 Case study design

The research design of phase three, centres around three individual cases that in turn represent a “collective” or “multiple case study” design (Stake 1995, pg: 5, Yin 2003, pg: 46). Multiple or collective case study designs have both advantages and disadvantages in comparison to single case study designs (Yin 2003, pg: 46). The multiple case study approach, however, is considered more compelling and therefore regarded as overall more robust (Herriott and Firestone, cited in Yin 2003, pg: 46). The three individual case studies centred on three schools, together making the “collective case study” for this research. The individual case studies were designed around a cross-section of qualitative and quantitative methods, as the approach to the research is a case
study. Due to the eclectic nature of the data collection, the methods enlisted in the research have also been guided by the work of Stephen Brookfield (1995). Brookfield identifies four lenses by which a teacher can improve their teaching and learning by developing into a critical reflective practitioner. The four lenses incorporate:

- Our autobiographies as teachers and learners
- Our students’ eyes,
- Our colleagues’ experiences,
- Theoretical literature

The lenses have been interwoven into the data collection methods to provide more strength. The methods involve reflective journals, pre-and post-surveys and semi-structured interviews. In Figure 5.3 a graphic representation of the integration of Brookfield’s lenses into this phase of the research is shown.

![Figure 5.3](image)

**Figure: 5.3 Graphical representation of Brookfield’s four lenses transferring into data collection methods.**

The “theoretical lens” is incidental by comparison to all of the other lenses. The theoretical dimension came through surreptitiously through the dynamic of the school-university partnership. Weekly visits by the researcher to the schools, for informal chats and support, would often defer to theory behind current investigation and classroom practice. It was important that the theory did not take over from the development of the pedagogical tool.
Reflective Journals

Both teachers and pupils were involved with the reflective journals; the journals are addressing Brookfield’s first lens, “our autobiographies as learners and teachers” (1995) [see Appendix G and H]. The purpose of the reflective journal was to start getting the teachers to analyse their teaching and to engage them with thinking as learners (Larrivee 1999, 2000). The autobiography was used as a stepping stone into the research, but also into self reflection. Getting the teachers to engage in self-reflection is the first step in getting them to analyse their teaching and ultimately analysing their practice. Brookfield reminds us of the possibility of “denial and distortion” entering the self reflection process and the importance of the other viewpoints e.g. “students eye’s” and “colleagues’ views” (1995, pg: 33). The pupils are also completing reflective journals, as it is important for the pupil voice to be represented. Both sets of reflective journals were administered weekly by the class teacher. The design of the reflective journals was developed in a scaffold formation: starting with tick the box questions, to writing reflective paragraphs. This design was implemented to aid the teacher and pupil with self-reflection. It is envisaged that when these were analysed they will reveal a progression in teacher’s attitude towards teaching and learning.

Reflection Seminars

The reflection seminars were in place to support the third lens in Brookfield’s four critical lenses: this lens of “colleague’s views”, is about sharing ideas and experiences together, becoming a critical support unit for one another. It was envisaged that these reflection seminars would help the teachers to remain as a support contact to each other. Like focus groups, the seminars were aimed at provoking discussion; they involved pair work and key questions, rather than a particular set of questions. The reflection seminars were a useful way to get feedback from all parties, as they were all achieving trying to achieve a similar goal (Cohen et al. 2000, pg: 287). It was also a practical way to highlight any challenges or changes that they would make in the future.
Pre-and Post- Survey
The pre-and post-surveys involved pupils, and the focus of this was to draw upon the pupil voice and see if attitudes changed over the course of the research [see Appendix I and J]. The surveys were designed to investigate the pupil’s attitudes to science. The surveys were divided into three key areas:

- Interest in Science
- Teaching Styles
- My Learning

Like the pupil reflective journals, the surveys were guided by the second of Brookfield’s lens “students’ eyes”. In the literature it outlines that when pupils trust a teacher they become honest about the teacher’s methods etc and that sometimes it can be quite harrowing for teachers to see how pupils view them (Brookfield 1995, pg: 34). It is envisaged that when the results are analysed, they should show a change in attitude towards the current learning environment. As the pedagogical tool devised is pupil-centred and pupil-focused, this increase should be greater. The pre-and post-test surveys are also quite exploratory in nature, as in addition they explore age, gender, and previous experience with science.

5.5.3 Study Cohort
The sampling process for phase three was in turn influenced by the research design of multiple case studies. Multiple case studies require more extensive resources and time and therefore it was decided that sampling would be contained within a reasonable distance of the University of Limerick, with ease of access for the researcher (Yin 2003, pg: 47). The sampling method used for this phase of the research was one of non-probability, and a convenient sampling process was applied to the research design. Convenience sampling is choosing those nearest to serve as participants, and continuing the process until the required sample size is reached (Cohen et al. 2000, pg: 102). Convenience sampling is most often used for case study research (Cohen et al. 2000, pg: 103).
It was also important, while working with the sample available from the mid-west region, to maintain a variety of schools within the study to offer more robust findings. For the study to be more feasible it was decided that the selected schools be near each other also. This would also help with setting up a support network for the teachers involved. The selection of schools was geared towards large co-educational post-primary schools, which were willing to be involved when invited by the research team.

5.5.4 Validity and Reliability
Case study research is tested through external validity, and also through construct validity. These tests have been identified by Yin as key points for a high quality research project involving case study design (2003, pg: 34).

External validity differs for both qualitative and quantitative research projects (Yin 2003, pg: 37). For the positivist researcher, external validity is sine qua non while for the interpretive researcher, human behaviour is complex and irreducible (Cohen et al. 2000, pg: 109). As a result, external validity has been a major barrier for case study research (Yin 2003, pg: 37). It needs to be appreciated that survey generalisation and case study work cannot be compared. Survey data relies on statistical generalisations, whereas case study research relies on analytical generalisation (Yin 2003, pg: 37). In case study research the investigator is generalising to a broader theory; generalisation is not automatic and a theory must be tested by replicating the findings in similar situations, especially as critics identify single case studies as a poor basis for generalizing (Yin 2003, pg: 37). In this research project, external validity is assured in phase three by the incorporation of three schools, replicating the same form school-university partnership, and utilising the same tools of investigation. Findings from the three schools will be analysed and generalised to a theory base around school-university partnerships, as a model for the professional development of lower secondary science teachers.
*Construct validity* is very problematic for case study research, as it is focused on “operationalising” forms of construct; and clarifying what the researcher means when using a particular construct (Cohen et al. 2000, pg: 110, Yin 2003, pg: 35). Many critics of case study research have indicated the failure by some investigators to develop an operational set of measures when carrying out case study research. Other reviews have also identified the “subjective” judgements that are made when collecting data by case study researchers. It is therefore important that the “construction” that is made by the researcher match other constructions of the same underlying issues. This can be achieved in two ways: a) by correlating with other measures or b) by sourcing out the research construct from a wide review of literature (Cohen et al. 2000, pg: 110). Yin (2003, pg: 35) identifies that for a case study researcher to meet the test for construct validity they must cover two particular steps:

- Select the specific types of changes that are to be studied (and relate them to the original objectives of the study),
- Demonstrate that the selected measures of these changes do indeed reflect the specific types of change that have been selected.

These steps can be achieved using Yin’s case study methods that he identifies for testing the quality of a research project (2003, pg: 34, 36). The three ways to ensure construct validity are:

- Use multiple sources of evidence
- Establish a chain of evidence
- Have key informants review draft report

To ensure construct validity throughout the research project, these three steps were monitored and administered carefully. The incorporation of data triangulation in the research project has ensured a variety of sources of evidence within the phases. Each phase of the project has a chain of evidence, for example, the policy text analysis in phase one has been documented in full, and each text analysed in a specific and coherent manner. On completion of phase three, each participant and school was asked to review the case study specific to their school and their work. With reference to case studies, and reliability Yin identifies two methods: 1) using the case study protocol in data collection and 2) developing a case study database (Yin 2003). In acknowledging
this Yin is highlighting the importance of documenting each part of the research procedure to eliminate bias and doubt.

**5.5.5 Ethical Considerations**

Investigators cannot expect access to a nursery, school, college, or factory as a matter of right. They have to demonstrate that they are worthy, as researchers and human beings...

(Cohen et al. 2000, pg: 53)

This phase of the research investigation was based within local post-primary schools in the mid-west region of Ireland and therefore negotiation of access was a major ethical consideration in the research project. The schools and teachers were approached by my supervisor and most had a previous experience working with different researchers within the same University department. Meetings were arranged in the individual schools for my supervisor and the author to visit, and the teachers were invited to take part. Information sheets were disseminated to the schools and teachers outlining what the GIMMS project was about, and what their specific involvement would be. The teachers were informed that the author was carrying out her thesis on the some of the findings that emerged and that the author would be the research assistant on this project. Two weeks after our initial visit the author revisited the teachers to answer any further questions that they may have and to sign them up, if ready, to the GIMMS research project. To help with the negotiation of access and to place teachers at ease, the author accompanied the co-ordinator of GIMMS on all visits to the schools for the first two months, after which the author established a rapport with teachers and principals and was able to come and go as the author pleased, once sufficient notice was provided.
5.5.6 Research Analysis

Data collected in phase three used mixed methods and so the analysis incorporated both qualitative and quantitative analysis. The reflective journals from teachers were critically analysed by the researcher for emerging themes. The reflective seminars were recorded and transcripts from each seminar were critically analysed, coded and emerging themes outlined. The critical interpretation of the material was influenced by the purposes of the project to develop democratic communication and professional empowerment. The pre-and post-interest surveys carried out with pupils in schools were analysed using the quantitative Statistical Package for Social Sciences, (SPSS).

5.6 Limitations

Any research project within the social sciences will have limitations. While the author strove to minimise limitations, she also acknowledges that some will remain. Below the author outlines the limitations of the research project and how they occurred.

- The choice of documents sampled for the content analysis. These were chosen in order to delimit the influences of the current literature and gain a more objective view of the impact of policy, and therefore the author chose to start at 1960. This may be viewed as a limitation in this research project; however, this date was a cornerstone in the development of the Irish Education system.

- Bryman acknowledges that there is a limitation with the process of content analysis as a research analysis tool. The development of rules however helps to ensure objectivity and a systematic approach to content analysis research. Content analysis is subject to subjective bias as the researcher’s interest and concerns are often reflected (Bryman 2008, pg: 275).

- The schools that were chosen in phase three brought limitations to the research project as they were specifically chosen by the research supervisor and the author. These schools were specifically chosen due to their high numbers of lower secondary science teachers and most importantly their location near the University of Limerick for developing a school-university partnership.
The sample cohort of pupils for the pre-and post-tests was not matched. The tests were categorised in terms of schools that took part in the study, rather than by pupil name.

5.7 Chapter Summary

This chapter has explored the methodological approaches used within the research project. It has outlined the three phases of development that the project has undertaken. At the beginning of this chapter the author explained the concept of mixed methods research and outlined the paradigms of research that have affected and influenced the research methodology and data collection. Operating in the area of social sciences research brings concerns around validity and reliability. The author remained cognisant of these issues throughout the study and dealt with these issues in-depth, in order to ensure that these issues were given the appropriate consideration within a research study of this magnitude. The research has taken into consideration the important role of ethics and strove to adhere to the British Educational Research Association (BERA) Guidelines for Ethical Research. These concepts of validity, reliability and ethical consideration are all explored within each phase of the research, so as to ensure compliance. The three phases, which were outlined in this chapter, offer a framework for the results of the study to be presented in the subsequent chapter. The overall aim of the research and research questions will be used to triangulate the data in Chapter 7.
6.0 Research Findings
6.0.1 Introduction

In the findings chapter the author seeks to identify what’s worth fighting for in relation to innovation and change. Through the three sections of findings the author will outline why there is a need for a democratic and relational approach to policymaking for innovation and change, why there is a need for partnership and community, and why the culture and context of any situation classroom or school cannot be ignored if innovation and change are to occur and be sustainable. The chapter is divided into three sections, similar to the research methodology chapter, with each section representing a phase of data collection, as shows Figure 6.1. The discussion chapter will then bring the three phases of data collection findings and analysis together.

Section one will outline the findings from the content analysis of policy documents. The purpose of this stage of data collection was to offer a cultural context to teaching and learning at lower secondary level in Ireland to inform the literature review. Research has shown that any project that does not take into account the culture and context is doomed to fail (Sarason 1971, 1996). The findings are a pertinent part of data collection, as they not only highlight what policy documents say, but they also draw attention to what they do not say. An outline and rationale for each document used within phase one is included within the appendices (see Appendix C).
Section two will explore the National Survey that was distributed to the Lower Secondary science teachers. The purpose of this survey was to investigate the attitudes and beliefs of lower secondary science teachers in Ireland to curriculum development, teaching and learning methodologies and assessment. The data collected from phase two is presented under the following headings:

- Sample Demographic
- Attitudes towards Curriculum Development
- Pedagogy of the Irish Science Classroom
- Views towards Professionalism

Section three, will outline the results from phase three of the study, the case study schools. The findings of the case studies will be examined through the four different lenses offered by Stephen Brookfield and are presented under the headings from the emerging theoretical framework. These include:

- Demographic Profile of Case Study Schools
- Developing Democratic Ownership and Empowering Teachers Professionally
- Positives of Eclectic Pedagogy
6.1 Phase One - Findings

The findings in this section are very significant to the framework and development of the overall project. Ultimately this phase of the findings will guide the research literature and help create a cultural context to teaching, learning and assessment in Ireland from a policy perspective. This section will outline and explore the significant themes which emerged from the NVivo analysis of the documents. Below is a tag cloud graphical representation of the themes which were coded from the policy documents (see Figure 6.2).

A tag cloud works by representing the most common word/theme in a larger font size. Therefore from the graphical representation above it can be concluded that the major
themes which emerged included curriculum, examinations, development, learning, teachers, assessment, relation, science and teaching. The author has since classified these coded themes into three main areas which will in turn drive the literature review and further study (see Figure 6.3). Further information on the development of the main themes is offered independently under each segment of phase one findings.

The first section addresses the “progress of curriculum development” within an Irish context. This section explores the policy documents surrounding lower secondary science policy formation and curriculum development. The second section within this first phase of findings explores whether there is a need for eclectic pedagogy within the Irish classroom. The first segment seeks to outline the story of the “pedagogy of the Irish classroom”. This section also addresses the notion of science as a practical subject. The third and final section in phase one of the findings addresses the “deficiencies within professional development”. In the last decade there has been a marked effort to promote teaching as a profession and strive for professional status within society (Teaching Council Act 2001, The Teaching Council 2007). However, on analysis of the policy documents it was recognised by the author that this was to be a difficult task. History or policy does not lend itself to the promotion of teachers as professionals, especially when it is compared with the accountability and autonomy of other professions.
6.1.1 Progress of Curriculum Development

This section of phase one findings aims to explore what the policy documents have revealed, on matters concerning to curriculum development. For purposes of clarity, the following topics have been coded independently and re-coded to form under the theme “progress of curriculum development”:

- Provision of science
- History of the JC
- Syllabi development
- Purposes of science in Irish education
- History of change
- Department of Education
- Appointments

The findings under this theme will now be explored under the following headings:

- The process and history of curriculum innovation and change
- The provision of Science at Lower Secondary

The author envisions that these two areas will offer a rich cultural context to the reader on the past and current position of the process and history of curriculum change and consecutively provide some light on the provision of science from a policy makers viewpoint.

The process and history of Curriculum Innovation and change

The documents indicate that the process of curriculum development in Ireland is highly centralised and conservative in nature, and as a result innovation and change can be very slow to occur (ICE Report 1975, OECD 1991, Department of Education Ireland 1992). The Intermediate Certificate Examination (ICE) committee, in their report on the form and function of the Intermediate Certificate in 1975, acknowledged that this centralised approach needed to come to an end. It was not only affecting the durability of the system but prolonging the process of innovation and change. In 1991, it was still evident from the OECD review that centralisation still existed. Ireland was still relatively lethargic towards change, with the reviewers acknowledging that since the Investment in Education Report (1965) that “although there has certainly been the
remarkable quantitative expansion…the system as such has remained largely the same” (Hyland and Milne 1992, pg: 83). Even describing the policy makers as functioning “reactively rather than pro-actively” (OECD 1991). The OECD examiners reiterated how the education system functioned as a classic but highly centralised bureaucracy (OECD 1991). This centralised bureaucracy was having adverse effects on the teaching and learning taking in place in the classroom, as well as restraining the voice of the teacher.

The 1992 Green Paper was the first acknowledgment that the centralised top-down approach to policy and curriculum formation was not working “as well as being inefficient, distracts the department from its central task of strategic policymaking” (Department of Education Ireland 1992, pg: 4). This policy document was also the first to show strong recognition that change was needed for the sake of Ireland’s young people and Ireland’s economic future, and young people tended to lack skills for industry: technical skills, problem solving ability, critical thinking skills (Department of Education Ireland 1992, pg: 11). The following 1995 White Paper proposed radical changes to policy and curriculum development, introducing for the first time, multilateral dialogue. It also encouraged developing partnerships with local universities and schools, identifying that “breadth, balance and coherence” would underpin curriculum development at post-primary level (Department of Education Ireland 1995, pg: 45).

The centralised top-down approach to curriculum development and policy formation is further enhanced throughout the policy documents from the standing of the teacher. It is quite evident from the policy documents that policies were intended for all those interested and involved in education - “educationalists, parents and other interested parties” (CEB 1986, pg: 8). Most notable, however, throughout the review of the documents has been the lack of teacher presence and teacher voice in the documents. It can be seen from the earlier documents that teachers were not necessarily viewed as part of the process of policy formation or curriculum development. Particularly when one examines the appointments to councils, committees and boards, is it evident that since the “Report of the Council of Education”, appointments to committees and councils regarding educational matters was not only determined by the DES, but for the majority of the time the ratio of teachers involved was nonexistent or
minimal. This continued right through the 1970s and 1980s until the introduction of social partnership. Social partnership was introduced to depoliticise the development of education and curriculum and instead try to develop a partnership concord. Documents that ensued the 1980 White paper, demonstrate that some changes were introduced, for example, the suggestion of the Curriculum Council, social partnership, multi-lateral dialogue, and the formation of the Curriculum Examination Board (CEB) (Department of Education 1980, pg: 48). These partnerships incorporated many people from industry and university, with the teacher being represented by the Teacher Unions (TUI, ASTI).

The CEB was one of the boards developed to embrace and integrate social partnership and subsequently became the National Council for Curriculum and Assessment (NCCA), which we have today. The CEB was one of the first to acknowledge the change that had occurred in Irish society and in the economy and recognised it was time for change.

The Board recognises the need to re-assess our educational goals in the context of the late twentieth century. Schools must ensure that they contribute to the development of those attitudes and attributes which will enable young people to avail of the opportunities of life in the twenty-first century.

(Curriculum and Examinations Board, 1986, pg: 8)

They wished to promote a framework, which would develop further the virtues and values that had shaped the existing system (CEB 1986, pg: 6). The Board made the call for external bodies/agencies to get involved and create partnerships with schools, including third-level institutions (CEB 1987, pg: 12). In 1987 the CEB was disbanded and replaced by the NCCA, and in 2001 the NCCA would become a statutory body for the development of curriculum and assessment. It needs to be acknowledged, however, that the role of the NCCA is only to advise the Minister for Education, so it is questionable to what extent the system is actually decentralised, and working in partnership. Looking at today’s system one has to question what impact these measures have had on the education system. The curriculum is still developed in a top-down, centralised manner.
The provision of Science at Lower Secondary

From the initial analysis of the policy documents it was evident that the role and development of science at lower secondary level within the Irish education system has been quite considerable (Department of Education 1965, CEB 1987, Department of Enterprise Trade and Employment Ireland 2006). This final section within “analysis of curriculum development” will explore the development and provision of science within broader curricular matters. It is envisaged that this section will offer a cultural context to the position of lower secondary science.

Within the policy documents the role of science is quite prominent and is generally correlated with economic growth and expansion. In some instances the notion that science is necessary and worthwhile for the sake of a child’s personal and academic development is often over shadowed by its economic importance. The Council of Education in their report, while not agreeing to implement science as an essential subject, did agree on the importance of getting pupils to incorporate science into their general education and did recognise lower secondary education as a “distinct unit” (Department of Education 1962, pg: 182). The Investment in Education report in 1965 acknowledged that science education was an area that was in need of investment for the sake of the country’s future (Department of Education 1965). While in 1986 the CEB report In our Schools listed science and technology as one of the eight areas of experience in their “wheel of experience”, giving full recognition to the importance of science and technology within a pupil’s lower secondary education (CEB 1986, pg: 11). In their later 1987 report Science, Technology and the Post-primary curriculum, the CEB subsequently outlined that science was an essential part of a child’s personal development, but more importantly it was necessary for developing our society and our economy (CEB 1987, pg: 7). This view was again further expounded and promoted within the 1995 White Paper Charting Our Educational Future, which highlighted the important role that science plays in relation to economic development, and its influence on society (Department of Education Ireland 1995, pg: 46, 48). Since 1995 there have been various policy documents published to promote science, each carrying the same message that there is a need to promote the uptake of science at secondary and tertiary levels of education for the sake of the economy and society (ICSTI 1999, NCCA 1999b, a, Department of Education and Science Ireland 2002c, Peters 2002, European Commission 2004, Department of Enterprise Trade and Employment Ireland 2006,
OECD 2007, NCCA 2009, Perkins et al. 2010). The decline of science uptake at upper secondary and the low level of science graduates leaving tertiary education is having a serious consequence on the economy and the industry that locates in Ireland.

The Junior Certificate science syllabus was published by the Department of Education in 1989. The Junior Certificate programme was introduced to replace the Intermediate Certificate, which had been in place since the formation of the state. The report on the form and function of the Intermediate Certificate Examination (ICE Report 1975) identified many drawbacks to lower secondary education in Ireland, and the introduction of this new programme was to help rectify some of the issues raised in that report (ICE Report 1975). Junior certificate science was created to cater for all abilities and levels of achievement; it was to be offered at two levels, higher and ordinary. Former syllabi such as Science (Syllabus A including ISCIP), Science (Syllabus E) and Rural Science were all disbanded and instead replaced by one common syllabus (Department of Education 1989, NCCA 1989, pg: 1). In 2003 a “revised science syllabus” was launched. The 2003 syllabus differed in a number of areas: increased emphasis on scientific investigation reduced overall length, simplified structure, and learning outcomes were introduced, which replaced objectives. There was also an embodying of the investigative approach, and the introduction for the first time of a new three tier assessment structure inducting assessment of practical work (NCCA 2003c). The integration of learning outcomes de-emphasised the method of approach taken by teachers, and allowed for flexibility in designing experiences that suit all level of student ability, achievement and interest (NCCA 2003a). This new approach to teaching and learning was a first in the curriculum development of science since the 1960s and it was a real acknowledgment of science as a practical and activity-based subject. The next section will explore what policy said about teaching, learning and assessment.
6.1.2 The need for Eclectic Pedagogies

This section of the phase one findings will report on the attitude towards teaching, learning and assessment within the policy documents. This section is envisaged to highlight to the reader the need for an eclectic pedagogy. It is apparent, from both the national and international policy documents, that Ireland has a strong reliance on traditional, didactic methods of teaching and learning (Department of Education 1980, OECD 1991). This, paired with a profound dependence on assessment of learning rather than assessment for learning, has only demonstrated that policy in Ireland militates against approaches that research has indicated are important for successful understanding and deep learning. The author feels that an eclectic pedagogy is an area worth fighting for within the current Irish education system, in the effort towards innovation and change for the contemporary Irish classroom. Within the NVivo software programme matters relating to teaching and learning were classified further into the following key areas:

- Pedagogy of the Irish Classroom, policy perspective
- Learning Science: a practical subject?
- Assessment of science

Pedagogy of the Irish Classroom, A policy perspective

The biggest contributions relating to teaching and learning were mainly through the OECD studies, primarily the Programme for International Student Assessment (PISA) (2001, 2003, 2006, and 2009) and Teaching and Learning International Survey (TALIS) (2008) studies, and their own independent reviews in 1965 and 1991. The NCCA “Guidelines for Teachers” advocated inquiry-based science education in the late 1980s and early 1990s however, as the research literature has shown, this did not emerge to any significant degree in practice. This segment will explore the product-driven technical approach to teaching and learning in Ireland that affects the pedagogy of the classroom.

The first occurrence within the content analysis relating to methods or approaches to teaching came from the ICE report (1975). The Committee were the first to acknowledge the ideology of “teaching for the exam” within our national system of
education. It was an official acceptance that teachers were under pressure to teach for the exam, with pupils saying "is that on the exam?" It was also the first reference that teaching and learning in Ireland was becoming very technical in nature, with an almost product-driven approach to learning. The 1991 OECD report further identified Ireland as having a very traditional approach to schooling, with an emphasis on authoritative relationships and structuring lessons around texts (1991, pg: 6). They described our curriculum as "academic, subject-central tradition, with a narrowing of the subject focus as specialization takes over in the later years" (OECD 1991, pg: 66). There were dissatisfied that school buildings were being developed without any consideration for co-operative learning, or non-instructional forms of learning. They appealed for an increase in flexibility and variety within teaching and learning (OECD 1991, pg: 56). They indicated that co-operative learning and non-instructional forms of learning were not to the fore, and instead Ireland’s education system was one that valued the “products” of learning rather than the process of learning (OECD 1991, pg: 55). Unfortunately, in recent research these findings by the OCED in 1991 have been replicated. The Teaching and Learning International Study (TALIS 2009) indicates that Irish teachers have a strong preference for “structured practices”, and are opposed to “enhanced activities” or “student-orientated practices”. Structured practices include stating learning goals, summarising earlier lessons, homework review, and checking exercise books, contrasting with practices that would include, assigning projects, debates, essays, employing ability grouping, giving student’s individual tasks (Shiel et al. 2009, pg: 7). This international study further identified that “female teachers are less likely than males to hold direct transmission beliefs about teaching” (Shiel et al. 2009, pg: 12). The TALIS report in 2009 indicated that while teachers in Ireland have strong endorsement for constructivist beliefs over transmission beliefs about teaching, the endorsements are somewhat less that their comparison countries of Austria, Denmark, Belgium, Norway and Poland (Shiel et al. 2009).
Learning Science: a practical subject?

In relation to the teaching and learning of science, the 1980 White Paper was the first acknowledgment for the need to incorporate experiments and practical work in school science when the Minister of Education called for experimental work to be integrated into the Leaving Certificate. The White Paper outlined that the exclusion of experimental work and skills development, militates against the aims and objectives outlined in the syllabus (Department of Education 1980, pg: 52). However, it is somewhat disappointing to find that the piloting of experimental work only took place in physics and the rationale was not educational. The reasons stated for including experimental work, was that it militated against the “allocation of time and facilities in schools”, which schools had already received (Department of Education 1980). The CEB however in 1986 continued the emphasis towards integration of practical work into science, outlining that “all students should have adequate exposure to the practical process of scientific experience” (CEB 1987, pg: 13). The Board urged that science was viewed as part of general education to which all students were to be exposed. While the report by the CEB does offer suggestions in relation to teaching and learning, it did not dictate how content should be taught, or make any recommendations in relation to methodologies for teaching and learning of science. This however shifted slightly the following year with the publication of Science and Technology in the Post-primary Curriculum where science is identified as a practical subject, indicating that learning should take place in a continuum (CEB 1987, pg: 13). The report outlined that science teaching should be an activity-based learning experience, and there was consensus that the teaching and learning of science must involve the “scientific methods of enquiry which are both practical and quantitative” (CEB 1987, pg: 13). It acknowledged that “appropriate teaching methodologies are essential for successful implementation of science syllabus”, however, it did not offer any guidance or suggestions towards possible changes to teaching methods or learning strategies to enhance this approach (CEB 1987, pg: 13).

One of the problems, however, associated with learning science through practical or experimental investigations were resources, or lack thereof, which was the case for some time. The Investment in Education report by the OCED in 1965 was the first acknowledgment within the literature that pupil’s teaching and learning was suffering due to lack of resources and laboratories (Department of Education 1965, pg:
340-341). It seems that the issues surrounding resources and laboratories did not rise again until 1986, when the CEB identified that the physical problems with teaching and learning science were the facilities and resources available to schools. Many schools did not have the facilities or the equipment to provide education in science as it should be. The OECD review indicated two possible reasons for such a scarcity of resources: 1) the high birth rate and 2) Ireland was a poor country (1991, pg: 45). The high birth rate and demands for new schools had meant that all monies were going towards the construction of new schools. After the introduction of the 1989 syllabus, grants were made available to upgrade school laboratories for the new Junior Certificate and Leaving Certificate programmes, and further capital grants were made available at the beginning of the last decade in order to facilitate and supplement equipment for laboratory work and ICT in the teaching of science (Department of Education and Science 2009, pg: 9). When the revised science syllabus was introduced in 2003, it was introduced on a “phased” basis allowing for grants to be made available to schools to upgrade resources and laboratories for the new syllabus (Dennehy 2003). The revised syllabus was now dependent on the fully-stocked and equipped laboratories, as for the first time, school course work would count towards final assessments. The assessment procedures of lower secondary science have seen some dramatic changes in the last few years and will now be explored.

Assessment of Science

In his review of the history of Irish education Coolahan (1981) acknowledged that the mode of conduct for public examinations around the time of the Investment of Education report (1965) did not suit science education or the pupils who studied it at that time. This was further developed by the ICE Committee (1975) in their report, where there was full acknowledgement of the need of a national assessment around the age of 15. The Committee indicated in the report that they felt that the Intermediate Certificate was now unsuitable for most pupils, and the predominant written character of the examination, did not favourably enhance the acquisition of oral and practical subjects for pupils (Mulcahy 1981, pg: 47). However, this nationwide assessment required that some changes be implemented first, most notably these included a more varied mode of assessment, the incorporation of practical and oral work and a request was also made towards catering for varied abilities. Up until now, assessment papers
were the same for all. Mulcahy (1981, pg: 46) identified how “commonality of courses and examinations would appear to have worked very largely to the detriment of vocational or continuation education”. In their request for a more flexible form of assessment, the committee even suggested the incorporation of a school based assessment module.

From the documents it seems evident that no real progress was made about changing the assessment of science till the 1980s. The CEB in their 1986 report made recommendations “that priority in the use of new procedures should be given to areas that cannot be adequately assessed by written examinations (e.g. practical skills)” (CEB 1986, pg: 37). In 1987 this was developed further when they acknowledged that “assessment methods should reinforce the elements of the scientific method of discovery and learning rather than accumulation of given scientific knowledge” (CEB 1987, pg: 13). The OECD in 1991 also raised the issue of examination and assessment practices. Indeed the examiners pointed out that the domination of examinations particularly in secondary level, determined teaching and learning styles, fitting to examination requirements.

According to many educators and educationists, university entrance requirements continue to dominate the upper secondary school curriculum which in turn, dominates the curriculum of the lower secondary level.

(OECD 1991, pg: 72)

The unsuitability of the examination and assessment process for some students within the Irish education system was one of the foci of the Green Paper in 1992. In relation to science education this was most important, as students were missing out on hands on practical experience due to lack of resources. The lack of hands-on experience was affecting the development of young peoples’ skills in the area of science and technology, and their interest and participation levels were also affected subsequently.

The revised syllabus introduced in 2003 helped integrate a focus more towards practical work. Within the new syllabus the 100% written examination would cease and instead be replaced by a three tier component, incorporating two school-based assessments. 2006 would be the first year of this new form of assessment and so it was deemed that the next phase of data collection would investigate how this was welcomed by teachers.
6.1.3 Deficiencies in Professional Development

This section seeks to outline and explore the minimal representation of matters concerning professional development within the policy documents reviewed. When coding within NVivo, the following matters were deemed pertinent to the professional development of teachers: 1) any material relating to in-service or CPD and 2) the concept of mentoring. Within the content analysis it was very apparent that professional development and the professional status of teachers were somewhat low down on the scale of priorities.

It is evident from the content analysis of the policy documents that policy did not lend itself to promoting teachers as professionals, nor in practice did it encourage professionalisation. One of the most significant findings of the Investment in Education report (1965) was in relation to personnel within science education. There was a deficiency of qualified science graduates whereby “64 per cent of science teaching was conducted by non-science graduates” (Coolahan 1981, pg: 167, Hyland and Milne 1992, pg:252-253). Teaching at this time, however, was viewed more as a vocation than a profession, and thus qualified graduates were not essential. This is no longer the case as all teachers must be registered with The Teaching Council of Ireland. Further concern was raised by the ICE committee in 1975 when they deemed the system to “discourage teacher development and initiative, and shifts responsibility for assessment of pupils from teachers” (ICE Report 1975, pg: v). There was concern from the ICE committee that teachers were not being allowed the space to develop professionally, grow and become innovative in their work. Their professional status was perhaps being undermined by the removal of assessment to an external agency. It could also be argued that the pressures outlined by the ICE report in relation to “teaching for the examination” did not lend itself either to the professional development of teachers or the professionalisation of the teaching profession. The OECD report in 1991 further strengthened this view when they acknowledged that the inspectorate was made up of highly skilled teachers, mainly doing administrative work relating to state examinations instead of assessing teaching and learning practices: “secondary inspectors visit schools very rarely and though having functions of appraisal do not exercise them” (OECD 1991, pg: 43).
Once again the 1980 White Paper appears to direct the cycle of change. In terms of professional development, the paper declared that in-service training would be expanded to train as many teachers as possible to be better equipped to educate those with learning difficulties. The White Paper would also recommend an increase in the number of Education teaching centres around Ireland for the provision of in-service training. It also indicated that pre-service and in-service training was to be changed and the teacher given a more professional role, however, how this was to be accomplished was not outlined nor how this was to be achieved (Department of Education 1980, pg: 52). At this point the author would like to indicate some matters that cause some concern: the notion of change introduced, so it seems without out any cultural awareness or thought as to how it may come about; furthermore in-service being referred to as “training” lends itself to the undermining of the very notion of professionalism. Once again the situation of rhetoric versus reality emerges between the policy documents and the actualities of the classroom. In reference to science teaching the CEB made a direct application to the professional development of science teachers, recommending that pre-service and in-service teachers needed much more training and support in the tuition of science, saying “if the teaching approach is not appropriate, the most elaborately equipped schools will not succeed in offering a successful programme” (CEB 1987, pg: 12).

6.1.4 Summary of Findings from Phase One

The process of curriculum development and the management of innovation and change are quite slow within the Irish system. The system of educational change is somewhat conservative, which hinders the process of innovation and change immensely. The centralisation of curriculum matters needs revision and, in agreement with the OECD 1991, there is huge dissatisfaction with the subject-centred approach taken to curriculum development and related matters. It is quite evident that there is a need to find out from practising teachers what their views are on the process of curriculum development. Do they wish to be involved in the process, and if so why or why not? The policy documents have also revealed a very traditional philosophy regarding teaching; it has emerged that teaching in Ireland is very product-driven and follows the ideology, “teaching for the examination”. Further research needs to investigate if the TALIS report is correct. Are we entering the twenty-first century with a heavy reliance on
structured practices? Have teaching and learning methodologies remained unchanged since the 1960s? There is a need to fight back and a need to explore how the Irish science classroom can be made more innovative and help bring about change to incorporate a more eclectic mix of pedagogies. It is pertinent to the study that there is a consensus on what teaching and learning methodologies should be in today’s classroom if innovation and change is to happen. Due to the timing of this research it is also pertinent that the researcher investigates practising teachers’ views on the new three tier assessment system. The concept of curriculum development and pedagogy, in the opinion of the author, links quite strongly to the notion of professionalism and the professionalisation of teaching. Teachers cannot embark on taking a lead or stand on curriculum development matters if they do not feel empowered to do so, nor can they embark on integrating eclectic pedagogies without this empowerment. This sense of empowerment comes from developing a sense of worth, a sense of value, a sense of being, which in turn is ultimately a sense of professionalism. Innovation and change in curriculum or in pedagogy cannot occur without the professional empowerment of teachers. The three aspects are inextricably linked.
6.2 Phase Two - Findings

This section of the research findings chapter reports on the findings from phase two. The data is from a National Survey which was administered to Junior Certificate Science teachers. The survey design was explored within the research methodology chapter, but to recap it was planned to incorporate three key areas that emerged originally from the content analysis of the policy documents and which was further explored within the literature review. These areas are:

- Curriculum development
- Teaching and learning methodologies
- Assessment

The findings of this phase of data collection are quite significant as the survey was administered in April 2007. The first three year cycle of the “revised” syllabus was about to come to an end. June 2007 would see the first year of examination for the new “revised” syllabus nationally, which incorporated two elements of coursework. 500 surveys were distributed nationally to a random sample of schools, with a return of 213, giving a response rate of 43%. 207 of these were completed in full, with 6 surveys been returned with reasons for non-completion, which in themselves offers some rich context to data collection. As specified in the methodology section, the sample was randomly selected from the DES national post-primary provider’s database.

The findings from phase two are presented under the following headings

- Sample Demographic
- Attitudes towards Curriculum Development
- Pedagogy of the Irish Science Classroom
- Views towards professionalism
6.2.1 Sample Demographic

This first section of research findings from phase two will summarise the background information which was gathered about the research participants and their schools at the start of the national survey. The purpose of this background information was to offer context to the study, and to investigate if the sample was representative of the national situation. The surveys were administered one per school, so it was important that the returns would offer a representative sample of the national picture.

Demographics of the Participant’s Schools

As shown in the context chapter, there are primarily three types of secondary school providers in Ireland. It was therefore necessary to investigate what form of secondary school participants were teaching in. 55% of research participants came from the voluntary secondary school sector, 32% were involved in the vocational/community college sector, with the remaining 13% involved in community/comprehensive school sector (see Figure 6.4). These figures compare well to the National Statistics of post-primary education providers and were representative of the national cohort (see Table 6.1) (Department of Education and Science Ireland 2008, pg: 3, Power and Mooney Simme 2010, pg: 164)

Table 6.1 Comparison between Research Sample and National Statistics

<table>
<thead>
<tr>
<th></th>
<th>Research Sample</th>
<th>National Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary School Sector</td>
<td>55%</td>
<td>54%</td>
</tr>
<tr>
<td>Vocational/Community Sector</td>
<td>32%</td>
<td>34%</td>
</tr>
<tr>
<td>Community/Comprehensive Sector</td>
<td>13%</td>
<td>12%</td>
</tr>
</tbody>
</table>
The findings indicate that voluntary secondary schools are catering for a large portion of the post-primary market in Ireland (see Figure 6.4).

![Figure 6.4 School Type](image)

**Figure: 6.4 School Type**

The survey also sought to gather information regarding location; four options were specified to participants (see Appendix D). From the results illustrated in Figure 6.5, it is evident that no real disparity is evident between representations from localities, except perhaps those classified as rural.

![Figure 6.5 School Location](image)

**Figure: 6.5 School Location**

Cross-tabulation of school type and location (see Table 6.2), indicates a high percentage of the secondary schools involved in the study were from city and town locations, with vocational schools involved predominately from small towns and rural areas. These results would agree with the history and development of post-primary education in Ireland (Coolahan 1981).
Table 6.2 Cross tabulation of location of school & School type

<table>
<thead>
<tr>
<th></th>
<th>Vocational/com</th>
<th>Community/comprehensive</th>
<th>Secondary school</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>11</td>
<td>6</td>
<td>47</td>
<td>64</td>
</tr>
<tr>
<td>Large town</td>
<td>16</td>
<td>6</td>
<td>26</td>
<td>48</td>
</tr>
<tr>
<td>Small town</td>
<td>24</td>
<td>11</td>
<td>33</td>
<td>68</td>
</tr>
<tr>
<td>Rural</td>
<td>15</td>
<td>4</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>66</strong></td>
<td><strong>27</strong></td>
<td><strong>114</strong></td>
<td><strong>207</strong></td>
</tr>
</tbody>
</table>

From the data collected (see Figure 6.6) it is apparent that 61% of participant schools were co-educational, 21% were single-sex females, with a further 18% single-sex males (see Figure 6.6). The high level of co-educational secondary schools is most likely due to amalgamations of secondary and vocational schools in recent years. 9% of participant’s schools were part of the fee-paying sector.

![Gender Composition of Schools](image)

**Figure: 6.6 School type by Gender Make Up**

The number of pupils enrolled in the research study schools varied greatly across the six categories provided. The highest representation was seen from schools within the enrolment categories 201-400 and 401-600, as seen below in Figure 6.7. Only one school had <1000 pupils enrolled.
The number of full-time science teachers per school was collected: 62% of the schools had between 2-5 teachers for science full-time, with 29% having more than five teachers of science per school; 9% of those participating had just one teacher full-time for science.

**Participant Demographics**

The gender breakdown of participants was strongly dominated by females, see Figure 6.8. However, this is representative of the overall situation in post-primary education today in Ireland. The TALIS study identified that over 69% of the teaching cohort for lower secondary level was female staff (Shiel et al. 2009).
Due to the nature of the study being about innovation and change, it was decided to investigate how long participants were teaching. Within the research project the findings have demonstrated that a large percentage of the cohort belonged to the 25+ years of teaching, see Figure 6.9. The remaining categories are substantially lower and somewhat more evenly distributed. These findings also concur with those of the TALIS report, where over 35% of lower secondary teacher had over 20 years experience teaching (Shiel et al. 2009). When the figures are merged and re-evaluated it becomes evident that 54% of the respondents are teaching more than twenty years, while those teaching in the 0-10 and 11-20 categories are 25% and 21% respectively.

**Figure: 6.9 Number of years teaching**

In relation to qualifications, just fewer than 80% of the participant cohort came through the Higher Diploma route (Figure 6.10). Cross-tabulations reveal that those teaching more than 20+ years were more likely to come into teaching through the Higher Diploma qualification route see Table 6.3.

**Figure: 6.10 Qualification type**
Table 6.3 Cross Tabulation, Number of Years teaching and Type of Qualification (percentage)

<table>
<thead>
<tr>
<th>Type of Qualification</th>
<th>0-10</th>
<th>11-20</th>
<th>20+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concurrent Degree</td>
<td>56</td>
<td>24</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Higher Diploma</td>
<td>21</td>
<td>22</td>
<td>57</td>
<td>100</td>
</tr>
<tr>
<td>Graduate Diploma</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>General Degree</td>
<td>10</td>
<td>20</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>20</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>22</td>
<td>54</td>
<td>100</td>
</tr>
</tbody>
</table>

12% of the cohort participated in concurrent teacher education programmes, and cross-tabulation identified that those from the concurrent education programmes, were relatively new teachers (Table 6.3), while 57% of the participants classified within the Higher Diploma category have been teaching for more than 20 years. It should also be acknowledged that 38% of those who participated in the study had a postgraduate qualification, with an overwhelming 62% having obtained a Master’s degree.

As the survey was designed purposely for teachers of science at lower secondary level it was assumed and calculated that all participants (100%) would be involved at teaching science at Junior Cycle. Additional information was gathered on what other subjects the teachers at lower secondary taught. Figure 6.11 below indicates the breakdown of science and mathematics subjects taught by participants, while Figure 6.12 identifies additional subjects outside of science taught by the participants involved in the study. A high percentage of participants are involved in the delivery of personal development modules such as CSPE and SPHE.
Over 70% of the study cohort held a post of responsibility within their school. Figure 6.13 identifies the most common position held was that of assistant principal (37%), with special duties posts making up 32%, and only 2% of the cohort were vice principals within their schools. Special duties posts included in the survey consisted of positions such as Health & Safety, Resource Teacher, Exam Co-ordinator, Book rental scheme etc. Mann-Whitney tests identify significance between the length of time teaching and the post of responsibility held ($U = 1,424.00$, df = 5, $p =0.000$).
6.2.2 Attitudes towards Curriculum Development

This area of the findings is focused on developing and exploring the attitudes of participants to curriculum development. The research findings are represented by two themes:

- Views toward the process of Curriculum Development
- Views on the new revised syllabus

**Views toward the process of Curriculum Development**

When asked if participants were happy with the level of input by teachers into the development of the science curriculum over 45% of respondents said that they were not, with a further 30% unsure (see Figure 6.14). Kruskal-Wallis tests indicated that there were no significant associations between this and length of time teaching (p=0.316).
Probing and developing this area further, participants were asked if they felt teachers should have more of an input in curriculum development matters. 85% of those questioned indicated that they felt teachers should have more input, with many adding reasons/comments why they feel this way (see Figure 6.15).

**Figure 6.15 Should teachers have more input in curriculum development?**

It is quite evident from the data collection and comments made by teachers that there is unhappiness around their input into curriculum development. Within the survey an open-ended question was offered to look for the reasoning why teachers felt they should or should not have more input into curricular matters. Below is a sample of comments offered by participants who felt teachers should be involved and why.

“Experience of time management and what works”

(Male, 25+, secondary school, small town)

“We are the people on the ground delivering the curriculum”

(Male, 25+, vocational/community, city)

“Practising teachers have the trait knowledge and experience of what works in a classroom situation and what doesn’t work”

(Female, 5-10 yrs, secondary, city)

“Realistic approach”

(Female, 25+, secondary, small town)

“More aware of student’s capabilities”

(Male, 5-10 years, secondary, large town)
"The curriculum is developed without consultation”
(Female, 15-20 yrs, vocational/community, small town)

"As they are the ones that deliver the curriculum and deal with all the aspects be they positive or negative”
(Female, 25+, community/comprehensive, small town)

"Our feedback should be considered more and our comments at in-service should feed back into more than the JSSS”
(Female, 5-10 yrs, community/comprehensive, city)

Reasons why teachers should not be involved in curricular development matters any more than they already are included some of the following:

"Sufficient input now”
(Male, 25+, secondary school, small town)

"The new syllabus is practical orientated for real improvements laboratory assistance is necessary. If teachers were involved curriculum might be shorter”
(Male, 25+, secondary school, small town)

“Already represented thru ISTA and Trade Unions”
(Female, 20-25 yrs, secondary school, city)

“JSSS working well, giving good resources Teachers not on in-service should have access to these resources”
(Female, 25+, vocational/community, small town)

“Tried to but was told my opinion was ‘wrong’ ”
(Female, 5-10 yrs, secondary school, small town)

The above comments, both positive and negative, offer an insight into the teachers’ feelings regarding their engagement with curriculum development in Ireland. It can be concluded from the data collection that a high proportion of science teachers in Ireland at lower secondary are unhappy with the level of input by teachers into curriculum development matters. While it does not indicate significance (p>0.05) in a bi-variate analysis in the SPSS software, there is a trend observed through cross-tabulations that
those who feel teachers should not be involved in curriculum development matters are predominantly those teaching 25 years or more.

**Views on the new revised syllabus**

One of the objectives of the national survey was to establish teachers’ attitudes and beliefs towards the new revised syllabus. The five point rating scale used in the National Survey (see Appendix D) was merged into a three point scale representing “agree”, “unsure” and “disagree”. The ratings were merged to allow greater clarification of teacher’s attitudes and beliefs towards the revised syllabus.

Attitudes to the new syllabus were of particular importance as the changes to the syllabus were so recent and new. Overall teachers were unhappy with their level of input into the science curriculum; this point was further developed when teachers were asked to indicate their level of agreement with the statement that “The revised syllabus is more teacher friendly than the previous syllabus”. Kruskal-Wallis test examining these two statements indicated a high degree of significance (H (2) = 18.3, p = 0.00), thereby confirming that teachers who were unhappy with their level of input into the revised science curriculum, also believed that the revised syllabus is not more teacher-friendly than the previous one.

![Figure 6.16: Teacher friendly, levels of agreement](image_url)

**Figure 6.16 Teacher friendly, levels of agreement**

Figure 6.16 above indicates how 57% of the cohort disagreed with the statement “The new science programme is more teacher-friendly than the previous syllabus”. These levels of agreement were cross-tabulated with both the gender of the participant, and the number of years teaching but none revealed any significance with Kruskal-Wallis tests (p
Interestingly Kruskal-Wallis tests indicated that while there is no significant relationship between levels of agreement and years teaching, there is a trend indicating that those teaching longer felt that the syllabus was not teacher-friendly (see Table 6.4).

Table 6.4 Cross Tabulation “Teacher friendly * Years Teaching Experience”

<table>
<thead>
<tr>
<th>Years of Experience</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>43%</td>
<td>10%</td>
<td>47%</td>
</tr>
<tr>
<td>11-20</td>
<td>36%</td>
<td>11%</td>
<td>52%</td>
</tr>
<tr>
<td>21+</td>
<td>28%</td>
<td>9%</td>
<td>63%</td>
</tr>
</tbody>
</table>

48% of the cohort identified that they felt the new “revised” syllabus did not suit a mixed-ability teaching environment (see Figure 6.17). Bivariate correlations indicate that teachers who agree that the current programme is not suitable in a mixed-ability environment also do not believe that the new revised syllabus is pupil-friendly ($r_s = -0.145, p = 0.038$).

FIGURE: 6.17 GEARED FOR MIXED-ABILITY TEACHING, LEVELS OF AGREEMENT

As the literature has shown, time has always been a factor when delivering any new educational reform programme and perhaps the new revised syllabus is no different.
Figure 6.18 identifies that over 50% of the cohort agree that the allocated time is not sufficient for the delivery of the programme.

![Pie chart showing levels of agreement with the junior science programme being too long.](image)

**Figure: 6.18 Levels of Agreement with Length of the Junior Science Programme**

This belief that the programme is too long and allocation of time is too short is reinforced throughout the survey data. Teachers that believed that the new syllabus was too long also stated that it was not more teacher-friendly than the previous version ($r_s = -0.222, p = 0.001$). In section two of the survey “your views on curriculum development”, for example, cross-tabulations and bivariate analysis indicate that the 29% of participants, who agreed that time was too short, acknowledged if they were given the chance they would reduce content across some if not all three key elements of the curriculum [physics, chemistry and biology] (see Table 6.5 & Appendix D). However, this trend was not significant ($p > 0.05$).

*Table 6.5 Cross Tabulation “Length of Programme * Reduction of Content”*

<table>
<thead>
<tr>
<th>if given the chance to input into the Junior Science Curriculum which areas would you reduce content in</th>
<th>the junior science programme is too long</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>strongly agree</td>
</tr>
<tr>
<td>biology</td>
<td>2</td>
</tr>
<tr>
<td>physics</td>
<td>3</td>
</tr>
<tr>
<td>chemistry</td>
<td>1</td>
</tr>
<tr>
<td>all</td>
<td>23</td>
</tr>
<tr>
<td>none</td>
<td>19</td>
</tr>
<tr>
<td>biology and physics</td>
<td>1</td>
</tr>
<tr>
<td>physics and chemistry</td>
<td>1</td>
</tr>
<tr>
<td>missing</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
</tr>
</tbody>
</table>
Examining the potential of the new revised programme in relation to further study, the attitudes and beliefs of teachers is quite positive towards the potential of the “revised” curriculum for a pupil’s long term education. There is strong agreement towards the relevance of the subject knowledge for everyday life, and also on its necessity in the study of general science. Over 77% of the cohort disagreed with the statement that “the range of subject knowledge prescribed is irrelevant for everyday life” and a further 74% disagreed with “the subject knowledge covered in the programme is unnecessary”. Figure 6.19 below shows that 55% of the participatory cohort, acknowledged the significance of the subject knowledge as a substantial base for future study of science.

![Graph showing agreement, unsure, and disagreement]

**Figure: 6.19 Substantial basis for future study**

Also noteworthy at this point is the identification by teachers that the variance of subject knowledge between levels (higher and ordinary) was not significant. Nor did teachers identify any disadvantage in terms of future study with regards to the level of study chosen by pupils at lower secondary level.
6.2.3 Pedagogy of the Irish Science Classroom

This section of findings will explore the pedagogy of the Irish science classroom and will investigate teachers’ thoughts and attitudes towards teaching, learning and assessment. Unfortunately what seems to be clear is a strong correlation with the research literature; Irish teachers have a strong affliction towards constructivist views, however, in practice they still possess a heavy reliance on the textbook and structured practices within their teaching and learning. The findings are presented in two segments:

- Teaching and Learning Practices in Science at Lower Secondary
- Views towards the new Assessment Practices

Teaching and Learning Practices in Science at Lower Secondary

Within the survey participants were asked questions relating to the composition of their classroom: this referred to whether pupils were mixed, streamed, banded, set etc. A strong inference was made that mixed-ability banding was the most common and most frequent strategy in the Irish lower secondary science classroom. Participants identified that 80% were teaching in a mixed-ability setting (see Figure 6.20), and this was supported with over 87% identifying that they do not teach in a streamed setting further on in the survey.

![Class Type](image)

**Figure: 6.20 Composition of Pupil Banding in Participants Classroom**

There were high levels of recognition by participants that the usage and incorporation of active learning methodologies (ALMs) within their work was important. 75% agreed or strongly agreed that they made frequent use of active learning methodologies in their
lessons. However, when this was explored further it became evident that one form of ALM was considerably employed more than other innovative forms (see Table 6.6 and Figure 6.21). This was further validated by results from TALIS (2009) that acknowledged while teachers had a constructivist belief in theory, their practice was largely transmissive and traditional (Shiel et al. 2009).

Table 6.6 Analyses of Active Learning Methodologies Used

<table>
<thead>
<tr>
<th>ALM</th>
<th>% Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group work</td>
<td>71.4</td>
</tr>
<tr>
<td>Pupil Led Investigations</td>
<td>40.3</td>
</tr>
<tr>
<td>Peer Learning</td>
<td>26.2</td>
</tr>
<tr>
<td>Role Play</td>
<td>10.2</td>
</tr>
<tr>
<td>Team Investigations</td>
<td>53.4</td>
</tr>
</tbody>
</table>

Methodologies used for teaching and learning within mixed-ability settings incorporated the following: a variation in presentation, hand-outs and creating mixed groups. Techniques that were incorporated to a lesser extent included changing activities, giving individual pupils different homework, setting of individual goals or the re-arrangement of the classroom. Additional techniques identified individually by the participants in an open-ended question included usage of ICT, DVDs, games, quizzes, different questions for different abilities and peer learning. What was also evident from the data collection was that visitors to the classroom or trips outside the school were rather infrequent, with only 30% of participants acknowledging “always” using field trips as a method of developing teaching and learning in science. Visits to industry, third-level institutions, science museums and/ or visitors to the classroom were all
ranked in the “never” used column, and were substantially higher in comparison to those that “sometimes” tried field trips.

To gain an insight into frequency of the use of textbooks and whiteboards, participants were asked “How often would you rate your use of the following in the teaching of your lessons”. A list of materials, resources, and pedagogical approaches were then given, with teachers rating from “always, sometimes, never or NA”. There were two main reasons for the incorporation of this question: 1) the research literature had shown a strong dominance in Ireland towards the traditional teaching and learning approaches and 2) the policy documents did not seem to offer very much in the form of eclectic approaches for the teaching and learning of science. The findings show that the textbook, workbook and white/black board came out on top. This reinforced what was found in the literature: Ireland has a strong dominance of reliance on the textbook and structured practices. Methods such as debate, cross-curricular approaches and pupil demonstrations were all somewhat lower in comparison, see Figure 6.22. It also supported the claim from phase one of the research project, that there is a need for eclectic pedagogies in the lower secondary science classroom.

![Usage of Teaching and Learning Equipment](image)

**FIGURE: 6.22 FREQUENCY BREAKDOWNS OF TEACHING AND LEARNING EQUIPMENT**
Views towards the new Assessment Practices

Gathering the views of participants specifically about the assessment measures was an important part of this survey, due to the significance of the timing of distribution. As explained earlier the survey was administered in April 2007 which was near the end of the first full national assessment of the new revised syllabus, after a phased introduction. This new three-tier assessment model broke the construct of a 100% written terminal examination that had dominated lower secondary science since the 1970s.

Within the new three-tier component, there were two coursework elements and one written element. 61% of the participants agreed with a marks allowance of 65% for the written examination, however, overwhelmingly 53% felt that 10% was an unfair reward for the practical component of coursework A.

“10% for practical copies is unfair to students who keep a copy up to date. Too much effort has to be put in by teacher to “try” and get copies”

(Female, 15-20, secondary, large town)

“I am unhappy with the 10% for practical copy as students have too much writing to do as they may have a science copy as well”

(Male, 25+ yrs, secondary school, small town)

“Good but the students are not assessed directly on their practical skills”

(Female, 0-5 yrs, vocational/community, small town)

While participants felt a 10% marks allowance for Coursework A was unfair, 63% of participants did recognise that the project was worthwhile and offered pupils a more active role within the subject. Comments offered when asked for their views on the current curriculum assessment of junior cycle science included:

“35% already allotted make the written exam easier to approach. No choice is a problem for students some questions can only be answered by very bright students”

(Female, 15-20, community/comprehensive, large town)

“Quite like it”

(Female, 20-25, vocational/community, small town)
However, the majority only felt the new process was adequate, with room for improvement. Many comments being offered such as:

“Level of written paper far too demanding for weaker students at Higher Level”

(Male, 15-20, community/comprehensive, rural)

“Not at all happy as too much time pressure – 3rd year and plagiarism occurring whole sale with input by teachers unacceptably high but understandable”

(Female, 20-25, community/comprehensive, large town)

“I fully endorse the c/w component but I feel it was introduced without full consideration for a) amount of theory also to be covered b) increase in teachers’ workload when it comes to preparing labs/equipment etc.”

(Female, 0-5 yrs, secondary school, large town)

It is clear to see for the comments offered that while participants did agree with the marks allocations there was some issues they felt needed to be rectified. The majority of participants identifying clearly that there were experiencing difficulty with the project, coursework B, element of the new assessment, see Figure 6.23.

**Figure: 6.23 Percentages of Participants Experiencing Difficulty with New Assessment**

When asked to develop on what difficulties they were having, the greatest difficulty was with regards to time, others remarking that questions were too long and discouraged weaker pupils.

“Get project too late, need it early in 3rd year”

(Female, 15-20 yrs, vocational/community, city)(#200)
“Timing of the project component and access to lab and lab equipment”
(Female, 5-10 yrs, secondary, city)

“Wide open to abuse: very unfair, if done correctly they absorb far too much time from the course and far too much work on the teacher”
(Female, 25+ yrs, secondary, city)

“Just need for lab assistance”
(Female, 20-25 yrs, secondary school, large town)

From the Figure below (see Figure 6.24) it is clear to see that teachers felt that this new coursework B was too much pressure, that it was hard when pupils were absent and that there was a need for technicians, and it involved too much work. All these factors are related and could possibly have been avoided if teachers were invited to participate in curriculum development and policy formation at an early stage. The data collection shows that it is not that teachers are opposed to the notion of the coursework B, just to the administration and development of it. There seems to have been a lack of cultural awareness and understanding by those developing policy about what teachers are facing on the ground; yet again rhetoric versus reality is present in the Irish classroom at lower secondary.

![Difficulties Expereinced by Participants](image)

**Figure: 6.24 Difficulties Experienced by Participants with Coursework B**
There was neither agreement or disagreement on whether greater emphasis should be placed on practical work rather than on written work within the assessment of lower secondary science, see Figure 6.25. There is, however, a trend identifying that those who believed there should be a practical examination also assessed practicals in their classroom ($\chi^2 = 5.606$, df = 2, $p = 0.05$)

![Figure 6.25 Agreement Levels for More Emphasis on Practical Work](image)

Reasons offered for each side included that there:

“Students get more enjoyment out of practicals and learn more – would promote science subjects at senior cycle”

(Female, 25+, vocational/community, small town)

“They need the written element if they want to move on to senior level sciences”

(Female, 25+ yrs, secondary school, city)

“Takes a lot of time to get practicals set up and tidied away – need lab assistants”

(Female, 15-20 yrs, community/comprehensive, rural)
Interestingly however over 49% of participant’s felt that there should be a practical exam in science similar to the technology subject (see Figure 6.26).

**Figure: 6.26 Levels of Agreement with a Practical Exam for Science**

Comments offered in support of a practical examination by participants included:

“I would like to see a practical test supervised by examiners properly remunerated”

(Male, 20-25 yrs, vocational/community, small town)

“Coursework B Problematic-standards school based/teacher based causing variation. Should have practical exam”

(Male, 25+ yrs, secondary school, city)

“This is a disadvantages school. To get attendance for the period of the project is very difficult. The writing up of same is very difficult. My pupils are good at experimental work (they have won prizes at Salter’s). They do all the mandatory practical’s the 10% is ...They need a PRACTICAL EXAM (like the JC H. Economics). This is the only fair way to assess SKILLS”

(Female, 25+ yrs, community/comprehensive, city)
6.2.4 Professional Membership of the Irish Science Teacher

Care has to be taken when investigating professionalism and matters around professional development. The author felt it would be misguided to pose too many questions pertaining to professional membership for fear of causing offence, and thus impacting on response rate. The notion of teachers as professionals and levels of professional development undertaken by teachers can sometimes be a contested issue. Consequently, matters pertaining to professionalism were not explored in much depth and only somewhat indirectly within the national survey. The premise for the researcher was instead to gain some information regarding membership of professional organisations. Investigating whether teachers had membership in professional organisations would help to understand the current climate in Ireland towards such organisations. The researcher would then further explore how many participants involved themselves in the opportunity to further their career/learning, for example, through in-service or additional training within the professional organisations.

Participants were invited to respond to the following question “are you a member of any of the following organisations or institutions?” A list six organisations was included:

- ISTA Irish Science Teachers Association
- ASE Association for Science Education
- IoP Institute of Physics
- IoB Institute of Biology
- ICI Institute of Chemistry of Ireland
- IASTA Irish Agricultural Science Teachers Association

It evident from the Figure 6.27 below that membership of professional organisations was somewhat biased towards one organisation, namely the Irish Science Teachers Association (ISTA). 66% (n=136) identified membership of the ISTA, however, even within that a high number of teachers were not members, 32%, (n=66). ASE membership was expected to be low as a result as this being the UK version of the ISTA, however, teachers can be members of both. Within the others professional organisations, IoP, IoB, and ICI received 9%, 3% and 4% membership respectively.
Participants were afforded the opportunity to include any organisation that they were members of that they felt had been excluded. 12 participants took the opportunity and organisations included the Biology Support Service (BSS), Institute of Engineers Ireland (IEI), Royal Society of Chemistry (RSC), Institute of Maths (IMA) and Applied Maths Teachers Association (AMTA), TL21- an R&D project being developed from NUIM, NCTE, Dublin Naturalists Field Club and Irish Learning Support.

To further investigate participant’s involvement with professional organisations, those who had answered yes to the above question were asked “Do any of the organisations you are affiliated with, offer in-service in the following areas”. There was a mixed response to the question with a high level of participants failing to answer the question or marking it n/a (n=62). Training in data logging, ICT and laboratory practicals were the main in-services identified offered by the organisations listed previously (see Figure 6.28). Cross-tabulations reveal that these three areas are covered through the ISTA.
In relation to professional membership, it needs to be acknowledged that over 96% of participants in the research were indeed members of a teacher union, so why not the same for the professional bodies?

### 6.2.5 Summary of data collected in Phase Two

Phase two is a representative sample of both schools and teachers involved in lower secondary science nationally. The majority of those teaching in lower secondary science are female and these have predominately been teaching for over 20 + years. This concurs with the research carried out by the OECD (Shiel et al. 2009). It is also clear from the research that the voluntary secondary school sector in Ireland is the largest secondary provider at present catering for over 55% of national cohort (Higgins 2009, pg: 17, Power and Mooney Simme 2010, pg: 164).

The three key areas outlined from the content analysis in phase one were further explored within the survey, however, with the exploration of professional development somewhat limited for reasons put forward. In relation therefore to curriculum development it was found that generally participants are unhappy with their level of input into curriculum development matters. 85% of the research cohort said they believed that teachers should have more input into matters surrounding curriculum development. Reasons put forward in support of this included having the “trait knowledge” and a “realistic approach”. These findings are quite pertinent as it was clear from phase one that the teacher was certainly not viewed as part of the curriculum
process and indeed in recent years was involved only towards the end at consultation. This response by the teachers in the survey only strengthens the argument for moving away from a centralised approach to curriculum development, and a full engagement with the teacher.

Regarding the new revised curriculum, there was strong agreement with the practical and project elements. However, participants were prompt to articulate that they did not feel this new syllabus was teacher-friendly. Participants felt while the practical component was great and worthwhile, teachers needed more support in terms of time from the SEC and on the ground in the form of laboratory technicians. Indeed throughout the survey where possible participants reiterated the call for support. Over two-thirds of teachers acknowledged they were having difficulty with Coursework B, and at the top of this difficulty list was “not enough time”, “extra pressure” and “hard when students were absent”.

With regards to teaching and learning methodologies, the findings from phase one were reinforced once again. A move towards more eclectic pedagogies for the Irish science classroom is a necessity for both the subject and for pupils’ learning and development. The majority of Irish science teachers are teaching in mixed-ability setting and while there seems to be agreement on the need for variety and change, the majority of teachers still have a heavy reliance on the textbook and chalkboard. Interestingly there was a call for a practical examination for science, and this perhaps could be worth investigating in a further study.

Finally the last area that emerged from the content analysis of phase one surrounded professional development. Within the national survey it was deemed inappropriate to ask too many questions pertaining to professional development, as it might impact upon response rate and the other areas were of much too great importance within this phase of data collection. Therefore it was decided to only explore teachers’ professional membership. What has become evident is that such membership is quite low, with only two-thirds of participants engaged in membership with the Irish Science Teachers Association (ISTA). What was also evident from the data collected was that of the in-service courses available to teachers through the professional organisations, the majority of participants only attended ones relating to ICT, data logging and laboratory
practicals, and very few participants engaged in in-service courses dealing with how people learn, or teaching mixed-ability groups etc.

To conclude, it is apparent that there is awareness among teachers of the importance of teaching and learning methodologies, especially when working with mixed-ability groups. However, what is obvious is that lower secondary science teachers are consumed with the pressures of time and laboratory management with the new assessment practices, and so support in terms of professional and collegial help is needed here. Teaching and learning methodologies cannot change when teachers are grasping for time and support. Perhaps if teachers were engaged more professionally with their counterparts and colleagues in their school and/or local network of schools, these pressures of time and management could be shared, lessened or even alleviated. What is also evident is that teachers are willing to engage and fight for innovation and change, when given the opportunity. There is a need for matters concerning curriculum development and policy formation to become more democratic and relational, where teachers can have their say, and policymakers can become aware of the contextual issues of the school and the classroom.
6.3 Phase Three Findings

Introduction
Phase three of the research project was developed around case studies that took place in three secondary schools in the mid-west of Ireland. Lower secondary science teachers within each school were approached and asked if they would be interested in researching and developing an innovative curricular tool, which would impact on and aid the teaching and learning of science in their school. This tool was used to bridge the gap that teachers felt needed to be addressed within the teaching and learning of their classroom. It should be recognised that “change” and “innovation” were coined loosely, and often used interchangeably. Often defined as by the researcher as:

Something new something different, something innovative, be it the way you present knowledge to the pupils, integrate practical work or teach a whole topic, as long as it’s something different, that you’ve not tried before. Innovation does not essentially have to mean something extravagant or that would need lots of extra time or work.

(9th November 2007)

6.3.1 Development of Phase Three
Merging the literature review and the findings from phase one and two of the study led to the emergence of a theoretical framework. This framework was used to theorise all that had been read and achieved in the study so far, and it was to act as a guide for the development of innovation and change in the contemporary Irish school and classroom. It would shape the development and analysis of phase three of the research study. The framework was developed around the notion that innovation and change for the contemporary Irish classroom integrates curriculum change, professional change and pedagogical change as one integral unit. Change within these three key areas leads to ownership, empowerment and an eclectic and innovative pedagogy. There are however pre-conditions for the framework, these include:

- Development of partnership
- Democratic communication
- Awareness of culture and context, and
- An appreciation of teacher as professional
This section of the findings will report on the data collected from phase three, the case studies. The data is presented through the four lenses outlined by Brookfield (1995) for *Becoming a Critically Reflective Teacher*. The case studies took place in three schools across the mid-west region of Ireland. The section begins by offering a demographic profile of the schools, so as to contextualise the project. The findings of phase three are then separated into two areas, representing the link to the framework (discussed in chapter four). These include:

- Developing Democratic Ownership and Empowering Teachers Professionally
- Professional empowerment

### 6.3.2 Demographic Profile of Case Study Schools

The multiple case study research was developed around three schools. There were, however, five different schools invited to take part in the study. Two schools ended their involvement at different stages; their reasons for terminating connection to the project are quite relevant to the Irish situation and will be discussed further on. All schools involved came from the Mid-west region of Ireland, which comprises counties Limerick, Clare and North Tipperary. Relative to the Irish context, each school involved was deemed to be a “large” post-primary education provider, due to its pupil numbers enrolled. Each school involved was also co-educational. This is quite important as just 477 of the 732 post-primary schools listed within the Department of Education statistics for 2006/2007, were categorised as co-educational (Central Statistics Office 2007). As mentioned earlier Ireland has a strong tradition of single-sex education.

Schools involved in the project were encouraged by the research team to carry out this research specifically with first years from the lower secondary level. First year pupils were encouraged due to the nature of the Irish curriculum and syllabi. Second and third year of lower secondary level are often stressful due to the nature of the state examination in June each year. The research team was aware of this and strove to make the project as accessible as possible. The Table 6.7 below offers some information on the three schools involved and their areas of investigation.
Table 6.7 Case Study School Demographics

<table>
<thead>
<tr>
<th>Name of School</th>
<th>Type of School</th>
<th>School Background</th>
<th>Lab Technician</th>
<th>Pupil Numbers</th>
<th>Mixed Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>Fee Paying Secondary School</td>
<td>Irish/International day &amp; week boarders</td>
<td>Yes</td>
<td>650+</td>
<td>Yes</td>
</tr>
<tr>
<td>School B</td>
<td>VEC</td>
<td>Suburbs</td>
<td>Yes</td>
<td>700+</td>
<td>Yes</td>
</tr>
<tr>
<td>School C</td>
<td>Community School</td>
<td>Urban/Rural Mix</td>
<td>No</td>
<td>700</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The demographic profile of pupils involved in the survey was predominately female, with an average age of 13. All pupils were belonging to the first year cohort in each school and the majority had taken science at primary level. Pupils were asked if they felt they would like to work in the future in science, the study cohort were quite consistent in a designated “don’t know” prior to the project starting. Within the project, pupils took part in two areas of data collection: pre-and post-surveys in relation to “Attitudes to Science” and a reflective diary while taking part in the project.

The Projects

This brief segment will offer a background to the individual projects that were undertaken at each school.

School A: promotion of an eco-friendly science classroom, while promoting a higher level of pupil involvement through the development of micro-scale experimental work at lower secondary level.

School B: promotion of ICT-enhanced technologies available in the school of topics in lower secondary science, with the purpose of increasing pupils’ digital competences but also pupils’ competences around graphs and graphing.

School C: comparison of ICT-enhanced approaches versus the traditional approaches of teaching in lower secondary science. With the possible promotion of ICT-enhanced learning activities in the future teaching and learning of lower secondary science.
As the literature outlined earlier, the technical ideology is quite dominant in the Irish classroom. However the, significance here was the identification of teachers viewing themselves as technicians.

The third phase of the research project set out to examine the suitability of the emerging theoretical framework as a vehicle for reform. The findings for phase three are represented under the following subsections:

1) Developing democratic ownership and empowering teachers,
2) The positives of eclectic pedagogies.

6.3.3 Developing Democratic Ownership and Empowering Teachers Professionally

Background
This subsection of findings explores the data that was collected in the creation and development of the school-university partnerships.

From the research literature it was demonstrated how teachers can become “change agents” of curriculum innovation and change efforts. It was, however, made evident from the content analysis of policy literature findings, that the role of the teacher in this area was minimal and somewhat limited. As outlined in the introduction to the thesis, the purpose of this study was to empower teachers to develop an ownership of curricular activities and become innovators of pedagogical change. The emerging theoretical framework was developed from the research literature to guide the researcher in striving to achieve the research purpose. At all times the researcher strove to incorporate the preconditions of the framework, outlined earlier in this section. It was an imperative for the researcher that an awareness of teacher and school culture be threaded through all stages. From the research literature and the emerging theoretical frame, it was evident that the reflective tool was also important in achieving this purpose (Larrivee 1999, 2000).
**Developing the Partnership**

**Initial Stages**

Initial meetings were held with teachers in schools that had a history of rapport with the University of Limerick between September and November 2007. These initial meetings were to explore the aims of the GIMMS project and offer teachers a sense of what the project would entail

“*Developing teacher motivation, exploring the cognitive process of learning, bridging the gaps in teaching and learning*”

(Field notes, 27th September 2007, Initial Visit to School B)

An essential part of this stage of the process was to indicate that the role of the university researcher would be of “*mentor, support and guidance*” (Field notes, September 2007). The relationship that would ensue was to be one of collaboration and shared dialogue (Furlong et al. 2000, Peters 2002). It would not be a relationship developed and led by University researchers, where teachers would be told what to do (Sarason 1996). At these initial meetings:

“*Cultural dissonance between the world of the school and university was most evident*”

(Mooney Simme and Power 2012)

As explored above, an atmosphere of “pressed for time” and “workload stress”, greeted the university researcher at some of the schools. There was an

“*Impression that this project would led to more work and so was greeted with negativity straight away from all concerned*”

(Mooney Simme and Power 2012)

This, of course, was to be expected having explored the data collected in phase two of the study, where teachers outlined a “need for technicians” and a “need for support” as the new assessment structures were just “too much for teachers”. This “workload pressure” impacted on the research project, leading two schools to withdraw in the early stages of the project.

As previously mentioned in the chapter, five secondary schools were initially invited to take part in the research project. As with any research project the reasons behind
withdrawal from a project are just as important as findings from those who completed the project, especially when consideration is applied to the literature review and findings from phase one and two of this research project. School D, withdrew at the beginning of the project, while School E was six weeks into the project before it withdrew.

School D felt that at this particular time the school could not be involved, circumstances had recently changed and the main science teacher was out due to illness and her substitute felt that she “had enough on her plate trying to find everything, and was not hard pressed to engage in a research project with the University of Limerick” (Field notes, 17th September 2007). The second school (School E) however was somewhat different. The clash of cultures was recognised when the dynamic partnership between the university and school was explained, and the impression of busyness and stressful lives was portrayed (Mooney Simme and Power 2012, pg: 198). It would be understandable due to past histories that some scepticism would exist (Clandinin and Connelly 1992). What was evident within this school was the dominance of the technical and product approach to teaching and learning and the pressures felt by the science teachers.

Look around you there, see all that equipment, we are supposed to get all that ready and tidied away before the next class, do you know how long that takes????

(Field Notes 28th February 2008)

**Curriculum Workshops**

Teachers from the case study schools were invited to take part in curriculum workshops. The purpose of these curriculum workshops was to strengthen the partnership, develop the democratic lines of communication and thus professionally empower the teachers involved.

The first curriculum workshop was held on the 14th January 2008 in the University of Limerick. This curriculum workshop brought together key stakeholders within the Irish education system and the case study schools. Representatives from the NCCA, SEC, JSSS, ISTA, TUI, and the Association of Secondary Teachers Ireland (ASTI) were all in
attendance. The format of the curriculum workshop was very informal, and was facilitated in a manner that supported a democratic and relational approach to collaboration: it assumed “an atmosphere of professional autonomy realised through discourse, decentralisation, and professional self-improvement” (Lang et al. 2007). Each school was invited to explain what their project was trying to achieve and why they were investigating this area. The workshop was received very well from participants, with all participants acknowledging that they found the seminar “very helpful”. The following comments on feedback sheets supported the view that the seminar was very helpful, with some participants identifying some strengths of the workshop:

“Communication with other groups”,

“Teachers talking about their practice and future practice”

Teachers displayed a positive attitude to the curriculum workshops, and they were enthusiastic about their involvement and the recognition they received. One of the key outcomes of this initial workshop was that the teachers recognised that they were no longer passive recipients and instead were players within the bigger picture:

“Seeing we are not alone in this project, learning from others and seeing the bigger picture”

Clearly this was the initial stage of teachers experiencing professional empowerment and curriculum ownership, which continued throughout the project. These experiences were carried throughout the project, with teachers remarking at the second curriculum workshop which was held on the 28th March 2008, at the end of the project:

“very good to see outside our own little box and to feel that we are engaged in something a little bit bigger than what goes on in our own little rooms because teaching in its very nature can be quite an isolating job”.

(Teacher A, School C, Curriculum Workshop #2)

The theme of ownership and its impact on practice was reinforced at the second curriculum workshop. Teacher B, in School A, described his sense of ownership developing through innovative pedagogical design.
“The other thing as well is that when you design the experiment yourself and you break it down yourself it is much easier to break it down into a step by step process for the students and to give each student a task and to get everybody in the group doing something because you have engaged in the experiment a lot more yourself from day one so it is a lot easier to break it down for the students and I think in terms of the planning in the classroom that has helped a lot”.

(Teacher B, School A)

The professional empowerment of teachers within the study led to the development of communities of shared practice and engaged teachers in democratic and relational collegial dialogue.

“Sharing ideas as well and chatting about what works and what doesn’t work and using lab quest is very straight forward but the sharing confirms best practice with how it works in the class. And then just things like collegiality and being a reflective practitioner because we don’t get time to write down notes to mull over what goes on in every class so this is definitely an opportunity to put a lot of thought into what we are doing and how we are doing it”.

(Teacher B, School B).

“The collegiality among the science department was definitely enhanced because there was a lot of working together and you had to do it whether you liked it or not so basically it enhanced the collegiality”.

(Teacher A, School C)

6.3.4 Positives for Eclectic Pedagogies

The literature review and the findings from phase one and two of the research project identified that teaching in Ireland was very traditional and didactic in nature. During the development of the theoretical framework it became apparent that learning was a process in which “student characteristics, teaching context and learning outcomes, mutually interact” (Watters and Watters 2007). This process of learning is limited by the traditional approach as it does not promote pupil learning and therefore limits the development of a cognitive lens by pupils.

Part of the case study work was the development of new and innovative ways for the teaching and learning of science at lower secondary level. Teachers were invited to introduce something new and innovative into their daily classroom. They were
encouraged to identify a particular area of teaching or pupil learning that needed a change. The gap identified varied from school to school for example: one gap identified was the inability of pupils to read graphs at upper secondary; for another school it was cost of chemicals and a greater focus on the “green school project”; another was simply just to increase engagement of pupils with ICT within the subject. The Table 6.8 below identifies the approach and changes that each school wished to investigate.

Table 6.8 Case Study schools

<table>
<thead>
<tr>
<th>Case study Schools</th>
<th>New Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>Micro Scale Science</td>
</tr>
<tr>
<td>School B</td>
<td>Data logging in Science</td>
</tr>
<tr>
<td>School C</td>
<td>Promotion of ICT enhanced Learning</td>
</tr>
</tbody>
</table>

The purpose of developing a new pedagogical tool was twofold: 1) to enhance the teaching and learning of the classroom and 2) to aid in the development of a school-university partnership from which professional empowerment would grow. This section however is only focused on documenting the development of the innovative pedagogies and their impact on the pupils and teachers within each school.

Increase in positive attitudes toward science

Pre-and post-tests were carried out with pupils involved in the study in each school to determine pupils “attitudes towards science” (see Appendix I and J). The purpose of these surveys was to assess if there was a difference in attitude after the implementation of the new pedagogical approaches. The pre-and post-surveys examined pupil interest, teaching styles and included a section entitled “my learning”, which explored the way each individual pupil preferred to learn. The pre-and post-scores from each school were entered into Microsoft Excel. However, due to a great deal of variation between schools around pupil numbers in both tests, a random sample of twenty data sets was selected from each school using SPSS. Table 6.9 below identifies the high levels of variation between schools. Variation generally occurred due to absenteeism from school on day of collection.

Table 6.9 Variation among pre- and post-test participation levels

<table>
<thead>
<tr>
<th>School</th>
<th>Pre (n = 182)</th>
<th>Post (n = 153)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>n=41</td>
<td>n=22</td>
</tr>
<tr>
<td>School B</td>
<td>n=81</td>
<td>n=76</td>
</tr>
<tr>
<td>School C</td>
<td>n=60</td>
<td>n=55</td>
</tr>
</tbody>
</table>
The demographics of both the pre-and post-sample were different as a result of the random sampling technique. The pre-sample had a gender breakdown of 34 males, 26 females (n = 60), while the post-sample group had a gender breakdown of 31 males, 29 females (n=60). 67% of the pre-sample cohort was aged 13 years, while 80% in the post-sample was 13. All participants in pre-and post-samples were in first year of lower secondary education. In terms of previous experience, 83% of the pre-cohort acknowledged they had taken part in science at primary level, while only 62% of the post-cohort had primary science experience.

Table 6.10 offers a selection of responses from the pre-and post-survey that pupils completed. These results displayed in Table 6.10 help to demonstrate how pupils that took part in the project demonstrated a positive increase in attitude toward learning and science.

The first section of the pre-and post-surveys related to “Interest in Science” pupils were asked to rate the statement “I like Science” on a Likert scale. From Table 6.10 it is evident that there was an increase in those that “agreed” to like science following the educational innovation intervention (63% up to 74%, n = 60). Pupils were also asked questions regarding the complexity of science, whether they felt under pressure in science class, and understood what was going on in class. Table 6.10 indicates that a large proportion of the pupils involved in the cohort study did find science complex (67%) however this was reduced post-intervention (58%). Interestingly, there was no change in level of agreement with the statement “I feel under pressure in science class” 27% agreed with this at both interval stages. Again in relation to complexity, there was a slight decrease in level of agreement with “I have no idea what is going on my science class”, indeed the level of disagreement rose from 63% (pre-test) to 75% (post-test). Perhaps the decrease in complexity might be related to the increase positive attitude towards science. Bivariate correlations carried out however, showed no significance between the complexity of science and levels of agreement of “liking” science pre- or post-intervention (p > 0.05).
The second segment of the pre-and post-surveys was around “teaching styles”. This section was to investigate what pupils preferred in the classroom environment. For example, did they like using posters, did they feel ICT helped them learn, did working in groups help them learn? Findings within this section showed that pupils’ thoughts about learning positively increased post-intervention. Pupils were asked questions regarding group work, and as Table 6.10 indicates there was a strong trend of agreement towards the usefulness of group work. With 70% of the study cohort disagreeing with the statement “Working in groups doesn’t help me to learn”, this level of disagreement rose to 72% post-intervention. Indicating perhaps that involvement in the project allowed pupils to work together more and therefore pupils could see the rewards more positively on their work. While there is no significant relationship between those disagreeing with “working in groups doesn’t help me to learn” and “science is
complex” (p > 0.05), cross-tabulations indicate that those who found group work helps them learn post-intervention, also found science not complicated post-intervention. The positive support for group work was strongly correlated by 70% of participants “agreeing” to another statement that “working in groups of 2 or 3 aids my learning” (n=60). Due to the fact that two of the three schools were integrating ICT into their educational innovation and change packages, it was important to investigate pupil’s attitudes towards ICT and computers. The pre-and post-data collection showed that 70% / 69% of pupils respectively felt that ICT was helpful for learning. As expected from the literature review a large number of pupils agreed that when related to their own lives learning was easier (see Table 6.10). There was an 8% increase in agreement post-intervention. This could correspond to the fact that each of the interventions were developed with the development of scientific literacy to the fore, making it pertinent to relate innovations to the world around us. There was strong approval among the findings for the promotion of assessment for learning methodologies and the importance of teacher feedback on pupil learning. 22% of the pre-and post- cohort strongly agreed to “I like when the teacher gives me personal feedback on my work”.

**Making Learning Easier**

In relation to each individual extension, it was very evident from School C (traditional versus ICT enhanced learning project) from those who took part that 89% enjoyed the new ICT presentations (n = 18). With reasons included in the open question as to why acknowledging

“Enjoyable” (male respondent)

“Easier to remember” (female respondent)

“Better than the book” (male respondent)

“Helped me learn better” (male respondent)

This enjoyment was further probed when pupils were asked in an open-ended question (Q3) what they liked and disliked (Q4) about the new approach. Those that liked it gave comments such as:
“Easier to understand” (male and female respondent)

“You learn more from the colours and the diagrams” (male respondent)

“Makes learning fun, more clearer” (female respondent)

“Helps you learn better” (female respondent)

This new positive view towards learning was also found in School B (ICT and data logging) that 90% of pupils in school B indicated that they enjoyed using the data loggers within science class (n=20). Fun and interesting were the two most common reasons why pupils enjoyed the data loggers from their responses to the open-ended question. With one pupil acknowledging,

“fun, didn’t realise I was learning” (female respondent)

In School A, where micro-scale science was the new pedagogical approach introduced, 85% of pupils were positive about this new approach. Comments in support of these included:

“Fun” (male respondent)

“Different to old method” (female respondent)

“Easier to use, easier to understand” (female respondent)

There was general consensus across all three schools that the reflective diaries were not a source of enjoyment with 60% in School A (n=20) and 60% in School B (n=18) and a further 77% in School C (n=18) saying “no” to enjoying them. This was further enhanced by the high levels of comments calling the journals “boring”.

6.3.5 Summary of Data Analysis

The results of this study indicate that school-university partnerships can work in the development of democratic ownership, professional empowerment and pedagogical innovations. The case study findings outline that the emerging theoretical framework provides a strong foundation in the fight for innovation and change. The
implementation of the pedagogical innovations as a tool for developing an SUP, has worked successfully, with teachers and pupils acknowledging an increase in positive attitudes towards the teaching and learning of science. Themes surrounding the area of curriculum ownership and teaching as a profession emerged, highlighting the functionality of the framework as a tool for innovation and change in the contemporary Irish school and classroom.
7.0 Discussion
7.0.1 Introduction
This chapter of the thesis draws together the research literature and findings in order to answer the research questions set out at the start of the project. The journey from the exploratory phase one of content analysis on policy documents right through to the case studies of phase three, offers a unique insight and perspective into teaching and learning of lower secondary science in Ireland. Each research question is followed by a table outlining the emergent themes and main findings in relation to that phase of the research, addressing the specific research question. To aid the understanding of this chapter the researcher has incorporated the research questions below for consultation.

7.0.2 Aim of Research
The aim of this research project is to empower teachers professionally to develop curriculum ownership and pedagogical innovation in the teaching and learning of science in the contemporary Irish school and classroom.

7.0.3 Research Questions
- To explore the impact of policy on the teaching and learning of science through content analysis of International and Irish Government documents from the 1960s
- To investigate the attitudes and beliefs of lower secondary science teachers in Ireland to curriculum development, teaching and learning methodologies and assessment
- To examine the role of a school-university partnership as a means for implementing curricular change and developing teachers as professionals in the Mid-West of Ireland
7.1 Addressing Research Question 1

To explore the impact of policy on teaching and learning of science through content analysis of International and National Documents

The research literature and research findings have revealed some very interesting themes concerning the impact of policy. It was evident from the exploratory study into the policy documents, that the process of curriculum development was skewed towards those in power. Appointments to curriculum councils and committees were very much dominated from ministerial posts with little input coming from the classroom (NCCA 2011b). There was minimal representation of the teacher and teacher voice within the process of curriculum change. The teacher was viewed within the documents as “technician”, with the curriculum process “separate” to their role (Cochran-Smith and Lytle 1990, Hargreaves 1994). This lack of teacher voice is a problematic area in the development of teaching and learning and for the progression of “teaching as a profession” (Sarason 1990, Ostermeier et al. 2010). Findings from phase two of the research project indicate that it is not just the researcher who feels this impact of policy. 85% of those who participated in the study felt that teachers should have more input into the process of curriculum innovation and change. The research literature also argues the importance of teacher voice, as teachers’ can become “agents of change” and offer significant insight into schools and classrooms (Dalin 1993, Fullan 2001b, Goodson 2001). Participants in the national survey also believed this and feel that since they “were teaching it”, they could offer a “realistic approach” and therefore should be involved. This absence of teacher voice within the policy documents supports the finding that the process of change in Ireland occurs in a top-down manner (Goodson and Hargreaves 1996b, Goodson 2001). The OECD (1991), Gleeson (2000), Trant (2007), Shiel et al. (2009) identify in their work how the system is “highly centralised” and “bureaucratic”, and they have demonstrated how this top-down approach has resulted in a very fragmented system of education with many stakeholders grappling for power (Gleeson 2000). Callan (1995) further acknowledges how “conflicts over knowledge and power” were evident within the education system, as those in power fought over dominant, personalised issues. Sarason (1996), and Fullan (2001a) clearly outline that often the failure of curricular reforms occurs because people do not a have a clear and coherent sense of the meaning of the change, or there is a lack of trust between both
parties and even a belief that the change is unwarranted. The impact of this top-down, centralised bureaucratic approach on the process of curriculum change could, according to the research literature, be rectified. The literature identifies how partnerships between teachers and policymakers offer a more mutually beneficially and successful approach for the process of innovation and change (Goodson 2001, Hargreaves and Shirley 2009). The partnership approach to innovation and change is more inclusive and democratic, and goes beyond the “red tape” (Fullan et al. 1995, Giddens 1998). Ireland, as it was viewed from the content analysis, is no stranger to the process of partnership. The integration of social partnership in the 1980s was a significant accomplishment of the change and reform efforts of that era. Now, however, there is a need for a more inclusive and democratic approach, as the research literature has shown that in some cases social partnership seemed to only enhance sectoral interests rather than any common goal (Gleeson 2000). Partnerships within the new millennium must be inclusive of teachers’ and pupils’ needs and have a strong understanding and appreciation for cultural awareness. They also need to be flexible and adaptable, as the face of teaching and learning is continually evolving. It is evident from the national survey findings that teachers would engage in a partnership process if given the opportunity, as their level of dissatisfaction with the level of input currently available to teachers was so high. An additional benefit to a partnership approach to innovation and change is the open acknowledgement of the presence and importance of culture. Throughout the content analysis it was evident that policy makers deemed all schools to be the same, with little recognition of the cultural differences between schools and within classrooms. The lack of awareness of school culture can bring about failure, as belief and values, relationships, structures and strategies in schools are ignored. Working in partnership with teachers, around the development of curricular change, takes into consideration these factors and permits the crossing of boundaries.

It is apparent from the research findings, and also supported from the research literature, that there is a strong divide between the rhetoric and reality of the lower secondary classroom. The 1960s and 1970s documents called for a change in relation to teaching and learning practices and were the first to outline the need for practical work and the importance of the role of practical work. Unfortunately, it is evident from the policy documents analysed that while the importance of practical work was acknowledged, until recently (2003) it was not a specific requirement within the
curriculum and assessment of lower secondary science education (Department of Education and Science 2003, NCCA 2003c). Despite the fact that practical work is now a core component of the lower secondary science curriculum and assessment it is still somewhat technical and prescriptive in nature. Chapter two of this thesis sought to bring the underpinnings of the Irish education system into perspective and these too were further supported from the research findings. Classical Humanist ideology and its technical culture were evident in the examination of the policy documents. The documents highlighted the fear that policy makers sought to adopt ideas around practical work and inquiry-based science, in order to add breadth and balance to lower secondary pupils’ education, but it became evident that this was not the case in practice (Higgins 2009). Since the 1970s it has been recognised that policy impacts on teaching and learning by relating it into a product-driven approach, bound by a process of national examination (ICE Report 1975, Gleeson 2009). This product-driven approach to teaching is further espoused by the reconstructivist ideology that has entered in recent years (Trant 2007). The recession, market values and government strategies have overshadowed progressive ideologies for the sake of the economy and industry (Drudy and Lynch 1993). The two other phases of data collection further support this notion of product-driven approach bound by the curriculum. In phase two, for example, one teacher noted that while they did not complete the survey and acknowledged that this was because he was “too busy washing test tubes and preparing for leaving certificate examinations”. Phase three of the research further enhanced this perspective on the impact of policy on teaching and learning methodologies. While carrying out the case study work in schools it became evident that teachers had “busy and stressful lives” (Mooney Simme and Power 2012). While teachers may have indicated a strong preference for social constructivist views towards teaching and learning, their practice is still very influenced by the traditional and technical ideologies (Shiel et al. 2009).

Another aspect that was developed from the content analysis was the deficiencies around professional development. It is evident that policy in Ireland does not lend itself to the promotion of teaching as a profession in Ireland. Do we also have a rhetoric and reality dichotomy in relation to professional development? The idealistic view is of “teaching as a profession” on paper (Teaching Council Act 2001, The Teaching Council 2011) but the reality is that it cannot fully be developed until innovation and change occurs, where teachers are empowered and ownership evolves.
It is evident from the content analysis of policy documents that Ireland is now a multicultural and diverse state, which brings new and important aspects and challenges to the lower secondary science classroom. Now, more than ever, there is a need for teachers to play a significant role in the process of curriculum development. There can no longer be ignorance around the importance of teacher voice and the important evidence teachers bring to school culture. Table 7.1 below offers a summary of the main findings and emergent themes from phase one, address research question one.
Table 7.1 Emergent themes from RQ 1

<table>
<thead>
<tr>
<th>Emergent Themes / Main Findings</th>
</tr>
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<tbody>
<tr>
<td>● Curriculum development within Ireland is highly centralised, conservative and bureaucratic. Innovation in Ireland can be slow and the system has often been described as “lethargic” towards change.</td>
</tr>
<tr>
<td>● Educational change in the Irish context is orientated towards product and investment. Development within education policy is strongly influenced by economic growth and expansion.</td>
</tr>
<tr>
<td>● The position of the teacher at policy level is very minimal; there is a lack of teacher presence and most poignantly there is lack of teacher voice. Many appointments to committees and councils are still governed from a ministerial level.</td>
</tr>
<tr>
<td>● Within the Irish education system at lower secondary science plays a prominent role and is generally correlated with economic growth and expansion.</td>
</tr>
<tr>
<td>● The development and integration of science as a core subject or as a literacy skill is often overlooked and overshadowed for economic benefit and gain.</td>
</tr>
<tr>
<td>● There have been many documents produced at policy level aimed at “promoting science”, at lower secondary level calling for an uptake in science.</td>
</tr>
<tr>
<td>● Within Ireland there is a strong reliance on traditional and didactic pedagogies, with a profound dependence on assessment of learning rather than assessment for learning. As recent as 2009 Ireland was deemed to have a strong preference for “structured practices” in teaching opposed to “enhanced activities” (TALIS 2009).</td>
</tr>
<tr>
<td>● Only recently has there been an incorporation of the practical elements of the subject science within the lower secondary science curriculum, and this is still maintained through a written element rather than a practical skills element.</td>
</tr>
<tr>
<td>● Policy in Ireland does not lend itself to promoting teachers as professionals nor in practice does it promote the professionalisation of teaching.</td>
</tr>
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</table>
7.2 Addressing Research Question 2

To investigate the attitudes and beliefs of lower secondary science teachers in Ireland to curriculum development, teaching and learning methodologies and assessment

The current demographic of lower secondary science teachers is predominantly female, with a high proportion of these teaching for over twenty years. The majority of current science teachers came into teaching through the Higher Diploma in Education route, with only 12% entering the teaching profession through the concurrent route. Of the sample obtained a large proportion of those engaged in teaching lower secondary science have posts of responsibilities and teach personal development subjects such as SPHE and CSPE. This was to be expected as questionnaires were addressed to the “Head of Lower Secondary Science”. The findings from phase two found that the average lower secondary science classroom is working within a mixed-ability setting, over 80% of participants identified teaching within a mixed-ability setting in their science classrooms.

It was evident from the survey of national science teachers that there were parallels between the impact of policy and the realities of the classroom. The research literature and phase one research findings demonstrated that a major impact of policy was on the technical view of teaching and the resulting minimal input of teacher voice (Cochran-Smith and Lytle 1990, Clandinin and Connelly 1992, Trant 1998, 2007). It is apparent from this research project that this has impacted on the Irish classroom quite strongly, both professionally and pedagogically. The literature cautions us that centrally-imposed initiatives often leave teachers feeling “increasingly disempowered and professionally marginalized” (Peters 2001).

Along with the considerations made in answer to the first research question, the survey results show that teachers want more input, and that they are unhappy with the current level of input at curriculum level. They feel that they have experience of what works and they are aware of pupils’ needs, and that they can offer a pragmatic approach. One statement offered by one of the teachers supports this view; teachers should be involved because they can offer a “realistic approach”. This sense of realism by the teachers heightens the concept that policy makers are very much involved in
rhetoric when it comes to the practices and policies of the lower secondary classroom. The top-down manner in which curriculum is developed is causing problems, and changes are being imposed without a true understanding of the settings they are alleged to improve (Lortie 1975). Policymakers are not taking school culture into consideration. As outlined in the research literature, reforms fail when policymakers neglect to take into account the teachers, the pupils and the school culture (Sarason 1971, 1996, van Driel et al. 2001). The overlooking of culture is further supported by one teacher acknowledging “practicing teachers have the trait knowledge and experience of what works in a classroom situation and what doesn’t work”. It is clear from the teacher’s comment that teachers “on the ground” believe that those in influential positions, who are imposing curricular change downwards, have minimal recognition for the experience and culture of the classroom, something which is highly supported by the research literature (Lortie 1975, Dalin 1993, Sarason 1996, Goodson 2001). The literature highlights the importance of culture for successful reform; it outlined how a knowledge of the culture of the school was imperative for successful change; to embrace culture, was to embrace successful lasting change (Waller 1932, Sarason 1971, Deal and Kennedy 1983, Deal and Peterson 1999, Stoll 1999).

Reflecting back on the phase one findings, the concept of the teacher as technician surfaces again: teachers are starting to feel like the “faithful implementer” (Atkin and Black 2003), “responder rather than initiator” (Goodson 2001) and it would seem they may have tired of this role. Over 85% of the participant cohort acknowledged a wish to be involved in curriculum development and planning. What if partnerships were developed between teachers and policymakers, where teachers became true partners and culture was embraced? This is what Darling Hammond (2009) refers to as a “democratic approach”, where local ownership is instilled to increase accountability and suit local needs. James and Connolly (2000) acknowledge how imposed top-down change can bring denial and sometime emotions of anger, while self-initiated change can bring excitement and relief. The embodiment of this lack of culture was supported further when teachers openly acknowledged, within phase two findings, that they feel the new syllabus is not teacher friendly. Do teachers feel that the new revised syllabus is teacher unfriendly due a lack of trust, a belief that the change is unnecessary, a belief that the change is not feasible or a fear of failure (Morrison 1998, James and Connolly 2000)? Perhaps if teachers were involved from the initial stages, where they could feel
ownership, then they would in fact feel part of the process and gain empowerment from what they are teaching. A system of “co-operation rather than confrontation” (Trant 1998) would then result.

A further emerging aspect within the findings of phase two, which can also be linked to policymakers’ neglect of culture, was the dominance of time pressures. Within the research findings teachers openly acknowledge how time, or rather a lack of it, is affecting their work. Some teachers identified that time was an area of difficulty that they were facing, particularly in relation to the new programme of assessment. There was an expressed desire and need for laboratory assistance, from teachers that took part in the survey. Many participants in the further comments section expressed a need for laboratory assistance in order to aid the development of their teaching and also for the sake of pupil learning. While teachers agreed with the introduction of the revised lower secondary science syllabus over 50% of teachers thought the programme was too long for the time allotted.

The literature identified that science education is failing and there is widespread concern regarding the decline in those up taking science at both secondary and tertiary levels of education (Department of Education and Science Ireland 2002c, Hampden-Thompson and Bennett 2011). Several research and policy interventions have been implemented to help support and develop the uptake of science (Department of Education and Science Ireland 2002c, Smyth and Hannan 2002, Prince and Felder 2006, 2007). As recognised in the literature, science education is changing, and the contemporary science classroom requires “more than a knowledge of basic concepts”, it necessitates an understanding and appreciation for the “how” and “why” (Osborne 2007).

The phase one findings showed that a technical approach was taken with regards to teaching and learning from a policy perspective. While practical work was implemented as a core element in 2003, it is still delivered in a very technical and transmissive manner (Higgins 2009). Documents outline mandatory practical investigations, while professional associations dictate how to approach prescribed investigations (NCCA 2003c, a, ISTA 2008). The philosophies of learning science at lower secondary in Ireland are very much part of the traditional paradigm of learning.
Teachers who participated in the survey acknowledged beliefs of social constructivism and inquiry-based learning, and acknowledging frequent use of ALMs. However, when probed further the research identified that teaching is largely through transmission. This was supported from various strands within the findings, for example, while 75% of respondents acknowledged frequent use of active learning pedagogies, there were variations noted in the types implemented: 71% identified group work, while only 26% acknowledged that they use of peer learning. There were extremely low levels of engagement of pupils with “science in context”, visits to industry and third level. These low levels were further supported by the high usage placed on the textbook, workbook and chalk/white board by participants. This was to be expected, as the phase one findings did not indicate much promotion of eclectic pedagogical approaches and from the findings above it seems that teachers are under so much pressure for time that perhaps there is no room for pedagogical innovations.

The joint findings from phase one and phase two acknowledge that there is a strong need within lower secondary science classes for eclectic pedagogies. Many of the issues with pupils learning in science is that “many children find it difficult to understand ideas put forward in science lessons” (Osborne and Freyberg 1985). To combat the issues of learning in science there is a need for policy makers to work with teachers to promote eclectic pedagogies with a view to increasing scientific literacy. The “how” and “why” of science need to be made explicit so that pupils can appreciate science.

The findings from phase one and phase two of the study support that the five challenges outlined by Gilbert (2006), (also Gilbert et al. 2011) need to be addressed within the Irish context if science education is to move forward. The five challenges outlined by them were:

- Overload
- Isolated facts
- Lack of transfer
- Lack of relevance
- Inadequate emphasis
The development of pedagogical content knowledge of teachers is one way of perhaps combating these issues. PCK and scientific literacy are an important aspect of teachers’ professional knowledge and therefore essential for the progression and development of innovative pedagogical approaches to the teaching and learning of science. Table 7.2 below, offers a summary of the emergent themes and main findings from phase two of the research, addressing the second research question.

**Table 7.2 Emergent themes from RQ 2**

<table>
<thead>
<tr>
<th>Emergent Themes / Main Findings</th>
</tr>
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<tbody>
<tr>
<td>- Teachers are unhappy with the current level of input within curriculum development, 85% acknowledging that practising teachers should have an input.</td>
</tr>
<tr>
<td>- The revised syllabus for Lower Secondary science in Ireland is identified by Lower Secondary science teachers as more pupil friendly than previous syllabi.</td>
</tr>
<tr>
<td>- Teachers, however view the revised syllabus for Lower Secondary science as teacher-unfriendly.</td>
</tr>
<tr>
<td>- Teachers believe that the current syllabus is not geared for a mixed ability setting, nor is it adequate for the time allocated.</td>
</tr>
<tr>
<td>- There is agreement that the current programme is a substantial base for future study of science.</td>
</tr>
<tr>
<td>- The majority of Lower Secondary science teachers nationally are teaching in mixed ability setting.</td>
</tr>
<tr>
<td>- Group work is the most common active learning methodology that teachers are using within Lower Secondary Science, with peer-learning the second lowest followed by role play.</td>
</tr>
<tr>
<td>- The textbook and blackboard/whiteboard still dominant within the teaching and learning of science at Lower Secondary level.</td>
</tr>
<tr>
<td>- Teachers are unhappy with the 10% allocation for the assessment of Coursework A.</td>
</tr>
<tr>
<td>- In relation to coursework B, 66% of participants are experiencing difficulty.</td>
</tr>
<tr>
<td>- 49% of those who participated feel that science should have a practical skills day exam.</td>
</tr>
<tr>
<td>- “lack of time” is an overriding factor of difficulty by Lower Secondary science teachers.</td>
</tr>
<tr>
<td>- The ISTA remains the most common professional organisation for teachers.</td>
</tr>
</tbody>
</table>
7.3 Addressing the Final Research Question

To examine the role of a school-university partnership as a means for implementing curricular change and developing teachers as professionals in the Mid-West of Ireland

The current view within curriculum matters is that teachers should be encouraged to engage with curriculum issues (Clandinin and Connelly 1992, NCCA 2011a). The evidence from phase two of this research project (see 6.3.3) would suggest that teachers in Ireland do wish to become involved in curriculum matters; they feel it is their right to be involved “because we teach it”. The research literature suggests that for successful and deep change to occur in the curriculum, teachers need to be involved from the design and implementation phases (Keys and Bryan 2001, Stolk et al. 2011). Therefore this research put forward the concept of an original theoretical framework, designed from the research literature, to help develop teachers as agents of change.

The evidence from the first and second phase of data collection reinforced the perspective of the technical view of teaching in Ireland, with findings also showing evidence of minimal teacher voice in a very bureaucratic and centralised system. These two issues are contrary to what is required for developing curriculum ownership and creating professional empowerment. Change within education is a complex and multi-faceted process. Teachers can become agents of change, and are a strength to be considered within the development of innovation and change (Trant 1998, Goodson 2001). Evidence from phase three would suggest that there was some form of measured success from the implementation of the framework and that there is an authenticity in these concepts from the research literature. While engaged in phase three, teachers developed ownership over curriculum, and created innovative approaches to pedagogy, while empowering themselves as professionals.

The author believes that the essential factor in success is due to the recognition of the central role and attention paid to the impact of culture. There was from the very beginning an acceptance and integration of school culture (Dalin 1993, Prosser 1999b). The theoretical framework was built on preconditions of culture and context, supported by views of teaching as profession, democracy and partnership. It was evident from
phase two that teachers felt stressed and under pressure in the classroom due to recent changes: it was imperative than an understanding around this was recognised before and during the development of phase three.

"Where you have technical support and IT support it (developing innovative pedagogies) wouldn’t be such a problem. In our school it is not a major problem because there is a lab technician there to do it. It is not taking from the teacher time. But if you don’t have lab technicians or an IT technician then this work is taking from teaching time and there is no allowance for that”

(Teacher A, School A)

The cultural barriers that support resistance to change outlined by Dalin (1993), were addressed through the framework. The values of the schools and participants were not challenged and there was no imposition of change on teachers. They, in fact, become the owners and developers of change. This was further developed by the reflective element of the project, which engaged teachers in collegial dialogue and allowed time for solitary reflection. It helped teachers to share insecurities and uncertainties and “force us to be reflective in a very concrete way rather than just festering an emotional response to what went well or otherwise during the day”. The incorporation of distributed leadership in the form of a democratic partnership saw both parties as equals, “collegiality among the science department was definitely enhanced ....there was a lot of working together”. The development of the partnership was done in a non-bureaucratic manner and gave steadfast allegiance to the importance of democracy and the important role of democratic communication (Darling Hammond 2009). The voice of the teacher was heard within this project, right from the very beginning in the design and development phase (Trant 1998, Goodson 2001, 2003). Teachers were invited to co-produce the reflective journals, and the pre-and post- tests, and their opinion and input was sought “engaged in something a little bit bigger than what goes on in our own little rooms”.

As outlined in the findings it was imperative that those involved saw the role of the university as mentor and support. The literature acknowledged that curriculum change and innovations fail when teachers feel they are being told what to do, and when they do not feel a sense of ownership (Sarason 1996). The development of ownership was a key task for the research project. It is evident from the findings that this
ownership was achieved; teachers developed an awareness of belonging and “hearing our work is useful at National Level”. The findings from the research indicate that when invited into a process that is relational and democratic, teachers can gain confidence and ownership and in turn become key agents of change. The success at developing ownership and professionally empowering the teachers involved in the study had a subsequent positive effect. The evidence shows two key things:

- there is a strong need for eclectic approaches to teaching and learning in the Irish classroom and
- when teachers develop ownership and become professionally empowered they can become successful innovators of pedagogical change

The literature recommends that science education for the contemporary classroom needs pupils who can think critically, make judgements, communicate, collaborate and solve complex problems (‘Partnership for 21st Century Skills’ 2004, Loucks-Horsley et al. 2010). The pedagogical innovations that were developed by the teachers addressed these matters, and allowed teachers to reconceptualise their practice. The project from School B, for example, was about engaging pupils with the complex problems of graphing and developing an understanding for the purpose of graphs. Pupils within this project had to learn how to communicate and collaborate through ICT and data loggers. The innovations developed by the schools allowed for the development of context-based approaches to learning, which promoted the scientific literacy of the pupils.

It was evident from the pre- and post-tests that pupils involved in the study developed an increase in their interest of science, which was further developed with the acknowledgement that science was perceived as less complicated after the new approaches were implemented. The literature indicates that the quality of learning experienced by pupils is shaped by their learning experience, interests and aspirations. The evidence shows that teachers can become innovators and that these innovations can be successful in developing pupil learning (Pollard 2008). Pupils acknowledged that these new pedagogical approaches allowed for learning to become easier. The literature has identified that pupils often struggle with learning new concepts because of difficulties in understanding (Osborne and Wittrock 1985, Osborne 2007). However,
the success of the framework and the development of the innovative pedagogical approaches is somewhat overshadowed by the constraints on the system. As outlined in chapter two, the system of education in Ireland is underpinned by the Classical Humanist and Reconstructivist approaches to learning. A product-driven technical approach to teaching and learning was very evident throughout the project. The evidence from phase three also supports this dominance of the national examinations (Junior and Leaving Certificate). While teachers did gain ownership and develop professionally, the success was undermined by the teachers’ unease around the appropriateness and worth of the innovative pedagogy in relation to the state examinations.

“in State exams the questions may not be phrased in order to embrace our methodologies or for that matter if a student goes to describe these methodologies and maybe is a bit weak in getting the message across then what the student is trying to describe might not become clear to the person who is examining that and therefore the student will be at a disadvantage”

(Teacher A, School B)

Table 7.3 below, offers a summary of the emergent themes and main findings from phase two of the research, addressing the second research question.
Table 7.3 Emergent themes from RQ 3

<table>
<thead>
<tr>
<th>Emergent Themes / Main Findings</th>
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<tbody>
<tr>
<td>• ICT remains an area within Lower Secondary Science teaching that teachers feel motivated and interested in engaging with (2 of the 3 case study schools engaged in ICT orientated projects)</td>
</tr>
<tr>
<td>• Time is a limiting factor for the engagement of teachers in professional development projects such as this research project</td>
</tr>
<tr>
<td>• Cultural dissonance can be problematic when developing partnerships between schools and universities, democracy, appreciation for teacher and school culture are essential for the successful development of partnerships</td>
</tr>
<tr>
<td>• When teachers and policy makers engage with one another, there is a positive response from both parties; an admiration on behalf of the policy maker and a sense of belonging “ownership” to the bigger picture from the teacher</td>
</tr>
<tr>
<td>• The relationships developed while working together (between teacher and researcher, among teachers, and between teacher and pupil) in a co-inquiry setting empowers teachers professionally</td>
</tr>
<tr>
<td>• National assessment practices militate against teachers innovation and development, especially in projects such as this</td>
</tr>
<tr>
<td>• Educational innovations such as those implemented in the project can cause an increase in positive attitude from pupils involved</td>
</tr>
<tr>
<td>• Partnerships can be successful at developing, once democracy and culture is respected</td>
</tr>
<tr>
<td>• Pre-conditions for the development of successfully partnerships must involve equality and shared meaning</td>
</tr>
</tbody>
</table>
7.4 Conclusion

The impact of policy within the contemporary Irish science classroom is both negative and damaging. Policy development in Ireland militates against all the research literature, as curriculum is still delivered from a centralised location in a top-down manner. The presence and voice of the teacher at policy level is minimal and it is in the author’s opinion that phase two indicates the detrimental effect this is having. Phase two of the research identified that nationally teachers are unhappy with many features within the revised syllabus for science at lower secondary level, features that could possibly be avoided if teachers were engaged in the process from the beginning. There is no doubt from phase three of the study that the majority of teachers are willing to have an input into the development of curricular and policy.

Policy however is not just having an impact on the teachers and their attitudes and beliefs but it is also affecting the pedagogy of the classroom. From the content analysis it was evident that there is a profound dependence on assessment of learning and on traditional pedagogies within policy legislation. As outlined in the literature much of the philosophies around learning science indicate nowadays the need for a “hands-on” and “minds-on” approach to teaching and learning. Unfortunately, however, as recent as 2009 Ireland was still involved in “structured practices” and this was further enhanced with the results from the survey where teachers acknowledged the dominant usage of textbook and blackboard within their teaching. The professional development of the teacher is somewhat undermined by this strong reliance on structured practices, due to the dominance of national assessments.

The final phase of this research project identified that teachers are willing to engage when given an opportunity, which is respectful of democracy and of their school culture. Teachers are professionals in their own right and when given the opportunity can engage in examining and expanding their teaching and learning pedagogies. It needs to be acknowledged that the overbearing aspect of policy and national assessments is affecting what is happening in the contemporary classroom. There is therefore a need for teachers to be engaged as partners, only then can educational innovation be successful.
8.0 Conclusion and Recommendations
8.0.1 Introduction

This chapter is the final chapter of the thesis and will summarize the main findings from the research. Within this chapter the author will outline the significance and contribution of the study to the fields of both education and science education. The chapter will also outline the recommendations for action from the thesis along with some directions for future work.

8.1 Summary of Main Findings and Final Conclusions

The rationale for the project as outlined in chapter one was twofold. The first was the continuous debate surrounding the uptake of science at upper secondary and at graduate level from both a national and international perspective. The second rationale behind the project was the deep focus within the Irish system on curricular change at a content-only level. The background of the researcher outlined in chapter one and Appendix K, led to the incorporation of and recognition of the importance of school culture, teachers as professionals and more importantly, teachers as key agents of change. From her own personal experience and background the author wished to focus at lower secondary science as a focus for the decline at upper secondary. This was further supported by the research carried out by Smyth and Hannan (2006), in which they outline that lower secondary science experience was an influential factor in the uptake of sciences at upper secondary. At the beginning of the research project two recent national reforms had also been introduced: 1) the introduction of the revised lower secondary syllabus in 2003 and 2) the introduction of the Teaching Council (2007). Therefore the focus of the study was to examine the role of teachers as change agents in developing educational innovation in the lower secondary science classroom, in an effort to combat the decline at upper secondary level. From the literature it became evident that for successful change to occur, then teachers needed to be professionals, empowered to develop a sense of ownership over the pedagogical matters of their classroom. It therefore made sense to the researcher to begin with what is currently impacting the classroom and that meant examining Irish policy in relation to lower secondary science, and to examine, exactly what teachers are being told. The research project took a “macro” to “micro” approach to investigating its rationale. The author will now explore the main findings from the research project and end with some final conclusions.
Policy development within Ireland is militating against all that is identified in the research literature as necessary for deep and successful change, developed in a centralised and bureaucratic manner, dictated in a top-down manner with minimal input from the practising teacher. Change in Ireland as a result is slow. Within the Irish context science is viewed as important, however, this is due to its strong correlation with economic growth and expansion. The development within policy is externally driven by the economy and market targets, not primarily for the development of the critical consumer of science or even the future producer of science. Within the development of policy there is no acknowledgement of difference in school culture or context. Policy is developed as a “one size fits all” approach. The development of pedagogy within the Irish context has remained very much assessment and product-driven. As recently as 2009, there was international acknowledgement that Ireland still relies heavily on structured practices, with a major dependence on assessment of learning rather than assessment for learning. The practical element of science has only been recently introduced with the revised syllabus in 2003, however, its delivery is “recipe-style” and it is examined through written reports and not on practical skills. In general, it is evident that policy is Ireland does not lend itself to promoting teachers as professionals.

The findings from phase two of the research support those found in phase one. There is a sense of unhappiness by teachers with elements of the revised syllabus, and comments left by teachers acknowledge in the author’s opinion that these would not be present if teachers were involved from the very beginning, for example, the high level of teachers that are experiencing difficulty. The pedagogy of the Irish classroom remains mainly unchanged, with high usage of textbook and black/white board being maintained. This, however, in the author’s opinion is a side effect of the dominant product/assessment driven system of education currently found at lower secondary. This also militates against the literature surrounding learning science and Osborne’s (2007) ideas of “science for the twenty-first century”, where the purposes of science are to a) produce the critical consumer and develop scientific literacy but also b) to produce the science producer and develop scientific skills for future work/study within the scientific industry. Interestingly, there was a marked percentage of teachers who responded who felt science should have a practical examination for scientific skills.
While some teachers are willing to engage with universities and develop educational innovations for the contemporary Irish classroom, it is evident from the research findings in phase three that this is not the case in all schools. The findings from phase two and phase three corroborate that time is a limiting factor in many ways, in both the professional development of teachers, and, in the development of innovative pedagogies. Where teachers successfully engaged with phase three of this study, professional empowerment and curriculum ownership ensued, but more than that there was a “sense of belonging” to the bigger picture and collegiality among staff was enhanced.

For successful educational innovation and change to occur within the Irish context there needs to be an acceptance of the place of the teacher at the heart of educational development. There needs to be a practical of the limitations of the constraints imposed by the examinations and time available. The new Innovation and Identify Report (2010) envisages teachers developing short courses, but if this is to be successful then change needs occur regarding the limitations around time and assessment and their impact on to the contemporary school and classroom. Acknowledgement also needs to be given towards the purposes of science for a contemporary Ireland. It is the author’s opinion that we cannot strive for economic growth and expansion alone: to help combat the decline in science awareness needs to be developed of the importance of scientific literacy and the role of science in society. Government policy needs to move towards the development of critical consumers of science as well as producing future scientists.
8.2 Contributions to the field

The following section outlines some of the contributions this study has made to the fields of research.

- This research study offers the fields of education and science education a critical interpretation of national and European policy documents that influence the contemporary Irish science classroom and school. The review of the documents provides a synthesis of what policy is saying, and more importantly what it is not saying, to in-service teachers about the teaching and learning of science at a vital stage in a child’s education.

- At a national level the study also offers a unique insight into lower secondary science teacher’s attitudes and beliefs about curriculum and pedagogy in an Irish context. A representative national sample shows how teachers are unhappy with their current input in the curriculum and how they want to become engaged with the curriculum development process.

- The research study offers a model for the development of school-university partnership, built upon democracy, co-inquiry and culture awareness. The school-university partnership offers a means for developing educational innovation and change, professional empowerment and curriculum ownership. The partnership between both institutions is somewhat unique in that no accreditation or academic award was given from involvement.

- The study offers to the fields of both education and science education a theoretical framework for successful educational innovation and change in the contemporary Irish classroom. The framework developed within this project is unique and has the potential to be expanded and explored in a flexible manner to adjust to the culture differences of other schools.

- The pre- and post-surveys carried out with pupils offers a snapshot of pupils’ attitudes and interests towards science, but also their preference towards teaching and learning styles.
8.3 Recommendations for Action

In this section the author wishes to outline recommendations for action that should follow from the findings of this research project.

8.3.1 Recommendation One

Policy in Ireland has a strong impact on the teaching and learning of lower secondary science. Currently this impact is having a negative effect, as it is developing schools and classrooms that are dominated by traditional, didactic teaching methodologies. There is an interest in teachers engaging with policy makers and so a recommendation from this study would be to investigate different ways and means of integrating teachers into the process of curriculum change, which would be beneficial to both parties and one which allows the influence of school culture to be recognised.

Within the current Innovation and Identity strategy being rolled out by the NCCA, it is envisioned that teachers will become curriculum developers of their own short courses. Instead of letting teachers work in isolation around the country developing such short courses, perhaps the NCCA could take on board the success of the school-university partnership, and facilitate teachers to work in partnership with universities and institutes of technologies around Ireland.

8.3.2 Recommendation Two

The findings from phase two support the views from the literature on the impact of school culture on the success and failure of innovation and change. A recommendation from this project would be that in/when moving forward, statutory bodies like the NCCA should examine the possibilities of building flexibility and democracy within curriculum structures, which would allow teachers to identify what best suits the culture of their school and more importantly their classroom. The literature reminds us that school culture is complex (Prosser 1999b) and that no single blueprint can be proposed. All schools interpret change differently because in each school change meets different people, different circumstances and different conditions (Stoll and Fink 1996).
8.3.3 Recommendation Three
The European Union has reviewed the impact and positive aspects associated with Inquiry-Based Science Education (IBSE) (European Commission 2007). There has been some acknowledgement for IBSE methodologies within the Irish system, but the dominance of “recipe style” practical work cannot continue. There is a need to work co-operatively with teachers to implement and support the development of IBSE methodologies within lower secondary science classroom in Ireland.

There are currently many European Union projects working with schools investigating IBSE pedagogies e.g. ESTABLISH (http://www.establish-fp7.eu) and PROFILES (http://www.profiles-project.eu/) etc. There needs to be a promotion of or platform for these projects made available to Irish teachers and schools, so that teachers could opt to become involved, not just those schools who are randomly selected or purposely selected because they are near a university. Mechanisms for diffusing IBSE strategies and appealing teachers to use them, needs to be developed.

8.3.4 Recommendation Four
The framework developed in this project led the way for changing ethos and values in how innovation and change is implemented. It allowed for a type of discourse to be developed, that if recognised and supported by policymakers, would allow for the re-conceptualisation of practice.

This framework has the potential to be utilised within the Innovation and Identity programme currently being rolled out by the NCCA. This framework could potentially offer a guide and support to teachers when developing short course material. If teachers were engaged in partnerships that understood democracy, culture and community, then perhaps the outcome in terms of the short courses would be stronger and teachers would not feel so isolated.
8.4 Directions for Future work

In this section the author wishes to outline some recommendations for future work in light of the main findings from this research project.

- To investigate the ability of the theoretical framework in schools in a different social context, as those schools utilised in phase three were large middle-class schools. It would be worth examining whether the same findings would be present if the framework was developed in schools with educational disadvantage.

- To investigate the effect of gender on the findings, it would perhaps be worth repeating the case study work in three single sex schools, or two single sex and one co-educational and drawing a comparison. Would the gender of the school affect the findings? Would a different school culture be evident in voluntary secondary schools of single sex?

- It would be interesting to explore in more depth the pupils’ attitudes and interests as an aspect of the project. For example, instead of a cohort study in relation to the pre- and post-survey, pupils could be tracked independently to examine the impact of the project at the pupils’ level.

8.5 Final Reflection

The author wishes to conclude the thesis with a reflection from Freire which she feels summarises the project.

The educator with a democratic vision or posture cannot avoid in his teaching praxis insisting on the critical capacity, curiosity, and autonomy of the learner. One of the essential tasks of the teaching process is to introduce the learners to the methodological exactitude with which they should approach the learning process, through which the objects of learning are knowable. And this methodological exactitude has nothing to do with the discourse of the “banking system,” something that merely touches the surface of the object or its contents. It’s exactly in this sense that to teach cannot be reduced to a superficial or externalised contact with the object or its contents but extends to the production of the conditions in which critical learning is possible.

(Freire 1998)
Bibliography


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*Education Act 1998*, s.30, Ireland:


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Hyland, Á. and Milne, K., eds. (1992) Irish Educational Documents Volume 2, Dublin: Church of Ireland College of Education.


ISTA (2008) 'Practical Investigations',


Lang, M. (2012) 'What does it mean to be innovative in teacher continuing education and mentoring' in Mooney Simmie, G. and Lang, M., eds., *Whats Worth Aiming for in Educational Innovation and Change?: A case study of democratic mentoring as a deliberative discourse for teacher education in Austria, Czech Republic, Denmark, Germany, Ireland and Sapain*, Berlin: Waxmann.


NCCA (2003b) *Notes on the Revised Syllabus*, [online], available: [accessed 13th December 2008].


NCCA (2011c) 'Minister Quinn back National Council for Curriculum and Assessment (NCCA) proposals for junior cycle reform', available: [accessed 4th November 2011].


O’ Halloran, M. (2011) ‘Junior Cert cut to eight subjects to assist literacy and numeracy’, *The Irish Times*, 9th July,


P. A (2011) 'Minister orders cap on Exam Subjects', *The Irish Times*, 8th July,


Appendix A _ Participating Universities and European Countries on the GIMMS Project

AUSTRIA

Helga Stadler
Susanne Neumann
Department of Physics Education, University of Vienna, Austria

Czech Republic

Eva Volnà
Hashim Habialla
Rostislave Fojtík
University of Ostrava, Czech Republic

DENMARK

Lotte Skinneback
Birgitte Stougaard
University College Lillebaelt, Department of Teacher Education in Jelling, Denmark

GERMANY

Doris Elster
Universitat Bremen, Didaktik der Biologie Bremen, Germany

Manfred Lang
Gunner Freige
IPN Leibnitz Institute of Science Education, University of Kiel, Germany

IRELAND

Geraldine Mooney Simme (Project Co-ordinator)
Sancha Power (Research Assistant)
Education and Professional Studies Department, University of Limerick, Ireland

SPAIN

Digna Couso
Roser Pintó
Universitat Autònoma de Barcelona, Spain
Appendix B  _ GIMMS Team meetings; agendas

Stage One: Preparation and Planning

November 2006 to end of January 2007

Provisional Agenda  GIMMS Conference
Gender, Innovation and Mentoring in Science and Mathematics Education
Castletroy Park Hotel and the University of Limerick, IRELAND

Thursday, 1\textsuperscript{st} February 2007
Arrival and Welcome 6pm
Castletroy Park Hotel, Limerick.

Seminar 1
6.30 to 8pm  The GIMMS Project
  - Revisit financial plan & Protocols.
  - Conceptual basis, PISA findings and issues in Science and Mathematics education in lower secondary (compulsory) education.
8pm Dinner in the Restaurant.

Friday, 2\textsuperscript{nd} February 2007
Millstream Courtyard, Room CM005, University of Limerick

9am to 11am Seminar 1 Case Study Research in Schools
  - Conceptual framework & Reflective Journal
  - Voices of teachers, students teachers, students and GIMMS team.
11am to 11.30am  Coffee/Tea Break
11.30am to 1pm Seminar 2 Report & Planning from Countries
  - Report from Denmark
  - Report from Germany
  - Report from Ireland
1pm to 5pm Lunch in Plassey House
2pm to 4pm Seminar 3 Report & Planning from Countries
  - Report from Norway
Saturday, 3rd February 2007  Castletroy Park Hotel, Limerick.

9am to 11am Seminar 1 Case Study Research in Schools
   - Framing the Research Questions & Reflective Journal
   - Voices of teachers, students teachers, students and GIMMS team.
11.30 to 1pm
   - Seminar 2 Background Comparative Knowledge
   - Gender, innovation, mentoring in science and mathematics education
1pm to 2pm
2pm to 3.30pm
   - Seminar 3 Background Comparative Knowledge
   - Gender, innovation, mentoring in science and mathematics education
3.30pm to 4.30pm Visit to St. John’s Castle, Limerick.
5.30pm to 7.30pm
   - Seminar 4 Writing the Strategic Plan
8pm Dinner in the Restaurant

Sunday, 4th February 2007, Castletroy Park Hotel, Limerick.

9am to 11am
   - Seminar 4 Writing the Strategic Plan
11am to 11.30am Tea/Coffee
11.30 to 1pm
   - Outline planning for stage 2
   - Web-site useage
1pm to 2pm Light Lunch.
2pm Depart.
GIMMS Team Meeting 2

4th - 6th October 2007

Venue: Vingstedcentret, Vingsted Skovvej 2, 7182 Bredsten
Tlf: +45 75 86 55 33
Fax: +45 75 86 40 69
Email: info@vingstedcentret.dk
http://www.vingstedcentret.dk/

Thursday, 4th October 2007

2pm to 3pm Report from Bruselles Meeting and general Administration.
3pm to 3.30pm Coffee/Tea Break
3.30pm to 5pm Dissemination and the Web-Site.
5pm to 6pm Key Question(s) for Comparative Study

Friday, 5th October 2007 Country Reports from the Countries

9.00am to 10.30am Report from Denmark
10.30 to 11.00am Coffee/Tea Break
11.30am to 1.00pm Report from Germany
          Report from Spain
1.00pm to 2.00pm Lunch
2.00pm to 3.30pm Report from the Czech Republic
          Report from Ireland
3.30pm to 4.00pm Break
4.00pm to 5.00pm Plenary Discussion (to be recorded)
          Concerning our progress to date and
          Direction to the future
5.00pm to 6.00pm Written Reflection on Progress to date

Saturday, 6th October 2007

9.00am to 11.00am The next Stage of the Project
11.00am to 11.30am Tea/Coffee Break
11.30am to 1.00pm  Action Plan for Stage II  
Action Plan for Dissemination  
Requirements for Bruselles 2007  
Date of next Meeting

1.00pm to 2.00pm  Lunch
GIMMS DRAFT AGENDA
24th, 25th and 26th April 2008
UNIVERSITY OF LIMERICK, IRELAND

Thursday, 24th April 2008

6.00 pm to 7.00 pm  Reception and Welcome
Geraldine Mooney Simmie, UL.

7.00pm to 7.45pm  Comparative Research Questions
Dr. Manfred Lang, GIMMS Evaluator.

7.45pm to 8.30pm  KeyNote Address: Gender in GIMMS
Dr. Helga Stadler, University of Vienna, Austria.

Friday, 25th April 2008

9.00 am to 9.40am  Report of Progress in Ireland

9.40 am to 10.20am  Report of Progress in Spain

10.20 am to 11.00am  Report of Progress in Czech Republic

11.00am to 11.30 am  Coffee/Tea/Break

11.30am to 12.10 pm  Report of Progress in Denmark

12.10 pm to 12.30pm  Summary: Dr. Rose M. Malone, NUI Maynooth

12.30 pm to 1.30 pm  LUNCH

1.30 pm to 2.45 pm  National Policy Makers Conference
Co-Chair: Dr. Joanne Moles

2.45 pm to 7.30 pm  Visit to Cliffs of Moher, Atlantic Ocean
Lahinch Strand & Guinness Tasting

7.30 pm to 8.30 pm  Revisiting the Comparative Research Questions

8.30 pm to 9.30 pm  Evening Meal, CastleOaks Hotel.
Saturday, 26th April 2008

9.00 am to 10.40am  Report of Progress in Germany
10.40am to 11.00am  Summary of Progress Reports
11.00 am to 11.20am  Coffee/Tea/Breaks
11.20 am to 1.00 pm  Strategic Planning for Stage III
1.00 pm to 2.00 pm  LUNCH
2.00 pm to 3.30 pm  Revisiting the Comparative Research Questions
3.30 pm to 3.45 pm  EVALUATION
GIMMS Team Meeting 4

Wednesday, 15th October 2008

Venue: Room CM2003 MillStream Courtyard
University of Limerick.

9.00am to 10.00am  Updates on Progress to Date
10.00am to 11.00am  Bruselles Evaluation Report
11.00 to 11.20am  Coffee/Tea Break
11.20am to 1.00pm  Bruselles Evaluation Report (continued)
1.00pm to 2.00pm  Lunch in Plassey House
2.00pm to 3.30pm  Planning for GIMMS Phase III
3.30pm to 4.00pm  Requirements for Reports from each Country
                  Financial Requirements for Phase II funding
4.00pm to 5.00pm  Any Other Business
DRAFT AGENDA   GIMMS Conference

Gender, Innovation and Mentoring in Science and Mathematics Education

Castle Oaks Hotel, Castleconnell and University of Limerick IRELAND Sunday 20th September to Thursday 24th September 2009.

Sunday, 20th September 2009

Arrival and Welcome 6pm (Tea/Coffee/Scone)
Castle Oaks Hotel, Castleconnell, Co. Limerick.
6.30 to 7.30pm The GIMMS Project
   Decide on the Agenda/Receipts/TimeSheets/
   Agree Schedule of Interviews
   INNOVATIVE PRACTICES/PRODUCTS
   Any Other Item
7.30pm to 8.30pm Dr. Rose Malone and Dr. Manfred Lang
8.30pm Dinner in the Restaurant.

Monday, 21st September 2009, Castle Oaks Hotel, Castleconnell

9am to 11am Diary Writing
   Revising Conceptual Framework for Project
   INNOVATIVE PRACTICES/PRODUCTS
   What we mean by mentoring, gender and innovation?
   How we interpreted the WorkPlan?
11am to 11.30am Coffee/Tea Break
11.30am to 1pm REPORT From DENMARK
1pm to 2pm Lunch
2pm to 3.30pm REPORT from SPAIN
3.30pm to 4.30pm Summary of the Conference so far
8.00 pm Evening Meal in CastleOaks Hotel.
Tuesday, 22\textsuperscript{nd} September 2009, Castle Oaks Hotel, Castleconnell and UL

9am to 11am Diary Writing, Agreed Format of Final Country Report
11am to 11.30am Coffee/Tea Break
11.30am to 1pm REPORT From GERMANY I and II
1pm to 1.30pm Travelling to University of Limerick
1.30 to 2.30pm Lunch in PLASSEY HOUSE, University of Limerick
Meeting Professor Marie Parker Jenkins Chair of Education
2.30pm to 4.00pm REPORT from IRELAND (Room in University)
4.00pm to 4.30pm Summary of the Conference so far
8pm Evening Meal in Castletroy Hotel
9pm Traditional Music Evening in Dolans Pub, Limerick City.

Wednesday, 23\textsuperscript{rd} September 2009, Castle Oaks Hotel, Castleconnell

9am to 11am Diary Writing
Agreeing the Text-Book/Final Report for the Project
11am to 11.30am Coffee/Tea Break
11.30am to 1pm REPORT From the CZECH REPUBLIC
1pm to 5pm Lunch
2pm to 3.30pm REPORT from AUSTRIA
3.30pm to 4.30pm CRITICAL WRITINGS by ALL TEAM MEMBERS
INTERVIEWS to be completed
5pm WALK IN ADARE VILLAGE
7.30pm Evening Meal (G.M.Simmie’s Apartment)

Thursday, 24\textsuperscript{th} September 2009

Castle Oaks Hotel, Castleconnell.

9am to 11am Diary Writing
Revisiting Reports from each Country
11am to 11.30am Coffee/Tea Break
11.30am to 1pm A summary of our Final Results, INNOVATIVE PRACTICES/PRODUCTS/Evaluation
1pm to 5pm Lunch & Departure
**Appendix C _ Sample of Documents used in the Policy Text Analysis**

<table>
<thead>
<tr>
<th>Name of Publication</th>
<th>Author</th>
<th>Year of Publication</th>
<th>Rationale for Inclusion</th>
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<tbody>
<tr>
<td>Investment in Education Report</td>
<td>DES OECD</td>
<td>1962-1966</td>
<td>The Investment in Education survey was a joint longitudinal study between the Irish Government and the OECD (Hyland and Milne 1992, pg: 29). The task of the study was to assess the needs of the educational system both in terms of human capital and material resources, in essence it was to evaluate “Irelands long-term educational needs” (Department of Education 1965, Introduction, Hyland and Milne 1992, pg: 30, 33). Although not essentially a policy document, the recommendations of this report became the agenda for policy restructuring.</td>
</tr>
<tr>
<td>White Paper on Educational Development</td>
<td>DES</td>
<td>1980</td>
<td>The White Paper on Educational Development was developed and presented to both Houses of the Oireachtas, in December 1980. Even though the paper came some 15 years after the Investment in Education Report by the OECD, it was looking to address some of the matters reported in it. In essence the White Paper was also devised to address decisive changes that had affected the system the previous decade.</td>
</tr>
<tr>
<td>In our Schools; a framework for curriculum and assessment</td>
<td>CEB</td>
<td>1986</td>
<td>CEB was set up in 1984. Its 1986 publication called “In Our Schools” was an outline of how the CEB felt the Irish Education system should move towards. The Board developed a framework for curriculum change at lower secondary and outlined a series of recommendation. The report identified that the current system had done huge work, and praised its huge impact on society. It acknowledged the change that had occurred in Irish society and in the economy and recognised it was time for change.</td>
</tr>
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</table>
This discussion paper explores science and technology as an essential part of a child’s personal development but also for developing our society and our economy (CEB 1987pg: 7). The paper identified issues for policy in developing both science and technology (CEB 1987pg: 10-12).

Published by the Department of Education in 1989. The Junior Certificate programme was introduced to replace the Intermediate Certificate. Junior Certificate science was to cater for all abilities and levels of achievement; it was to be offered at two levels, higher and ordinary. The syllabus was drawn up by a national course committee established by the NCCA.

‘Guidelines for Teachers’ was developed by the NCCA to help and support teachers implement new syllabi. First issued to schools and teachers as part of wider support programme which included in-service training (NCCA 1989, pg: 1).

This review was carried out by the OECD, nearly 30 years after, Investment in Education, 1962. The review of Ireland’s education system was part of a long established series of reviews of national policies for education across the different OECD member countries (OECD 1991, pg: 3). The review consisted of three parts, a) the examiner’s report b) summary of review meeting and c) the background report prepared by the national authorities in advance of examiners visit (OECD 1991).

The focus of the Green Paper was to concentrate on areas which required change and development, mainly equity for all, preparation for working life, education resources and training and developing teachers (Department of Education Ireland 1992, pg: 2, 5). The paper was established to initiate a “wide national debate among education professionals, parents and all who have a commitment to the quality of education” (Department of Education Ireland 1992, pg: 2).

The White Paper of 1995 was brought into being by Minister Niamh Breathnach. It describes a comprehensive agenda for change and development within the Irish Education system, and charts its future direction (Department of Education Ireland 1995pg: xi). The paper outlines policy directions and objective for future developments including significant organisational developments (Department of Education Ireland 1995pg: xi).

The report shows a decline of 2,000 students opting out of taking science for the Junior Certificate between the years 1999 and 2001, with a corresponding decline of 4,000 opting out of higher level for the same time period (SEC 2001, pg: 2).

The focus of the 2000 study was for students to understand and interpret evidence, the OECD viewed at this time scientific literacy as a general competency for life, “to show that they can acquire, interpret and act on evidence…in situations where science can be applied” (OECD 2001, pg: 24).

The revised course developed from many years of discontent, but also general worry about the decline of science take up at upper secondary education in Ireland. The 2003 syllabus differed in a number of areas; Increased emphasis on scientific investigation, The 100% terminal examination was replaced by a three component assessment, incorporating a terminal exam of 65%, Coursework A (10%) and...
Junior Certificate Guidelines for Teachers, revised syllabus

<table>
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<th>Source</th>
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<tr>
<td>NCCA</td>
<td>2003</td>
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Guidelines were produced by the NCCA to offer support and help to teachers. Initially only available online and were distributed at in-service training that supported the integration of the new revised syllabus. The document was a lot more informative than the preceding document. The guidelines offered support and help in areas such as course structure and levels, skills and processes of science, ideas for learning activities, assessment, science in relation to the general curriculum and most importantly teaching methodologies (NCCA 2003a, pg: 3).

Learning for Tomorrows World, PISA 2003

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<tr>
<td>OECD</td>
<td>2004</td>
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The emphasis of the 2003 report was on the application for science knowledge and skills in real life situations. Due to a limited time available for the assessment of science it was not possible to access all areas of scientific knowledge and so a selection of contexts was assessed instead (OECD 2004, pg: 286). The selection of contexts addressed the main fields of science, while maintaining a relevance to real life (OECD 2004, pg: 287). Ireland was ranked 10th, with a lowest possible ranking of 13th, “no real difference to PISA 2000” and still remained “statistically significantly above OECD average” (OECD 2004, pg: 295). OECD indicated that deficiencies in scientific skills could have a major impact on the economy and labour market, and so Ireland maintaining a high ranking was a very positive factor for science education and the development of science in Ireland.

Chief Examiners Report on Junior Cycle Science

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<tr>
<td>SEC</td>
<td>2006</td>
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2006 was the first year of examination for the 2003 revised syllabus. Candidates not taking science were predominantly female (63%), while interestingly enough females that do take science were seen to take mainly higher level science (SEC 2006, pg: 5,6). The percentage of candidates receiving grade D or above at Ordinary level declined by c. 6% - 7% (SEC 2006, pg: 10). Analysis of student’s choice did not take place in this report as the new revised syllabus did not allow candidates any choice within the paper.

Science Competencies for Tomorrows World, PISA 2006

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<th>Source</th>
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<tr>
<td>OECD</td>
<td>2007</td>
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The main domain of the 2006 report was scientific literacy; the report would observe the end of the first cycle. The purpose of the 2006 assessment was to gain “a detailed understanding of student performance in and attitude to science” (OECD 2007, pg:25). Focused on pupil attitudes to science, as a percentage of OECD countries observed a marked drop in percentage of pupils studying science and technology over 15 years (OECD 2007, pg: 16, 20). This was a huge policy issue for Ireland at this time also. Over 50% of the assessment was given to assessing science, examining three types of competencies within science, a) identifying scientific issues, b) explaining scientific phenomena and c) using scientific evidence.

Teaching and Learning International Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
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<tr>
<td>OECD</td>
<td>2009</td>
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</tbody>
</table>

TALIS was an international survey project carried out by the OCED in 2007 and 2008 (Shiel et al. 2009). The focus of TALIS was on learning environments and teaching conditions in post-primary schools. The purpose of the survey was to assist countries to review and develop policies that make teaching more attractive and effective. The TALIS survey looked specifically at aspects of ‘teacher professional development’; ‘teachers’ beliefs, attitudes and practices’; ‘teacher appraisal and feedback’; and ‘school leadership’.
Appendix D _ National Survey

University of Limerick

National Survey

Of

teachers on the

Junior Science Programme.
General School information

1. Please indicate where your school is located
City □ Large Town □ Small Town □ Rural □

2. Please indicate the type of school you teach in:
Vocational/Community College □
Community/Comprehensive School □
Secondary School □

3. School by gender:
Girls only □ Boys only □ Co-ed □

4. Is your school a fee-paying school?
Yes □ No □ Don’t Know □
If Yes, please indicate the amount: _____________________________

5. Does your school have a voluntary contribution?
Yes □ No □ Don’t Know □
If Yes, please indicate the amount: _____________________________

6. Number of Science Teachers currently employed in the school on full time basis:
1 □
2-5 □
5+ □

7. Please indicate the number of pupils in the school
Less than 200 □ 201-400 □ 401-600 □
601-800 □ 801-1000 □ more than 1000 □

8. The Junior Science classes you teach are they - streamed or mixed ability?
Streamed □ Mixed Ability □ Banded □
Teacher General Profile

Please tick ☑ the appropriate boxes.

1. Gender:

Male ☐ Female ☐

2. Number of Years Teaching

0-5 ☐ 5-10 ☐ 10-15 ☐ 15-20 ☐ 20-25 ☐ 25+ ☐

3. Type of Qualification

Concurrent Teaching Degree ☐
General Degree with H. Dip ☐
General Degree with Grad. Dip ☐
General Degree ☐
Other (please specify) ________________________________
____________________________________________________

4. What are your main degree subjects?

Biology ☑ Chemistry ☐
Physics ☐ Agricultural Science ☐

5. Have you any additional post-graduate qualifications?

Yes ☐ No ☐

If Yes, please specify,

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

- 16 -
6. What subjects do you teach? (☑ All relevant boxes)

<table>
<thead>
<tr>
<th>Subject</th>
<th>✔️</th>
<th>☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior Certificate Science</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Junior Certificate Maths</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Leaving Certificate Maths</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Leaving Certificate Biology</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Leaving Certificate Physics</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Leaving Certificate Chemistry</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Phys/Chem.</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Transition Year Science</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Others (please state)</td>
<td>☑</td>
<td>☐</td>
</tr>
</tbody>
</table>

7. Do you hold a post of responsibility in your school?

Yes ☐ No ☐

If Yes, please specify which post,

<table>
<thead>
<tr>
<th>Post</th>
<th>☑</th>
<th>☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Home School Community Liaison</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Vice Principal</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Irish Language</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Assistant Principal</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Permanent Resource Post</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Learning Support</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Chaplain</td>
<td>☑</td>
<td>☐</td>
</tr>
</tbody>
</table>

Others, please state

8. Are you a member of a teaching Trade Union?

Yes ☐ No ☐

If Yes, which trade union? ASTI ☐ TUI ☐

9. Do you and any of your pupils partake in any of the following?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT Young Scientist</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Science Olympics Ireland</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Science Summer camps (DCU or UL)</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>Young Environmentalist</td>
<td>☑</td>
<td>☐</td>
</tr>
</tbody>
</table>

Additional others, please state


Please indicate ☑ your reaction to the following statements.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>StrONGLY AGREE</th>
<th>AGREE</th>
<th>UNSURE</th>
<th>DISAGREE</th>
<th>STRONGLY DISAGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The Junior Certificate Science Programme is too long for the allocated time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Pupil participation and input in the programme is too little</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>The range of subject knowledge covered in the programme is unnecessary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>The subject knowledge prescribed is irrelevant for everyday life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>The Junior Certificate Science Programme, is not a substantial basis for future study of science</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>There is too much variance in the degree of subject knowledge between the higher and ordinary level science programme.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>The course does not contain enough practical experience for students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>The current programme is not geared for teaching in a mixed ability learning environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>The new science programme is more student friendly than the previous programme</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>The new science programme is more teacher-friendly than the previous syllabus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Biology is adequately dealt with in the syllabus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Physics is adequately dealt with in the syllabus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Chemistry is adequately dealt with in the syllabus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Your views on Curriculum Development

1. Are you happy with the level of input by science teachers into the science curriculum?

   Yes ☐  No ☐  Unsure ☐

2. Do you think that practising teachers should have more input into the curriculum programme development?

   Yes ☐  No ☐

   Please give reasons for your answer

3. Please indicate ☑ from the following list changes you would make to the Junior Science Curriculum if given a chance.

<table>
<thead>
<tr>
<th>Reduce content in</th>
<th>Biology ☐</th>
<th>Physics ☐</th>
<th>Chemistry ☐</th>
<th>All ☐</th>
<th>None ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extend content in</td>
<td>Biology ☐</td>
<td>Physics ☐</td>
<td>Chemistry ☐</td>
<td>All ☐</td>
<td>None ☐</td>
</tr>
<tr>
<td>Less detail in</td>
<td>Biology ☐</td>
<td>Physics ☐</td>
<td>Chemistry ☐</td>
<td>All ☐</td>
<td>None ☐</td>
</tr>
<tr>
<td>More detail in</td>
<td>Biology ☐</td>
<td>Physics ☐</td>
<td>Chemistry ☐</td>
<td>All ☐</td>
<td>None ☐</td>
</tr>
<tr>
<td>More pupil participation in</td>
<td>Biology ☐</td>
<td>Physics ☐</td>
<td>Chemistry ☐</td>
<td>All ☐</td>
<td>None ☐</td>
</tr>
<tr>
<td>More focus on practical element in</td>
<td>Biology ☐</td>
<td>Physics ☐</td>
<td>Chemistry ☐</td>
<td>All ☐</td>
<td>None ☐</td>
</tr>
</tbody>
</table>

4. Please indicate ☑ your level of agreement with the following statement
   “The current Junior Science Programme in Ireland is structured for a modular approach, treating all 3 sciences separately rather than a general science (integrated approach) approach”
   Strongly Agree ☐  Agree ☐  Unsure ☐  Disagree ☐  Strongly Disagree ☐

   Please give reasons for your answer
Teaching and Learning Methodologies

Please read below and ☑ your choice.

1. Are you a member of any of the following organisations or institutions?

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish Science Teachers Association</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association for Science Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute of Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute of Biology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute of Chemistry of Ireland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irish Agricultural Science Teachers Association</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Others please list below:

2. Do any of the organisations you are affiliated with, offer in-service in the following area’s?

<table>
<thead>
<tr>
<th>Area</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed ability teaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active learning approaches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discovery learning techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different pedagogical approaches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT enhanced learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special needs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data logging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory practical’s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Others please list below:
3. Please indicate ☑ the most relevant answer

1. I get enough support from my school in relation to the development of teaching and learning methodologies

   Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

2. I get enough support from my Principal in relation to the development of teaching and learning methodologies

   Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

3. I get enough support from the Head of our Science Department in relation to the development of teaching and learning methodologies

   Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

4. I get enough support from the Department of Education and Science in relation to the development of teaching and learning methodologies

   Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

5. I get enough support from Junior Certificate Support Services in relation to the development of teaching and learning methodologies

   Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

6. I get enough support from the Irish Science Teachers Association in relation to the development of teaching and learning methodologies

   N/A ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

7. I get enough support from my trade union in relation to the development of teaching and learning methodologies

   N/A ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐

8. I get enough support from the NCCA in relation to the development of teaching and learning methodologies

   Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree ☐
**Your Views on Teaching and Learning Methodologies.**

1. Please respond to the following statement:
“I make frequent use of active learning methodologies in my lessons”.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. If you agreed with the above statement please indicate from the selection what methodologies you employ frequently?

<table>
<thead>
<tr>
<th>Group Work</th>
<th>Peer Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupil-led experiments</td>
<td>Team Investigations/Research</td>
</tr>
<tr>
<td>Role Play</td>
<td>Assessment for Learning</td>
</tr>
</tbody>
</table>

   Additional Others please list below:

   

3. Please ☒ indicate how often you use the following:

<table>
<thead>
<tr>
<th>Field trips</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visits to industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitors to the class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visits to third level institutions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science museum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   Additional others, please state

   

4. Do you teach the Junior Science Programme in a mixed ability/banded setting?
Yes □ No □

5. If you answered Yes, to teaching in a mixed ability environment do you adapt your lessons to address all levels within your class?
Yes □ No □

6. Do you teach the Junior Science Programme in a streamed setting?
Yes □ No □

7. Please indicate ☒ below the teaching and learning strategies that you use to address mixed ability?

- 22 -
<table>
<thead>
<tr>
<th>Handouts</th>
<th>Group work of mixed groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting individual goals</td>
<td>Different homework for some students</td>
</tr>
<tr>
<td>Re-arranging classroom</td>
<td>Variation in presentation of lesson</td>
</tr>
<tr>
<td>Role Plays</td>
<td>Changing activity every 15 mins</td>
</tr>
</tbody>
</table>

**Additional others, please state**

---

8. How often would you rate your use of the following in the teaching of your lessons? (If the equipment is not available in your school please indicate also)

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whiteboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead Projectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Projectors</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Laptops</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Room</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive whiteboards</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Specific IT Software e.g. crocodile clips</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of Film/TV/Audio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of Posters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text book</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Work Book</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Peer Learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair Work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross Curricular Approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Demonstrations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pupil Demonstrations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Assessment

The Junior Science Programme has a second component in its assessment, first examined in 2006. Please answer the following the questions in relation to the new assessment of Junior Science Programme.

Written Examination

1. The written examination which now accounts for 65% of the total marks for the Junior Certificate Science Programme is a satisfactory representation of the amount of material covered in the course

   Strongly Agree  Agree  Unsure  Disagree  Strongly Disagree
   □          □          □        □        □

Practical Copy

1. The laboratory copy which accounts for 10% is a fair representation for the amount of time, effort and material that is covered by both pupils and teachers in the classroom

   Strongly Agree  Agree  Unsure  Disagree  Strongly Disagree
   □          □          □        □        □

Project

1. The project component which is a new element in the Junior Science Programme is worthwhile and offers the students a more active part in the science programme

   Strongly Agree  Agree  Unsure  Disagree  Strongly Disagree
   □          □          □        □        □

2. Are you experiencing any difficulty with this new assessment procedure?
   Yes □  No □

If yes, please specify in order of priority any areas in which difficulty is occurring mainly

______________________________________________________________________
______________________________________________________________________
_________
**Your views on assessment**

1. Please indicate ☑️ the most appropriate, in your lessons do you generally adopt
   - Assessment for learning methodology (no grade, written comment) ☐
   - Assessment of learning methodology (grade learning, no feedback) ☐

2. Do you think the Junior Science programme should place greater emphasis on the practical element rather than the written?
   - Strongly Agree ☐
   - Agree ☐
   - Unsure ☐
   - Disagree ☐
   - Strongly Disagree ☐

   Why?

   ___________________________________________________
   ___________________________________________________
   ___________________________________________________

3. What are your views on the curriculum assessment of the Junior Science Programme at present?

   ___________________________________________________
   ___________________________________________________
   ___________________________________________________

4. Do you think that a practical day exam similar to that in the Technology Subjects should be introduced for science so as to assess pupils’ techniques in science?

   Yes ☐
   No ☐
   Unsure ☐

5. How often do you assess your pupils’ progress? (Please tick ☑️ most relevant answer)

   Weekly ☐
   Monthly ☐
   End of term ☐
   End of chapter ☐

6. Do you give assessment on practicals?

   Yes ☐
   No ☐
7. On average how often do you give homework to your pupils?

- Nightly
- Every second night
- Only at weekends
- Ever night except weekends
- Never

8. When giving feedback to the class indicate which are relevant to you:

<table>
<thead>
<tr>
<th>Feedback Type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One-to-one, oral feedback</td>
<td></td>
</tr>
<tr>
<td>Whole class, oral feedback</td>
<td></td>
</tr>
<tr>
<td>Written feedback (words as suppose to grade)</td>
<td></td>
</tr>
<tr>
<td>Written grade with no feedback</td>
<td></td>
</tr>
<tr>
<td>Written grade with feedback</td>
<td></td>
</tr>
<tr>
<td>Class Average (grade)</td>
<td></td>
</tr>
<tr>
<td>Class Average (comment)</td>
<td></td>
</tr>
<tr>
<td>Please add any additional comment that you may have on the following areas</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
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Thank you for taking part in my survey.
Dear Teacher,

I am pursuing a Masters in Education under the supervision of Geraldine Mooney Simmie entitled “Junior Certificate Science: An approach to meet the needs of the 21st Century classroom”. The research is looking at the Junior Science syllabus, teachers’ attitudes and beliefs in areas such as curriculum development and teaching and learning strategies and assessment.

This research is being undertaken by Sancha Power (Masters Research student) and by Geraldine Mooney Simmie (Lecturer in the Education and Professional Studies Department).

Participation in this study is voluntary and completion of the questionnaire will take approximately 20 minutes. The survey is intended for current practising Junior Science teachers so I would ask that if you do not teach this that you pass this survey onto a colleague who is currently involved in the Junior Science Programme. The information gathered will be treated with the upmost confidence and anonymity. Each questionnaire will be coded for tracking purposes; no individual will be identifiable from their questionnaire. Data will be stored securely in the offices of the Department of Education and Professional Studies. Once analysis has been completed all questionnaires will be destroyed. The results from the survey will be reported in my thesis or paper(s). I would greatly appreciate it if you could fill in the enclosed questionnaire and return it directly to me using the stamped addressed envelope provided before 14th May 2007. If at any time you wish to withdraw from this research you may do so.

Kind Regards,

________________________
Sancha Power
April 2007

Email: sancha.power@ul.ie       geraldine.mooney.simmie@ul.ie
Phone: (061) 213460              (061) 213029

If you have concerns about this study and wish to contact an independent source, you may contact; The Chairman of the University of Limerick Research Ethics Committee C/o Registrar & Corporate Secretary’s Office University of Limerick (061) 202022
Appendix F _ Covering Letter for Participation

Information Sheet

Dear Teacher,

My name is Sancha Power and I am pursuing a Masters in Education under the supervision of Geraldine Mooney Simmie, lecturer in the Education and Professional Studies Department at the University of Limerick. My research is entitled “Junior Certificate Science: An approach to meet the needs of the 21st Century classroom”. The purpose of this research is to examine the Junior Science syllabus from a teacher’s perspective, to examine teachers’ attitudes and beliefs in areas such as curriculum development, teaching and learning strategies and assessment. All of which are pressing issues faced by practising teachers every day.

Participation in this study is voluntary and completion of the questionnaire will take approximately 20 minutes. I am aware that this is a busy time of year for you but I would greatly appreciate your assistance with this work as the more respondents’ to the survey the more significant the data will be and the greater the insight obtained into the needs of Junior Science Teachers. The survey is intended for current practising Junior Science teachers so I would ask that if you do not teach this subject to pass this survey onto a colleague who is currently involved in the Junior Science Programme.

The information gathered will be treated with the upmost confidence and anonymity. Each questionnaire will be coded for tracking purposes; no individual will be identifiable from their questionnaire. Data will be stored securely in the offices of the Department of Education and Professional Studies. Once analysis has been completed all questionnaires will be destroyed. The results from the survey will be reported in my thesis or any research papers which disseminate from this. If at any time you wish to withdraw from this research you may do so.

I would greatly appreciate it if you would take the time to fill in the enclosed questionnaire and return it directly to me using the stamped addressed envelope provided.

Kind Regards,

________________________
Sancha Power
May 2007
Email: sancha.power@ul.ie    geraldine.mooney.simmie@ul.ie
Phone: (061) 213460    (061) 213029

If you have concerns about this study and wish to contact an independent source, you may contact; The Chairman of the University of Limerick Research Ethics Committee C/o Registrar & Corporate Secretary’s Office, University of Limerick, (061) 202022
Appendix G _ Teachers Reflective Journal

(Please note this is just one cycle of the journal, this was repeated 10 and stapled together as one reflective journal for each teacher in the study)

GIMMS 2008

Teachers Reflective Journal/ Daily Diary

Name: ___________________________________________

School: __________________________________________

- 30 -
Day: __________________________  Date: __________________________

Time: __________________________  Class Group: ____________________

Number in attendance: __________  Subject: _________________________

Concept or principle being explored:
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Please ☑ the relevant boxes (you may use more than one)

1. Teaching Methods used in class:

   Individual Learning  □  Discovery Learning  □
   Group Learning  □  Active Learning  □
      Peer Learning  □
      Whole Class Teaching  □

2. Resources used in class today:

   Blackboard  □  Whiteboard  □
   Overhead projector  □  Data projector  □
   Data Logger  □  Posters  □
   Computers  □  School Text book  □
   Work book  □
Please list any additional equipment:
(Note if same as previous lesson, just indicate as “same”)
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
____________________

3. Levels of Motivation encountered by the **students**:  
High ☐  Medium ☐  Low ☐

4. Levels of Motivation encountered by you while incorporating this new design today  
High ☐  Medium ☐  Low ☐

5. What would you say was innovative about your approach to this topic?  *(Please tick all those appropriate)*  
Presentation ☐  Content ☐  Both ☐  Motivation levels ☐

Other(s) (please specify)
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

6. In what ways did you display gender awareness in teaching this topic?  
Examples friendly to both ☐  No difference ☐  Integrated the girls / boys more through questions or participation ☐
7. Do you make any interdisciplinary connection between today’s topic and other subjects?

Yes  ☐  No  ☐

If yes, please specify which one:
- Irish  ☐
- Maths  ☐
- Home Economics  ☐
- English  ☐
- Art  ☐
- Metal Work  ☐
- French  ☐
- P. E  ☐
- Wood Work  ☐
- German  ☐
- Religion  ☐
- Technical Graphics  ☐

8. How did you verify learning occurred with your pupils?

- Homework  ☐
- Oral Questioning  ☐
  - Verbal Explanation of the process  ☐
  - Written task within class  ☐

9. Did you incur any difficulties?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

______

______
10. What is your overall reflection on the experience (post lesson)
In this section, please highlight the strengths and/or weakness that you encountered this week.
Please also indicate if you would make any changes in the future.

______________________________________________________________________
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Appendix H _ Pupils Reflective Journal

(Please note this is just one cycle of the journal, this was repeated 10 and stapled together as one reflective journal for each teacher in the study)

GIMMS 2008

Pupils Reflective Journal

Name: _____________________________________

School: _____________________________________

Instructions:
Answer the questions from 1 – 9 to the best of your ability.
If you have any questions, ask your teacher for help
General Information

Please ☑ the relevant boxes:

1. Gender
   Male ☐ Female ☑

2. How old are you?
   11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐

3. What Class Group are you in?
   1st year ☐ 2nd Year ☐ 3rd Year ☐
Describe in your own words what you were learning about this week:
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

Please ☑ the relevant boxes (you may use more than one)

1. Please rate your previous knowledge of this subject:
   Extremely poor ☐                Below average ☐
   Average ☐                        Above average ☐
   Excellent ☐                       

2. How interested were you in this topic?
   Very Interested ☐                Interested ☐
   Somewhat Interested ☐            Not Bothered ☐
   Bored ☐                          

3. What did you like about this topic?
   Interesting ☐                     Experiment ☐
   Working in Groups ☐              Activities ☐
   Investigating ☐                  Equipment used ☐
   Other ☐                          

If “Other” please explain:
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
4. What did you dislike about this topic?
   - Boring topic ☐
   - Too Difficult ☐
   - Knew it before ☐
   - Too much maths ☐
   - Too easy ☐
   - Other ☐

If “Other” please explain:
_____________________________________________________________________________________
_____________________________________________________________________________________

5. What would you say was new about your teachers approach to this topic? *(Please tick all those appropriate)*
   - How it was presented ☐
   - Motivation of Teacher ☐
   - How the content was taught ☐
   - Use of Equipment ☐
   - Higher levels of pupil involvement ☐
   - Other ☐

If “Other” please explain:
_____________________________________________________________________________________
_____________________________________________________________________________________

6. What would make this topic more interesting for you?
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

7. How did you make sure that you had learned from this class?
   - You didn’t ☐
   - Read over it at home ☐
   - Completed Homework ☐
   - Questions in book ☐
   - Looked it up on internet ☐
   - Other ☐

Please name the “other” option, you used:
_____________________________________________________________________________________
8. Did you have any difficulty in trying to understand and learn this topic? If so what could have helped you to understand it better?

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

9. What are your overall thoughts on this week’s class?
These questions may help:
Were they fun, exciting? Did you learn something new? What do you think helped you to learn; bookwork, using new equipment?? Were you bored? Did you know it all already?
Please say if you would like anything changed for next time.

______________________________________________________________________
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Appendix I _ Pre Student Survey

GIMMS

You’re Attitudes toward Science
General Information

Please ☐ the relevant boxes:

1. Gender
   Male ☐ Female ☐

2. How old are you?
   11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐

3. What Class Group are you in?
   1st year ☐ 2nd Year ☐ 3rd Year ☐

4. Did you do science as a subject in primary school?
   Yes ☐ No ☐ Don’t Know ☐

5. Would you like to work in the area of science in the future?
   Yes ☐ No ☐ Don’t Know ☐
**Interest in Science and Maths**

Please rate the following statements by circling one of the numbers from 1 – 7.

Record your answer and quickly move onto the next statement.

The numbers represent the following:

1=Strongly Agree  
2=Agree  
3=Agree Somewhat  
4=Don’t Agree or disagree  
5=Disagree Somewhat  
6=Disagree  
7=Strongly Disagree

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1. I like science
1  2  3  4  5  6  7

2. Science is of no value in my life
1  2  3  4  5  6  7

3. I like using numbers and formulas in science
1  2  3  4  5  6  7

4. Science is complicated
1  2  3  4  5  6  7

5. Science is a subject that everyone can learn easily and quickly
1  2  3  4  5  6  7

6. I use science everyday in my life: at home
1  2  3  4  5  6  7

7. I have no idea what is going on in my science class
1  2  3  4  5  6  7

8. Science will be beneficial for me when getting a job….
1  2  3  4  5  6  7

9. I get frustrated with the maths formulas and equations in science
1  2  3  4  5  6  7

10. I can learn science
1  2  3  4  5  6  7

11. I find new science ideas hard to learn
1  2  3  4  5  6  7

12. I feel under pressure in science class
1  2  3  4  5  6  7
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<td>6=Disagree</td>
<td>7=Strongly Disagree</td>
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13. I struggle to keep up with the learning in science
1 2 3 4 5 6 7

14. I really enjoy science class
1 2 3 4 5 6 7

15. I don’t like using chemicals and glassware
1 2 3 4 5 6 7

16. I like learning about plants and animals
1 2 3 4 5 6 7

17. Learning about famous scientists is interesting
1 2 3 4 5 6 7

18. Understanding about how things work is interesting
1 2 3 4 5 6 7

19. It is easy to relate learning in science into other subject areas: maths
1 2 3 4 5 6 7

20. Changing results in experiments’ into graphs is difficult for me.
1 2 3 4 5 6 7

21. I use a form of science everyday at school
1 2 3 4 5 6 7

22. I find it difficult to relate science to the world around me.
1 2 3 4 5 6 7

23. I like maths
1 2 3 4 5 6 7

24. Maths is all theory and no fun
1 2 3 4 5 6 7
Teaching Styles

Please rate the following statements by circling one of the numbers from 1 – 7. Record your answer and quickly move onto the next statement. The numbers represent the following:

1=Strongly Agree
2=Agree
3=Agree Somewhat
4=Don’t Agree or disagree
5=Disagree Somewhat
6=Disagree
7=Strongly Disagree

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1. Working in groups doesn’t help me to learn

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2. I find it difficult to concentrate when we are reading from the text book

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3. I find it difficult when we write out notes from the board

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4. Writing down notes as the teacher call them out is difficult

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5. Using computers and ICT helps me learn

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6. I find it easier when the teacher relates the topic to our own lives

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7. When the teacher links new material with previous work I find it easier.

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8. I like when the teacher uses posters, coloured pictures and diagrams

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9. I find it difficult to learn when the teacher demonstrates a practical activity

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10. Working in groups of 2 or 3 aids my learning

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11. General discussions and debates about science help me to learn

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12. I like when the teacher gives me personal feedback on my work

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My Learning

Please rate the following statements by circling one of the numbers from 1 – 7.

Record your answer and quickly move onto the next statement. The numbers represent the following:

1=Strongly Agree
2=Agree
3=Agree Somewhat
4=Don’t Agree or disagree
5=Disagree Somewhat
6=Disagree
7=Strongly Disagree
1. I learn best when we use posters, and coloured pictures

1 2 3 4 5 6 7

2. When we make stuff, such as wall charts I learn loads

1 2 3 4 5 6 7

3. Predicting experiment results before hand helps me to learn best

1 2 3 4 5 6 7

4. I find that I learn greatest when I am listening to the teacher speaking

1 2 3 4 5 6 7

5. I often like to re-write my notes out to help me understand and to learn material in more depth

1 2 3 4 5 6 7

6. I like watching video’s and DVD’s in science they help me to learn

1 2 3 4 5 6 7

7. When the lesson is “hands on” I learn most

1 2 3 4 5 6 7

8. I like exploring new ways of doing experiments

1 2 3 4 5 6 7

9. I learn better when we read from the text book

1 2 3 4 5 6 7

10. When I am learning or studying I prefer to go home and re-read the material to get a full understanding of it

1 2 3 4 5 6 7

11. I like learning about different theories

1 2 3 4 5 6 7
12. Its fun and interesting when we become the scientists and carry out investigations
1 2 3 4 5 6 7

13. Solving problems helps me learn best
1 2 3 4 5 6 7

14. I learn best when I am actually doing an activity in the lesson, such as predicting, giving my opinion…
1 2 3 4 5 6 7

15. Brainstorming ideas in class really help me to learn
1 2 3 4 5 6 7

16. I learn best when I complete the practical investigation
1 2 3 4 5 6 7

17. I like having to “research” our learning, on the internet, or in other books
1 2 3 4 5 6 7

18. I prefer learning science using the computer and data projector than the blackboard and chalk
1 2 3 4 5 6 7

19. I like having to “research” our learning, on the internet, or in other books
1 2 3 4 5 6 7

20. I learn best when I can make lists of the main facts
1 2 3 4 5 6 7

21. Learning maths through activities makes learning easier
1 2 3 4 5 6 7

22. I find it easy to learn Maths when I can see a real life example of where I can use it
1 2 3 4 5 6 7

Thank you!
Data logger enhanced learning
1. Did you enjoy the science classes in which you used the data loggers?

Yes ☐  No ☐

Why?
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

2. Please circle the words that you think best describe your science class with the data logger activities (you can choose more than one)

Boring  Cool  Better than before
Exciting  Fun  Dull
Interesting  Enjoyable  Cute
Girly  Difficult  Easier

3. Describe in a few lines what you liked about using the data logger in science class?
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

4. Describe in a few lines what you liked least about using the data logger in science class?
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
5. Which would you prefer more?
1) Science class with some usage of the data loggers
2) Science class with little usage of the data logger
3) Science class with more usage of the data logger

(Please tick one)
Some usage
Little usage
More usage

Please say why you have chosen this answer
____________________________________________________________
____________________________________________________________
____________________________________________________________
____________________________________________________________

6. Did you enjoy the reflective journals that you completed each week in class?
Yes ☐ No ☐

Why?
____________________________________________________________
____________________________________________________________
____________________________________________________________
____________________________________________________________
____________________________________________________________

7. Any other comment about using data loggers in science class?
____________________________________________________________
____________________________________________________________
____________________________________________________________
____________________________________________________________

Thank you.
ICT enhanced learning
1. Did you enjoy the science class using the PowerPoint Presentations?

Yes ☐  No ☐

Why?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

2. Please circle the words that you think best describe your new science classes with ICT activities (you can choose more than one)

Boring  Cool  Better than before
Exciting  Fun  Dull
Interesting  Enjoyable  Cute
Girly  Difficult  Easier

3. Describe in a few lines what you liked best about using the data projector for science class?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

4. Describe in a few lines what you liked least about using the data projector for science class?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________
5. Which would you prefer more?
1) Science class using the computer and data projector or
2) Science class with the blackboard and chalk?

(Please tick ☐ one)

1) Computer and data projector ☐
2) Blackboard and chalk ☐

Please say why you have chosen this answer

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

6. Did you enjoy the reflective journals that you completed each week in class?
Yes ☐  No ☐

Why?
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

7. Any other comment about using computers more in class?
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
Thank you.

Micro Scale Science
1. Did you enjoy the science class using the micro scale equipment? e.g. the mini test tubes, the mini samples etc

Yes ☐  No ☐

Why?

____________________________________________________________

____________________________________________________________

____________________________________________________________

2. Please circle the words that you think best describe your micro scale science activities the best (you can choose more than one)

Boring   Cool   Better than before
Exciting   Fun   Dull
Interesting   Enjoyable   Cute
Girly   Difficult   Easier

3. Describe in a few lines what you liked best about micro scale science?

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

4. Describe in a few lines what you liked least about micro scale science?

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________
5. Did you enjoy the reflective journals that you completed each week in class?
   Yes ☐       No ☐

   Why?
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

6. Any other comment about micro scale science?
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

   Thank you.
Appendix K _ Personal Reflection

The purpose of this section is to complement the interpretative aspect of the research project by adding context and culture to the research from the researchers own personal background, influences and beliefs. It is important for the sake of the research project that the researcher outlines her own background, as its impacts on the study quite heavily. The authors’ secondary education took place in a large co-educational community college situated in the south east of Ireland. While in secondary education it became evident to the researcher that pupils learn differently, which was often affected by uniformity in classroom practice by some teachers. The author realised soon realised the impact of the national examinations. The prevailing dominance towards memorization and the written word was limiting pupils in learning and teachers in their practice. This influence on the importance of learning led the researcher to enter a teacher education programme at the University of Limerick. When the author arrived first into Teacher Education, she was going to ‘free’ the world and make learning applicable for all. Needless to say this was a little ‘optimistic’ when one explored in depth the philosophies and history of education in Ireland was explored in lectures and tutorials.

While undertaking this degree programme several aspects regarding the current education system came to light. One of the most pressing issues for the researcher on completion was around teacher voice and lack of teacher participation within curricular matters. The third and final year of the degree programme explored curricular change in Ireland and teaching as a profession in Ireland. This evoked a great sense of loss for the researcher as there was no connection felt between the two. Questions started to develop around the descriptive and technical nature of a ‘career’ in teaching. After participating in research with a tutor and postgraduate student from Education and Professional Studies Department (EPS) and concluding that she was not ready for a mainstream setting. The researcher embarked on to trying to ‘solve the problems of education in Ireland’ by applying for a postgraduate place in EPS. The centralised and bureaucratic approach of the system was militating against the development of teaching as profession in the eyes of the researcher. The concept of “teachers as agents of change” however was inspiring. It was the opinion of the researcher that teachers as curriculum makers or teaching as a profession was not going to be recognised until teachers were
professionally empowered to gain a sense of ownership. This needed to be investigated and there was a strong naivety to come around how ‘easy’ this should be. Graduating in biological science it only seemed natural to empower try and empower the position of the science teacher. Science is currently of major concern worldwide as numbers are declining at both upper secondary and tertiary level. Science to the researcher was not just be about learning facts and figures it was about the development of understanding everyday concepts making the learning relevant and practical for both teacher and pupil. For the science teacher, science should be fun and with pupils learning interactively. However, the dominant force that is the state examinations has led to a teaching and learning experience that is bound by rote learning and didactic pedagogies. The influence of the process of learning in Irish classrooms has been quite significant on the author, who believes that learning is a lifelong process, one that should be flexible and adaptable to the needs of all, and one that should be promoted into pupils from a young age.

When I embraced the post graduate research the policy documents only provoke the emotions around empower teacher voice. In the researchers opinion there was a obvious lack of acknowledgment of the teacher at policy level. There was a true sense of the teacher as “a responder rather than initiator of change”. The high response to phase two only added to this, and so when the researcher embarked on phase three, there was a real urgency to appreciate the conditions of teaching, the issue of time and the culture of school. When the researcher initially met with schools it became very evident that there was a clash of cultures that the author had not considered. The researcher was naive in thinking that all teachers would be motivated to engage and have their voice heard. Considering this, there was an unprecedented effort made by the researcher to ensure at all stages of the project that teachers were engaged at a level that suited their needs and that the culture of their teaching and their school was embraced.
Developing Partnerships with Science Teachers for Improving Practice

Sancha Power and Geraldine Mooney Simmie,
Education and Professional Studies Department, Faculty of Education and Health Studies, UL

Framework for the research

Science education is failing. There has been worldwide concern as numerous projects costing thousands of dollars try to fight the declining figures in science and science based subjects (Rowlands 2008, Hampden-Thompson and Bennett 2011). The failure of science curricular to attract and inspire learners is having massive consequences in many of the westernised countries including the United States, Australia, and Europe (Department of Education and Science Ireland 2002c, Peters 2002, Osborne et al. 2003, Matthews 2007, Rowlands 2008). As a result the teaching and learning of the secondary school science classroom has seen unprecedented changes in the last twenty years; research activity around science and technology has seriously influenced and impacted school science and its provision. The research literature on curriculum change identifies however how change can be a low key and meaningless affair or it can be something quite significant that impacts pupil learning and teacher practice. This research envisaged to offer a more inclusive approach for improving practice as it involved both policy makers and teachers and is often referred to as a partnership approach (Goodson 2001, Darling Hammond 2009). The partnership approach offers a democratic approach to changing practice and developing teachers as innovation practitioners. School-university partnerships (SUP’s) are one such partnership where both academic researcher and teacher work collaboratively to learn and create new knowledge (Rönnerman et al. 2008).
Research Questions

The research project wished to explore if school-university partnerships offer a way for implementing curricular change and improving pedagogical practice while developing teachers as professionals.

Methodology

This research methodology incorporated developing a school-university partnership with lower secondary science teachers in an effort to introduce curriculum ownership, professional empowerment and pedagogical change in the area of science at lower secondary. Five schools were invited to partake in the research with a sample of three case study schools opting to get involved. Two schools ended their involvement at differing stages; their reasons for terminating connection to the project are quite relevant to the Irish situation and are outlined further down. The case study was selected as a means of data collection as it enables “many situations to contribute to our knowledge of individual, group or organisational, social, political, and related phenomena” (Yin 2003). Tools for gathering data within the case study were of mixed methods with dominance towards the qualitative approach. Mixed methods attempts to respect the viewpoints of both paradigms, while seeking a workable middle ground (Johnson et al. 2007).

Outline Data

As part of the development of the school-university partnerships teachers were invited to introduce something new and innovative into their daily practice. They were encouraged to identify a particular area of teaching or pupil learning that needed a change. The purpose of developing a new pedagogical tool was twofold, 1) to enhance the teaching and learning of the classroom and 2) to aid in the development of a school-university partnership from which professional empowerment would grow. All projects were developed to improve on practice within the classroom. The Table below offers some information on the three schools involved and their projects
Table 1 Case Study School Demographics

<table>
<thead>
<tr>
<th>Name of School</th>
<th>Type of School</th>
<th>School Background</th>
<th>Lab Technician</th>
<th>Pupil Numbers</th>
<th>Mixed Ability</th>
<th>Project Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>Secondary School</td>
<td>Irish/International day &amp; week boarders</td>
<td>Yes</td>
<td>650+</td>
<td>Yes</td>
<td>Eco friendly science classroom</td>
</tr>
<tr>
<td>School B</td>
<td>VEC</td>
<td>Suburbs</td>
<td>Yes</td>
<td>700+</td>
<td>Yes</td>
<td>ICT enhanced technologies</td>
</tr>
<tr>
<td>School C</td>
<td>Community School</td>
<td>Urban/Rural Mix</td>
<td>No</td>
<td>700</td>
<td>Yes</td>
<td>ICT enhanced approaches v the traditional approaches</td>
</tr>
</tbody>
</table>

**Barriers for improving practice in Ireland**

The withdrawal of two schools from the project helped identify barriers for the improvement of practice within the Irish setting. There was an atmosphere of ‘pressed for time’ and ‘workload stress’ that greeted the researcher at some of the schools. There was an overwhelming

“Impression that this project would led to more work and so was greeted with negativity straight away from all concerned”

(Mooney Simme and Power 2012)

It would be understandable due to past histories that some scepticism would exist (Clandinin and Connelly 1992). What was evident within another school that withdrew was the dominance of the technical and product approach to teaching and learning and the pressures felt by the science teachers.

Look around you there, see all that equipment, we are supposed to get all that ready and tidied away before the next class, do you know how long that takes????

**Positive attitude towards improving practice**

Teachers displayed a positive attitude to the partnerships, they were enthusiastic about their involvement and the recognition they received. One of the key outcomes was that the teachers recognised that they were no longer passive recipients and instead were players within the bigger picture

“Seeing we are not alone in this project, learning from others and seeing the bigger picture”
(Teacher B, School A)

very good to see outside our own little box and to feel that we are engaged in something a little bit bigger than what goes on in our own little rooms because teaching in its very nature can be quite an isolating job.

(Teacher A, School C)

**Increase in positive attitude toward science**

Pre-and post- tests were carried out with pupils involved in the study in each school to determine pupils “attitudes towards science”. The pre-and post- surveys examined pupil interest, teaching styles and included a section entitled “my learning” which explored the way each individual pupil preferred to learn. As expected from the literature review a large number of pupils agreed that when related to their own lives learning was easier (pre n=46, post n=51). The table below outlines some findings in relation to pupil’s interest towards science pre-and post- intervention.

<table>
<thead>
<tr>
<th>Table 2 Levels of agreement with complexity, enjoyment, pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statement</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Science is complex</td>
</tr>
<tr>
<td>I feel under pressure in science class</td>
</tr>
<tr>
<td>I have no idea what is going on in my science class</td>
</tr>
</tbody>
</table>

There was also a shift in level of agreement towards a more concrete answer of yes, ICT does help me learn after the pre-and post- changes to practice. It was also evident from the research findings that students felt that the new improved practice made learning easier. Evidence from School C demonstrates that those who partook in the Traditional V ICT enhanced learning, 89% enjoyed the new ICT presentations (n = 18). With reasons included in the acknowledging

“Enjoyable” (male respondent)

“Easier to remember” (female respondent)

“Better than the book” (male respondent)
**Interpretation**

Change within education is a complex and multi-faceted process. Teachers can become agents of change, and are a strength to be considered within the development of innovation and change (Trant 1998, Goodson 2001). Evidence from the school-university partnership research would suggest that there was a form of measured success from the implementation of the partnership and that there is an authenticity in the concepts outlined in the research literature. While engaged in the partnership teachers developed ownership over curriculum, created innovative approaches to pedagogy while empowering themselves as professionals.

**Implications**

School-university partnerships can offer curriculum change agencies a way forward in the fight for science uptake and innovation at lower secondary.
This research project sets out to examine Junior Certificate Science teachers’ attitudes and beliefs to three key areas within professional education and practice; curriculum development, teaching & learning methodologies and assessment. The methodology incorporated a postal survey which was conducted on a national level to lower secondary science teachers. A sample was obtained using the Department of Education & Science (DES) database for post-primary providers for 2007. From this database a random cohort of 500 participants was selected to partake in the study and a 43% response rate was achieved.

The research uses the theoretical scaffold of the teacher as a professional learner to frame the study. It draws on the conceptualisations of Hargreaves & Goodson (1995) on the teacher as professional, Sexton’s (2007) work on extended professionalism and finally Darling Hammond & Bransford's (2005) model for a vision of professional practice for teachers.

The OECD report “Teachers Matter” (2005) indicated that teachers “need to encompass strong subject matter knowledge, pedagogical skills, the capacity to work effectively with a wide range of students and colleagues, to contribute to the school and the profession and the capacity to continue developing”. National reports have shown the need for an increase in uptake of science and the reformation of science education in Ireland to included an increase in the promotion of teaching and learning as a key concern (Strategy for Science, Technology and Innovation 2006) (Task Force on the Physical Sciences 2002).

The theory along with these significant national research findings have framed the three areas of the postal survey in a view to discover how teachers perceived themselves as professional learners and practitioners’.

The statistical package for social science (SPSS) was used to analyze the data from the survey. The initial findings indicate that overall while teachers are quiet
positive about the latest reforms in the junior science syllabus, they would prefer a stronger stake hold in the development of curricula in Ireland.

Sancha Power and Dr. Geraldine Mooney-Simmie

Department of Education and Professional Studies, Faculty of Education and Health Sciences, University of Limerick, Ireland.

In 2003 a revised syllabus for Junior Certificate Science was introduced. This course is activity based and emphasises practical experience of science for each individual student. The syllabus brought with it a new form of assessment for Junior Science, disregarding the traditional 100% exam. However, the Junior Cycle has subsequently been described as “subject-based in structure and largely traditional in style” and is currently under review by the NCCA. This study examines teacher's attitudes and beliefs towards the revised Junior Certificate syllabus, across three domains, curriculum development, teaching & learning methodology and assessment. This paper draws on teacher’s perspectives from the curriculum development and teaching & learning methodologies domains of the research. The research methodology incorporated a postal survey which was conducted on a national level to lower secondary science teachers. A random cohort of 500 participants was selected to partake in the study and a 43% response rate was achieved. Results have indicated that teachers are quite positive about the benefit to students. Nevertheless, results show that over 56% of those teaching identify the revised syllabus as being less teacher friendly than the old syllabus. Teacher time and a lack of laboratory facilities and technicians are a source of discontent.

Introduction

Second level education consists of a three year junior cycle (lower secondary), followed by a two or three year senior cycle (upper secondary) (Department of Education 1965pg: 10, Department of Education and Science Ireland 2004apg: 13). Lower secondary education is provided to children aged between twelve and fifteen. It comprises of three years on entry to post-primary education and ends with a state commissioned exam, referred to as the Junior Certificate Examination (Department of
The principal objective of the junior cycle is designed around completing a broad and balanced, relevant, coherent study in a variety of curricular areas (Department of Education and Science Ireland 2002a, Department of Education and Science 2003, Department of Education and Science Ireland 2004apg: 13). The curriculum for post-primary is determined by the Minister for Education and Science who is advised by the NCCA (National Council for Curriculum and Assessment undated).

Science at Lower Secondary
Science within lower secondary comprises of three main components, biology, physics and chemistry, and provides suitable preparation but is not mandatory for the study of science at upper secondary (National Council for Curriculum and Assessment undated). The original junior certificate science syllabus was established in 1989.

The structure of the 1989 Junior Certificate Science syllabus was devised into two parts the core, and the extension. The core was developed around four key areas scientific knowledge, skills, concepts and attitudes. There was five extensions available which were to be studied at both levels (OECD 2006, pg: 6). Higher level students took four of the five extensions, while ordinary students had to choose three extensions of their choice plus the core (OECD 2006, pg: 7). The examination of this syllabus was a 100% terminal exam.

2003 saw the introduction of the revised syllabus. It was activity based and placed emphasises on the practical experience of science for every student. Assessment was now divided into 3, Coursework A, Coursework B and a terminal exam, the percentage was broken down, 10%, 25% and 65% respectively (NCCA 2003c, pg: 32).

Teaching and Learning Science
Science has traditionally been taught through deductive and didactic methods of teaching and learning (Prince and Felder 2007). Research has shown however that pupils carry their own meanings and interpretations (Osborne and Freyberg 1985), it has shown that students taught in this deductive and transmissive manner become quite passive and as a result become quite disengaged and alienated from the classroom environment and what is being taught (Driver and Bell 1986, pg: 443, Carr et al. 1994, pg: 148). Teaching in this manner, transferring ideas from expert to novice attempts to
transmit to learners concepts which are precise and unambiguous (Carr et al. 1994, pg: 147). It gives the learner the impression that science is a body of knowledge to be memorized (Lyons 2006, pg: 595).

There is a current international disquiet over the condition of science education (Lyons 2006, pg: 592). Concerns about decline in enrolment and student interest have increasingly been expressed internationally including Ireland. Society calls for a more demanding and active curriculum, a more scientific and technologically advanced population is needed to meet the demands of the economy (Bennett 2003pg: 14). Science education literature offers continuous studies on how students learn, where difficulties lie, and what makes learning science easier (Driver et al. 1994, Bennett 2003, Lyons 2006). Research identifies that learning requires active involvement of the learner (Mortimore 1999, Bennett 2003, Prince and Felder 2006). An aim of the revised syllabus was to foster an appreciation for science through active participation and contribution.

**Methodology**

The researchers set out to identify teacher’s attitudes and beliefs towards the new revised Junior Certificate syllabus, across three domains 1) Curriculum Development, 2) Teaching & Learning Methodology and 3) Assessment. The survey design was guided two key research questions:

- To what extent are lower secondary science teachers in Ireland currently involved in new teaching and learning methodologies
- What motivations and concerns do lower secondary teachers have towards curriculum development and becoming future policy makers

A variety of question styles, including open, category, and scale type were incorporated. Reliability was tested using Cronbach’s alpha which scored .843, proving the instrument was reliable. To optimize response rates, it the layout was attractive and clear, subsequently the survey was divided into five specific categories: i) General school information ii) Teacher information iii) Curriculum development iv) Teaching & Learning methodologies and v) Assessment

Data collection was conducted through a postal survey, to obtain a national sample the survey was distributed to Junior Certificate science teachers across Ireland. A random sample of 500 schools was selected from the 733 identified from the Department of Education and Science, post-primary providers database for 2006/2007. Prior to sending the survey was piloted to junior certificate science teachers outside the
sample, third level academics, postgraduate students and members of the general public. Of the 500 surveys distributed, a total of 213 were returned, giving a response rate of approximately 43%.

**Background Information**

While the sample achieved (43%) was low, Table 1, identifies that, the sample gathered was representative of the national cohort of school types.

**Table 1: Classification of Survey participant schools.**

<table>
<thead>
<tr>
<th></th>
<th>My Sample</th>
<th>National Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary School Sector</td>
<td>55%</td>
<td>54%</td>
</tr>
<tr>
<td>Vocational/Community Sector</td>
<td>32%</td>
<td>34%</td>
</tr>
<tr>
<td>Community/Comprehensive Sector</td>
<td>13%</td>
<td>12%</td>
</tr>
</tbody>
</table>

61% of schools involved in the survey were co-educational, 21% were single sex girls, with a further 18% single sex boys. 50% of the study cohort was from schools with a pupil population up to 400, 43% of the cohort coming from schools with a pupil population from 401 – 800, and the remaining 6% representing the larger schools of 801+. Gender breakdown of participants was strongly dominated by females (62%), while 38% were male. This would be representative of the situation in secondary education in Ireland, the TALIS study identified that over 69% of the teaching cohort for lower secondary was female staff (Shiel et al. 2009). Table 2, identifies years of experience.

**Table 2: Participant Years of Experience.**

<table>
<thead>
<tr>
<th>Numbers of years teaching</th>
<th>0-5</th>
<th>5-10</th>
<th>10-15</th>
<th>15-20</th>
<th>20-25</th>
<th>25+</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of participants</td>
<td>10%</td>
<td>15%</td>
<td>10%</td>
<td>11%</td>
<td>15%</td>
<td>39%</td>
</tr>
</tbody>
</table>
Main Findings

Within the main findings of the research, two main themes have emerged; these are curriculum development and teaching & learning, both of which will be outlined below.

Curriculum Development Domain

Two themes emerged from analysis of the curriculum development domain, these included: 1) Pupil friendliness and participation and 2) Teacher friendliness

Pupil Friendliness and Participation

78% of teachers surveyed regarded the new ‘revised’ syllabus as being more pupil friendly than the previous. Teachers indicated that the level of participation and input by the pupils was realistic and adequate with over 66% disagreeing with the statement “Pupil participation and input in the programme is too little”. There is a slight trend towards newly qualified/recruited teachers agreeing that participation is too little. An overwhelming majority (88%) of teachers agreed that the new curriculum contained adequate practical experience for the pupils.

Teacher friendliness

Fifty-seven percent of the cohort disagreed that “The new science programme is more teacher-friendly than the previous syllabus”. There is a slight trend indicating those teaching longer felt that the syllabus was not teacher friendly. Over 90% of the participatory cohort is currently teaching in mixed ability, interestingly 48% identified that they felt the new syllabus did not suit a mixed ability teaching environment.

Over 52% agreed that the allocated time was not sufficient for the delivery of the programme. This unhappiness with length of programme and allocation of time is reinforced throughout the survey data, including:

There is an absolute need for technical support for teachers – the workload makes it impossible to fully implement the new syllabus effectively

(Male, city school, 20-25 years experience)

It is a huge workload if teachers are implementing it properly with no extra teaching hours e.g. investigations done in my free time and other teachers giving me students otherwise no time

(Female, city school, 10-15 years experience)
Cross tabulations indicate that 59 participants (28%) who agreed that time was too short, acknowledged if they were given the chance they would reduce content across some if not all three key elements of the curriculum [physics, chemistry and biology.

45% of participants acknowledged dissatisfaction with the level of input by teachers into curriculum development, with a further 85% thinking that teachers should have more input. Below is a sample of reasons why they feel this:

Practising teachers have the trait knowledge and experience of what works in a classroom situation and what doesn’t work

(Female, city school, 5-10 years experience)

We are the people on the ground delivering the curriculum

(Male, city school, 25 years + experience)

Realistic approach

(Female, small town school, 25 years+ experience)

**Teaching & Learning Methodologies Domain**

Analysis of the Teaching and Learning Methodology domain identified two themes 1) Classroom Practices, 2) Professional Support

**Classroom Practices**

Seventy five percent of the cohort agreed with the statement “I make frequent use of active learning methodologies”. Of those that agreed 71% identified group work as the most frequently employed method. Peer learning, role play and pupil led investigations were notably less used. Context based learning also experienced rather low status with only 24% sometimes or always taking trips to industry and 31% sometimes or always having visitors to the classroom.

98% of participants sometimes or always use the textbook in their classroom for teaching, while 80% use the whiteboard. 99% of participants sometimes or always use teacher demonstrations in comparison to 61% pupil demonstrations. Where available, only 36% of teachers use interactive whiteboards, posters and films are used more. Only 7% ‘always’ use the internet in their teaching and learning of junior science. Usage of the computer room and specific ICT software is always considerable low.
Handouts’, mixed groups and variation in lesson presentation were the three most frequently used techniques to improve teaching and learning for mixed ability. Others included re-arrangement of the room, change in activity and different homework for different students. Additional techniques included different questions for different abilities, use of DVD’s, mind maps, games, quizzes & ICT. The setting of individual goals was the lowest used technique.

**Teaching Support**

When asked to rate how supported they felt in the development of their teaching and learning teachers ranked the Junior Certificate Support Service the highest (67%), followed closely by their school principal, and head of science. Only 28% of participants found the NCCA supportive in developing their teaching and learning.

66% were affiliated with the Irish Science Teachers Association (ISTA), with affiliation to other professional bodies significantly lower. Data-logging, laboratory practical and ICT enhanced learning in-services were the highest rated of in-services offered by the professional organisations. Interestingly inquiry based activities such as active learning, discovery learning were significantly lower, while mixed ability and special needs in-services were shockingly low, 12% and 7% respectively.

**Discussion**

The emerging issues from this piece of research documented include 1) lack of teacher voice 2) low levels of inquiry based learning methodologies.

**Lack of Teacher Voice**

We have in Ireland a very centralised approach to curriculum development and curriculum change. Literature has shown that centralised or top-down approaches to curriculum change, only create a ‘surface change’ (Fullan 1991). Teacher voice can often be missing from the development of the ‘revised’ syllabus due to its top-down approach.

For ‘deep change’ to occur, teachers must have a voice, they must have a personal ownership within the change. Greater levels of teacher involvement may have lessened the view that the revised syllabus was not teacher friendly. A high number of participants in this study feel that teachers should have a more active role in curriculum development. While it is acknowledged that the teachers are represented in the
curriculum development process through the teacher unions, only 9% of teachers felt they had support from these unions in relation to teaching and learning.

Matters which have emerged in this research could easily have been reduced or eliminated if teachers had a voice in the change process. Problems with time, and length of programme, working with mixed ability, could all have been incorporated and catered for if practising teachers were involved. After all, as one participant said:

We are the people on the ground delivering the curriculum

Perhaps Trant’s (1998) idea of curriculum as “partnership” approach to curriculum development could help alleviate some of these concerns.

Inquiry Based Learning

In recent years Ireland has not fared well in research carried out on teaching and learning practices. Going from the data of the current study, there seems to be some signs of improvement with teachers frequently making use of group work. However, teachers still heavily rely on textbooks and teacher demonstrations. The recent TALIS report indicated that Irish teachers have strong preference for ‘structured practices’, opposed to ‘enhanced activities’ or ‘student-orientated practices’. The level of inquiry based teaching and learning in science classrooms can still be improved but that more CPD is needed. However, even if CPD is provided, one constraint on levels of inquiry based teaching may be the issue of time and classroom support. It is important to acknowledge that if these matters were addressed perhaps a more inquiry based environment would be created by teachers.

There is an absolute need for technical support for teachers – the workload makes it impossible to fully implement the new syllabus effectively

(Male, city school, 20-25)

Conclusion

The discontentment within the teaching community towards the ‘revised’ syllabus needs to be addressed. There is a need for teacher’s voice to be heard and taken into consideration. The top-down approach is having a negative effect on the education of our students. The junior cycle is currently under review, the NCCA should strongly adopt a “partnership approach” as suggested by Trant (1998) involving the teacher at all
levels of consultation. Increased inclusion of teachers in the curriculum process would not only allow deep change to occur but it would strengthen relations between teachers, the DES and the NCCA and create a more positive attitude to teaching and learning.

**Acknowledgements**

The author wishes to acknowledge the funding received from the Department of Education and Professional Studies, University of Limerick, to carry out this work.
In 2006, at the start of the GIMMS project, there were two national reforms in Ireland seeking to influence science and mathematics teaching and teacher education. These interventions included syllabus revision, in-service education and training of teachers, grant assistance for improved infrastructure in schools and changes in science assessment in lower secondary education. One reform was concerned with interventions to improve the uptake of science and mathematics subjects among pupils (*Report of the Task Force on the Physical Sciences*, 2002). The second reform was concerned with the enactment of a legislative framework, the *Teaching Council Codes of Professional Conduct for Teachers*, 2007, advocating for teachers to become publicly accountable within a self-regulating body with its own internal codes of professional conduct and standards.

At this time Ireland was experiencing a declining interest in the overall number of students choosing upper secondary physics and chemistry and theoretical mathematics (higher level mathematics). Gender issues most noticeable at upper secondary education. Uptake of chemistry and mathematics was becoming co-equal in terms of gender uptake but overall uptake was well below national expectation. Senior cycle physics continued to be chosen by a majority of boys.

In this chapter we report on the background and context for science and mathematics teaching in Ireland during the lifetime of the GIMMS project, 2006-2009. We outline key features of the case study, data collection and analysis procedures, and the findings that emerged from the GIMMS Ireland. Finally we discuss some implications for policymakers, teacher educators, school leadership and teachers alike.
Background and context for GIMMS Ireland

At the start of the 2000s while there was some evidence of teachers committed to interrogating their practice and working in collaboration the dominant discourse in schools appeared to mostly favour examination-success and teacher–centred teaching (Hogan et al., 2008, Mooney Simmie, 2007). In general it appears that teachers were more familiar with lower-order co-operation, such as sharing textbooks, resources, strategies and information about pupils, in preference to higher order co-operation which included reflective approaches to thinking about their practices, peer-peer observation, mentoring or collaboration based on a dialogue of curriculum, innovation and inclusion (OECD Teaching and Learning International Study, TALIS 2009). Transmission models of teaching were commonplace with teachers working in isolation at the school site as the preferred option. Innovation and educational change in GIMMS IRELAND involved teachers stepping outside the isolation of the classroom and deliberately engaging in a purposive and critical dialogue with colleagues, with teachers from other schools, with teacher educators and, at times with policymakers, on all aspects of curriculum development and pedagogy (OECD Teachers Matter, 2003).

PISA 2000-2003 findings on scientific and mathematical literacies, showed a decline from average to below average standards, indicated the need for changes in the syllabus and the teaching and assessment of science and mathematics (Cosgrove et al., 2005). Some changes to syllabus and assessment approaches were adopted. In the early 2000s junior cycle syllabuses in science and mathematics were revised in lower secondary education (DES Science Syllabus, Mathematics Syllabus). For example, science became a more hands-on subject with pupils mandated to complete a number of laboratory experiments. Changes in mathematics focused on approaches to teaching for understanding. Assessment of junior cycle science, which traditionally involved a three-hour externally evaluated written examination for all, 55,000 pupils approximately, was changed to a 65% written examination with additional marks allocated for practical work (10%) and investigation work (25%).
These syllabus changes were supported by in-service training of experienced teachers. This support was given in two phases. In the first phase teachers had access to a national support service which provided training workshops, school visits and on-line resources for a three year period, the Junior Cycle Science Support Service (JCSSS). The support service personnel, located within a regional education centre network, consisted of experienced teachers, seconded from their schools and working in co-operation with the inspectorate of the Department of Education and Skills (DES). This early implementation phase ended and was replaced by a much reduced generic support service. This generic service, the Second Level Support Service (SLSS), was responsible for supporting the implementation of reform measures in areas such as teaching, learning, discipline and assessment. In a similar way mathematics teachers had access to a similar support service, the Junior Cycle Mathematics Support Service. At this time a new pilot study Project Maths was developed to continue to assist mathematics teachers in a small number of schools (Ni Riordáin and Hannigan, 2009).

However introducing innovation and educational change onto the agenda of schools was far more complex a process than merely showing teachers newer methods of teaching and learning. New methods of teaching were less interesting to teachers who were coping with discipline issues and increased levels of bullying among young people. For example, the report of the School Development Planning Initiative, 2002 showed that schools and teachers ranked support with discipline and bullying among their primary needs and far higher than any perceived need for dialogue on teaching, learning and reflection.

An additional constraint was the nature of the final written examination. Preliminary analysis of written examination papers for the science programme, by the authors of this chapter, showed a high emphasis on testing rote learning and memorisation, requiring single word key answers and leaving little of no space for depth of explanation or engagement with key principles of scientific thinking. The task of teacher educators and others to develop capacity with teachers for higher-order thinking was going to offer a real cultural challenge within this contextual landscape.
GIMMS involved teachers and teacher educators in a mentoring framework that crossed borders between school and university and was reflective, collaborative and inquiry-oriented. The social justice and inclusion focus in the project was on advocating for gender-awareness. This highlighted the need for science and mathematics teachers to be responsive to the varying needs of boys and girls in their classrooms.

We sought to generate a sense of ownership of the project at the school site and in a number of different settings. After an initial period of consultation we found schools and teachers who were willing to engage with their colleagues, and with the Department of Education and Professional Studies at the University of Limerick, to develop a collaborative, experimental and reflective approach. The work progressed in stages, including firstly developing the principles, practices and products that shaped GIMMS Ireland and finally evaluating and disseminating the findings to a wider audience of teachers, teacher educators and policymakers.

Framework for GIMMS Ireland

The framework for GIMMS had been agreed at the first meeting of the European partners (Chapter 1, Figure 1). Throughout the lifetime of the project GIMMS Ireland continued to develop an evolving theoretical framework. This was based on insights of key researchers and thinkers in the areas of innovation and educational change including Maynard and Furlong (1995), Brookfield (1995) and Darling Hammond and Bransford (2005).

Maynard and Furlong (1995) has already been dealt with in Chapter 1. Their critical co-inquiry model of mentoring was the preferred option for GIMMS Ireland as it was not based on a reproductive frame and held the potential for real engagement and mutual learning for all stakeholders. Brookfield (1995) seminal text on becoming a critically reflective teacher became the preferred literature for the project team. He argued that one develops as a critically reflective teacher through a willingness to interrogate practice through multiple perspectives or lenses. These lenses he identified as the perspectives of pupils, perspectives of colleagues.
acting as trusted critical friends, the perspective of the research literature and the reflexive perspective gained from self-evaluation. Critical thinking in this way was framed as something that included both the wisdom of a reflective practice and the research literature. The key principle of engaging in this reflective, collaborative and inquiry-oriented way was found to be excellently framed within Darling-Hammond and Bransford’s (2005) professional practice model. This model considered professional practice as requiring knowledge of subject matter, knowledge of the learner and learning and knowledge of assessment.

This evolving theoretical framework, for GIMMS Ireland, assisted in the development of definitions of innovation, mentoring and gender awareness and gave greater clarity to the project goals:

- Educational innovative practices were interpreted as eliciting higher-order cooperation among science/mathematics teachers for the development of pupil-centred curricular practices. For example, teachers worked together in GIMMS Ireland in public incubation spaces that focused on a deliberative discourse on curriculum, learning and innovation within their school, across different schools and with the university.

- Mentoring was interpreted as a reflective relationship of learning between teachers, across their professional lifespan, and across borders between teachers and teacher educators with interchangeable novice-expert roles for the purpose of mutually enriching co-learning.

- Gender-awareness required that teachers and teacher educators consider gender as a specific criterion, when co-planning, designing materials, teaching and evaluating teaching to ensure that both boys and girls learning needs were included in the science and/or mathematics classroom.
Data collection and analysis

The research approach used a case study paradigm. Data collection methods involved triangulation of perspectives including the perspectives of teachers, pupils and teacher educator/researchers (Merriam, 1986). It was exploratory in design and capable of offering fresh insights into the possibilities and constraints of developing newer and innovative approaches for teaching for pupil learning in the dynamics of the public incubation space that was created and designed to generate innovation and educational change. Data sources included surveys, reflective journals by teachers and their pupils, focus group interviews and field notes taken at key stages during the lifetime of the project.

The main research and development tools for the project, reflective diaries, surveys, focus group interviews and evaluation instruments, were developed in partnership between the schools and university. Data analysis involved a constant comparison approach to the selection of themes and independent validation, between the two researchers, while using the theoretical framing for the project.

GIMMS findings

Findings from each of the phases are now considered giving a range of practices, perspectives and products from initial contact with teachers, to reflective journals of pupils to the voice of the teacher as captured in the focus group interviews.

Initial contact with schools and teachers

Seven schools were initially invited to partake in the GIMMS project, two of which withdrew at the beginning of the project. One school later withdrew while the project was in progress. The reasons behind withdrawal from the project were varied but all appeared to be concerned with the busyness of the school day and the lack of clarity from the project team at the university. One school felt that timing was an issue and a reason for not becoming involved. One science teacher felt that he/she “had enough on her plate trying to find everything, and was not hard pressed to engage in a research project with the University of Limerick.”
There seemed to be a lack motivation regarding working collaboratively and becoming part of the project in general, a sense of ‘my work is good enough already, it doesn’t need to be improved’ was felt and noted (Field Notes, 17/10/2007). Along with this lack of enthusiasm there was a sense of the busyness of the teacher workload and the lack of a reflective stance:

Look around you there, see all that equipment, we are supposed to get all that ready and tidied away before the next class, do you know how long that takes. (Field Notes 28/02/08 Teacher comment)

One of the schools withdrew some weeks into the project. They agreed to take part in a debriefing seminar to give insight into their reasons. It became apparent that there had been a lack of communication within the school and with the university. Some staff knew little or nothing about the project and felt that they had missed an opportunity: “that is very interesting, it’s a shame, I would have loved to identify how my students learn and work best” Field Notes 28/02/08. The project team learned the value of not making assumptions, checking back with teachers and schools on all protocols and procedures and providing greater clarity in the early phase about the type of commitment level required.

**GIMMS schools and teachers**

After the initial phase of consultation four schools eventually became involved with GIMMS and remained with the initiative to develop innovative practices. Three schools developed new approaches and practices in their science teaching and one school developed innovation in mathematics. All schools involved came from the mid-west region of Ireland, which comprises Limerick, Clare and North Tipperary. Each school involved was deemed to be a ‘large’ post-primary education provider. They were all co-educational. This is quite important as just 477 of the 732 post primary schools listed within the Department of Education Statistics for 2006/2007, were categorised as co-educational (Central Statistics Office 2007). Ireland has a strong tradition of single sex education. Most schools worked with either 1st or 2nd year pupils. Table 1 gives background information on the GIMMS schools and their area of investigation. School types were represented with one
community school, one fee-paying voluntary secondary school and two community colleges.

Table 1 Profile of GIMMS Ireland schools

<table>
<thead>
<tr>
<th>Name of School</th>
<th>School Background</th>
<th>Lab Technician</th>
<th>Student Numbers</th>
<th>Mixed Ability</th>
<th>Topic for GIMMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak</td>
<td>Suburbs</td>
<td>Yes</td>
<td>650+</td>
<td>Yes</td>
<td>Micro Scale Science</td>
</tr>
<tr>
<td>Ash</td>
<td>Suburbs</td>
<td>No</td>
<td>700+</td>
<td>Yes</td>
<td>Data logging in Science</td>
</tr>
<tr>
<td>Elm</td>
<td>Urban/Rural Mix</td>
<td>No</td>
<td>700</td>
<td>Yes</td>
<td>Promotion of ICT Enhanced Learning</td>
</tr>
<tr>
<td>Elder</td>
<td>Urban/Rural Mix</td>
<td>n/a</td>
<td>650</td>
<td>Yes</td>
<td>Incorporation of ICT into Mathematics Teaching</td>
</tr>
</tbody>
</table>

The GIMMS teachers, in consultation with the teacher educator, opted for different topics in science and mathematics. They planned to explore these in a collaborative and reflective way. OAK explored micro scale science using the stimulus of some mandated pupil experiments in the new syllabus. Their rationale for this type of laboratory practice included three main perspectives: for the improvement of pupil motivation, for health and safety considerations and for a ‘greener’ approach to using and disposing of waste chemicals and materials. Science teachers in ASH had previously attended national in-service education and training in the use of data logging equipment. While the in-service had provided some support to them they still felt that they were not fully confident in using this equipment. They wanted GIMMS to assist them in making better use of the equipment in their teaching of science for understanding. Science teachers at ELM had, in their new state-of-the-art laboratories, access to new ICT technology to improve presentation of lesson materials. They were not using this technology to full advantage. They wanted through GIMMS to explore differences in pupil learning between traditional ‘chalk and talk’ approaches and ICT-enhanced approaches to teaching instruction. Mathematics teachers in ELDER also wanted to explore teaching for understanding and the use of ICT-enhanced learning activities in the mathematics classroom.
GIMMS pupil’s perspectives

Pupils in the case study schools took part in a survey before and after the project. The demographic of pupils involved in the survey was predominately female, with an average age of 13 years. All pupils belonged to the first year cohort in each school and the majority had completed science to some degree at primary level. In terms of a future in science the study cohort were quite consistently positioned in a designated “don’t know” category prior to project. Within the project pupils took part in two aspects of data collection - a pre survey and post survey of “attitudes to science” and the keeping of a reflective diary.

The attitudes of pupils towards science were somewhat similar across the four schools pre and post implementation of the project. Most pupils agreed to like science while acknowledging a strong dislike for mathematics. This dislike for mathematics was further reinforced when “maths is all theory and no fun” was very strongly agreed with.

In terms of the preferred teaching and learning methods, again there were strong correlations between the four schools. There were strong preferences for the integration of ICT, coloured posters, videos, DVDs and diagrams to improve learning. All pupils surveyed agreed that working in groups aided their learning. Pupils were in favour of linking new material with old material and also liked when new learning was related to everyday life. Pupils agreed that mathematics was easier when explained through real life examples and learning was enhanced when done through activities. There was a strong preference from pupils also towards being actively engaged. In the section on ‘my learning’ pupils acknowledged that they learn more by doing, and that carrying out investigations was fun. In relation to predicting results before doing activities and experiments, pupils “didn’t know” if this was helpful. Perhaps they had no experience of using this approach. Pupils also identified that they liked receiving feedback from the teacher on a one to one basis.

Attitudes to teaching and learning of science and mathematics did not change in the post test surveys completed by the pupils. To investigate further the impact of
the curricular tool, the post surveys contained additional questions unique to each school’s project. This was where pupils’ perspectives were most keenly seen in relation to the project and developments made by the project team of teacher and university researchers. There was consensus across the four schools from pupils that they enjoyed the interventions that had taken place within the classes over the past few weeks. Common themes which emerged were concerned with how interesting they found the new approaches and how much easier it was to understand the subject matter presented. Comments across the schools in relation to why they liked the new approach inspired answers such as “interesting” (all), “fun” (all), “colourful” (ELDER), “easier to understand” (ELDER), “liked using modern equipment” (ASH) “because it helped me and the rest of the class learn better” (ELM).

Those that used data loggers acknowledged that it was “easier to get a graph”, “helped to learn”, “something different”. “Fun, didn’t realise I was learning”. When asked to identify key words which described the activities done, students circled “cool”, “enjoyable”, “fun” “difficult”. They were quick to acknowledge that there was some level of difficulty in using the new equipment. But overall, datalogging was viewed to be a success in integrating pupils with both science and mathematics data, “does engage them more in that they are I suppose because they are using this technology it looks more like a Nintendo DS and it gets them in that way” (ASH).

ELM had carried out a project also related to ICT and reported very positive results. The science teachers planned to continue to use transmission models of teaching but to use more visually attractive ICT ways of presenting the subject matter. The cohort of pupils involved identified a strong preference for the more enhanced ICT classes. When asked to comment why, statements like “its easier to understand”, “it is better than taking notes” “its much more interesting” “better than the book” were found. However, there were a few that acknowledged dislike for these new presentation methods; they preferred actively doing their own experiments “no I like experiments and doing things myself”.

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Those involved in the micro scale project indicated mixed feedback, some students really enjoyed the new equipment “interesting”, “cool”, “enjoyed it”, “cute”, “less mess” while others remarked how they found it “difficult working with the small apparatus”, “made your work harder, difficult to pour in liquids”, “easier to break”. This was strongly endorsed by the teachers when we met to share and reflect with colleagues, “the (pupils) are tuned into it because it is kind of like a television programme, it’s CSI,”... “They love it, its ultra modern, it’s not clunky” “however, some especially the boys find that their hands are big and awkward ....you have this big (boy) who is 14 but nearly six foot and his hand is this size and he twists it and the whole neck comes off the bottle” (OAK).

Possibly the greatest level of change of perspective was reached within the mathematics project in ELDER. The new approach generated huge interest among the pupils. Pupils remarked how there was “nothing to dislike” about the new approach. They found the new approach more “interesting”, liked it because it was “more colourful”, “she explained it more”, “because it was new”, “a new way of learning”. The mathematics teacher remarked on the high levels of motivation and new found enthusiasm and even a remarked change in classroom behaviour which she was hoping to achieve through the project (ELDER).

While innovative teaching and learning approaches were found to be a positive experience by pupils they were less complementary of having to write a reflective diary. There was a strong negative disposition toward diary writing from all pupils. Most of the pupils saw them as “no point”, “annoying” and “boring”. However one or two pupils in each school acknowledged a positive outcome in the way in which the reflective diary “made you think, “let you express your feelings”, “helps the teacher” and “because you know how far you have gone”. This experience of diary writing as part of a science or mathematics classroom was a new experience for pupils and for their teachers. It challenged, both the pupil and the teacher, in terms of thinking as well as improving their capacity for writing and literacy.

Teachers’ perspectives
The teacher autobiographies drew on three aspects of data collection - teacher reflective diaries and focus group interviews both of which were further supported by field notes taken by the researchers. On analysing the findings some commons themes emerged which may be considered in terms of a dynamic force field. What were the forces propelling and motivating teachers forward towards innovative and inclusive practices and what were the resisting forces pulling the teachers back to more traditionally inherited approaches to teaching, learning and mentoring?

Most teachers in the study made reference to time and workload as strong resisting forces with one teacher noting that this approach was not supported by the dominant culture:

"It took us too much time to cover the material, it took a couple of class periods that we didn’t really have for students to complete their questionnaires. It took us as teachers quite a lot of time to prepare material and assess it and all that sort of stuff so the time factor was definitely a negative and I would be including the reflection in that. (ELM)"

"It is written somewhere, somewhere in official documents it is written in small print that new methods are to be recommended but (while) it is written in small print, you don’t hear it spoken, it’s not really supported (OAK)"

GIMMS Ireland teachers engaged with the collaborative planning and reflective approaches with colleagues, pupils, teachers in other schools and with teacher educators and researchers. All teachers reported high levels of motivation while carrying out the project. This was strongly supported within focus group interviews where teachers commented that they had gained significantly through collaborative reflective dialogue about teaching for learning and learning new skills sets with colleagues and using ICT equipment in the school, *there was a lot of skill learning for teachers* (ELM). While teachers appreciated working together at school they appreciated the broader lens of working with other schools and the university:

"it is very good to see outside our own little ‘world’ and to feel that we are engaged in something bigger than what goes on in our own classrooms because teaching in its very nature can be quite an isolating job. (ELM)"
Some teachers were motivated by the way both themselves and their pupils were being ‘pushed’ into learning ‘how to learn’:

in my view one of the important things for students to learn as they go through secondary school is how they learn, and I felt that in engaging in the questionnaires and their own reflections that it began to develop how they did their own learning. (ELM)

This project forced us into doing it in a more analytical way, the whole process of reflecting and particularly as regards our methodologies. (ELM) Teachers were also motivated by such practical considerations as developing newer resources for immediate classroom use and one teacher stated that “sharing confirms best practice”:

we are devising some worksheets and these worksheets are going to be quite useful every time we use the lab quests so a few of us are devising worksheets and these are going to be available for the rest of the department so it is sharing resources as well (ASH)

The GIMMS approach helped sustain (pupils) concentration in class (ELDER) while another teacher noted the benefit of being challenged in their thinking:

things like collegiality and being a reflective practitioner because we don’t get time to write down notes to mull over what goes on in every class so this is definitely an opportunity to put a lot of thought into what we are doing and how we are doing it (ASH)

The critical factor that seemed to constrain was the emphasis that all teachers gave to the busy environment that was ‘teaching to the test’:

(I’m) concerned as to how this would relate to exams and application to exam questions in terms of marking schemes and how they will compare and we would be a little bit worried about examiners…maybe if a student wasn’t exactly clear on what they did would they even be able to get the message across about how they completed the experiment on a mini scale to a recognisable level on the exam (OAK)

In GIMMS Ireland there was largely gender silence from science and mathematics teachers. Teachers of these subjects appeared willing to engage with this issue at a rather superficial level, for example, using direct examples of boys and girls in visual aids. However teachers were reluctant to engage with this topic as a deeper level of discourse on this topic. It may be because science and mathematics teachers in Ireland have had a strong tradition of perceiving themselves as purveyors of subject matter knowledge and share less of a perception of their activist professional role as agents of change for social and political change (Sachs, 2003). Additional sustained
supports will be required if science and mathematics teachers are to become willingly to critically engage with this political and ethical aspect of teaching.

**Products, practices and dissemination**

GIMMS Ireland developed a number of new products and practices at the case study schools. These included a *Resource Booklet* of classroom resources and collaboratively designed *Reflective Diaries* for both teachers and pupils. A *Data logging Resource* manual was written and developed in one of the case study schools. All products were trialled and tested with other experienced science and mathematics teachers and student teachers.

Evaluations showed that the resource materials generated were valuable learning aids for pupils and increased the motivation of both pupils and teachers. They included visual learning aids, aids for micro scale practical pupil experiments and ICT-enhanced instruction and presentation. They also included reflective journals written by both teachers and pupils. While teachers and pupils engaged with the journals there was evidence that this process strongly challenged both teachers and pupils. The reflective process and reflective writing in particular, is known to have the capacity to develop deeper levels of higher order thinking skills and improve levels of literacy and depth of analysis (Bolton, 2010). This aspect of GIMMS Ireland was a new demand for experienced and accomplished science and mathematics teachers.

GIMMS Ireland results need to be viewed within the larger national background and context. The project succeeded in motivating science and mathematics teachers, and their pupils, to engage in writing reflective journals and sharing reflections about teaching, learning and innovation with each other and with teacher educators, and sometimes with policymakers. It was less successful in generating deeper levels of critical reflection and analysis. The depth of the cultural task involved in challenging and supporting experienced teachers move away from traditional teaching approaches is underestimated in national reform measures.
The reflective mentoring between the school-university partnership and within the classroom, between teachers and their pupils, was judged to be a success as a starting position for a deliberative discourse between teachers and teacher educators. The depth of collaboration and reflection engaged in during the various settings and groupings within the project was a new and innovative experience for all teachers in the project. It took place against the backdrop of largely transmission teaching, resistance to teacher writing and an examination system that, at the time, mostly favoured lower order questioning. The findings from GIMMS Ireland, including the pupils and teachers perspectives, show that public incubation spaces, like the ones provided in the project, can bring real change to a teaching team within a school through offering consistent levels of both internal and external support and challenge. This juxtaposition of internal and external discourse developed innovation and educational change within the project as critical thinking that supported experimentation and the development of creative ideas and practices.

GIMMS Ireland products, protocols and practices were disseminated to teachers, experienced teachers, beginning teachers and student teachers through a number of pathways. They were disseminated through the GIMMS web-site http://www.gimms.eu and through the publication of the Physical Science Journal which was issued in electronic format to all science teachers. They were disseminated to teachers in the mid-west region of Ireland through two national conferences, on the 14th January 2007 and 25th /26th September 2009 and through a poster presentation at the Chem-Ed Conference (2009) and the Department of Education & Professional Studies in the University of Limerick in 2009. GIMMS Ireland resource materials were disseminated to over two hundred second year student teachers in 2008/2009 at the University of Limerick. They were disseminated to teachers in twelve other European countries through networks and exchange made possible by connection with GIMMS transnational partners and another Comenius 2.1 project, CROSSNET Ireland (Mooney Simmie and Power, 2012).
Sustainability

GIMMS Ireland helped teachers develop the capacity to engage in a deliberative discourse at their school, with other schools and with a higher education institute through a school-university partnership dedicated to innovation and educational change. GIMMS opted for the development of a reflective and collaborative framing for mentoring as the preferred way to engage teachers and teacher educators, and sometimes policymakers, as partners in innovation and educational change. The project took place, at the same time, as the development of an academic pathway for a Masters in Educational Mentoring programme at the University of Limerick (Mooney Simmie and Moles, 2011).

Discussion and implications

GIMMS Ireland achieved a number of successful outcomes and identified some constraints that move science and mathematics teachers beyond traditionally inherited practices. It developed a reflective and collaborative framing for mentoring that generated a deliberative discursive inquiry on pupil learning, innovation and inclusion. This deliberative discourse crossed borders between a number of different communities, teachers, teacher educators and others. This extended network supported teachers’ critical engagement with their science and mathematics teaching through professional networks at the school site, beyond the school and with other schools through school-university partnership. As argued by Brookfield (1995) it is this multiplicity of border crossing perspectives and actors that is at the heart of becoming a critically reflective teacher. It was this variety of actors, and especially teachers interacting with other teachers, such as student teachers and beginning teachers, and teacher educators that gave experienced teachers access to research findings and new, innovative and ICT-enhanced approaches to teaching and assessment.

Innovative products and practices included the generation of critical thinking and creative thinking through public incubation spaces for teachers to exchange with new ideas and practices with each other as a school team, with colleagues from other schools and with teacher educators/researchers from the university. These incubation spaces consistently supported teachers’ ideas and activities as they tried to grapple with new ways of teaching that went beyond traditional pedagogies.
Innovation and educational change in the project was realised through these multiple settings and was most noticeable in the reflective writing engaged in by teachers and their pupils, in the creation of new laboratory systems for pupil experiments, and in the development of hands-on activities and ICT-enhanced activities for classroom use. It was also evident in the planning developed within the school-university partnership and the level of higher-order co-operation between teachers in the project (OECD TALIS, 2009).

Pupils’ perspectives in GIMMS Ireland showed evidence that new ways of teaching, and more engaged teachers, were found to make science and mathematics motivating and enjoyable while leading to improved understanding. This development was also observed in the school even when ICT was used largely to support teacher-centred models of teaching. Pupils’ perspectives were positive in both cases.

The pupils in GIMMS Ireland, and their teachers, were less supportive of having to engage with reflective diary writing and with learning about science and mathematics. Reflection is known to be a valuable tool for learning ‘how to learn’ and to improve thinking capacities (Bolton, 2010). Reflective practice and critical thinking clearly needs further support and persistence if deeper levels of innovation are to be achieved in the classroom and school. In this project it was a new experience for both teachers and pupils. If further developed this border-crossing deliberative discourse framing for innovation and educational change could become a valuable counter-weight to an overly busy school culture and assist the development of capacity for critical thinking and literacy among both teachers and pupils.

Teaching in innovative ways challenges the mind-set, values and existing traditional culture and dominant discourse of schools in Ireland. In GIMMS Ireland teachers remained highly motivated throughout the project and engaged fully with a range of actors including colleagues, teachers in other schools, the university personnel and others, including a number of national policymakers (Mooney Simmie and Power, 2012). They reported high levels of skill and competence learning, especially in the area of ICT, through this collaborative, border crossing reflective
platform. GIMMS Ireland had success in developing higher-order co-operation among teachers, removing teacher isolation and supporting collaborative teacher-teacher interaction and dialogue on curriculum matters.

Teaching to the test proved a consistent constraint to the development of innovation and educational change. GIMMS teachers constantly reported their concern that they might be failing their pupils by focussing on generating innovation in their classrooms rather than giving sufficient time to delivering ‘right answers’ to state examination questions. This dominant discourse of right answers and success in examinations overshadowed the entire project at all times. These findings are particularly timely as Ireland reviews its junior cycle assessment system and seeks to improve literacy and numeracy among pupils and teachers (National Council for Curriculum and Assessment Innovation and Identity: Ideas for a new Junior Cycle (2011) and Towards a Framework for Junior Cycle 2011, Department of Education and Skills Literacy and Numeracy for Learning and Life 2011-2020).

GIMMS Ireland gave science and mathematics teachers in each of the four schools access to a broad-based democratic network of colleagues, teachers in other schools, teacher educators and national policymakers. The school principal, in each of the GIMMS schools, showed a deep interest and commitment in pedagogical innovation and educational change.

Initially GIMMS Ireland schools and teachers required detailed guidance on the aims and outcomes of the project. They also required considerable scope for curriculum making and innovation. The balancing of these two opposites, detailed guidance and curricular freedom, was necessary in giving GIMMS teachers the ownership and motivation to complete the project successfully. It is clearly no longer sufficient to leave teachers, on their own or within their own professional networks to become curriculum innovators as envisaged by Stenhouse (1975) and others, during the golden age of curriculum making in the 1970s. Neither is it sufficient to see this as a top-down training problem of skill, competence and disposition. GIMMS argues that innovation and educational change requires a new approach from all education actors - a boundary crossing collaborative discourse between teachers, teacher educators and, others such as policymakers.
In conclusion, as long as teaching to largely lower-order tests is perceived as the route to pupil progression, and continues to be supported by policymakers and society generally, then trying to bring about innovation and educational change in the classroom and school will continue to remain a demanding, difficult and counterculture movement. It may be delusional to think that we can continue to do both simultaneously:

(we have a) shared understanding of education as an enlightening and emancipating force for the democratic development of each person. We have remained acutely conscious of the struggle to retain this conception of education as a human liberating force against the backdrop of a reductionist agenda sweeping the education world with its focus on outcomes and external modes of accountability. In our opinion, mentoring in teacher education needs to be underpinned by an alternative lens provided by the literature taking this broader educational landscape into account

(Mooney Simmie and Moles, 2011 p. 471)

Abstract: Innovations in science education are currently concerned with the continuum of teacher professional learning and the development of inquiry oriented pedagogical practices (Lang et al. 2007, Monsen 2003, Rönnerman et al. 2008). These innovations challenge the essentialist epistemology of traditional teaching and have widespread implications for future models of teacher education and collaboration between schools, policymakers and universities. CrossNet Ireland, an EU funded Comenius project, explored innovative pedagogical practices through boundary crossing in one school-university partnership involving teachers from three schools. The theoretical framework in this boundary crossing project draws from activity theory (Engeström et al. 1995), social learning theory (Wenger 1998, 2001) and Noddings’s (1992, 2003) theory of care. This combination provided an analytical lens for the study with educative, caring and contextually responsive strands. The research used a range of qualitative data collection methods including transcripts of curriculum workshops, field-notes and observations. Emerging findings show that pedagogical innovation happens when school and universities interact within a social network where power differentials are negotiated and professional trust and ownership are developed. Our findings assert that system wide reform through this type of distributed community, a term coined by Wenger et al. (2001: 122), plays a creative and critical role in assisting sustainable innovative pedagogical practices and teacher professional learning into the future.

1. Introduction

Twenty years ago innovation in science education simply meant (introducing) experimental practical work. In this project there is an ICT strand and a professional collaboration strand. They are both about communication. We are now seeing these as very central to science and very central to the way we construct knowledge about science – we do not see a simple correlation anymore between constructivism and discovery learning, we do not see that pupils will discover the principles of science if they just do the experiments, we now see that consultation, collaboration,
communication are central to the construction of meaning (National Policymaker, Curriculum Workshop, June 2008).

International findings indicate declining student achievement in the sciences and the need to develop teachers as professionals with new tools and capacities for pedagogical innovation (Programme for International Student Assessment PISA 2009). The momentum for such changes comes from the rapidly changing global economic landscape and the needs in an innovation age for flexible workers with a creative capacity to explore and learn within an array of social networks. The problem, evident across a number of OECD countries, places science teaching and learning at the epicentre of the educational policy process. Policymakers respond to the challenge in a number of different ways. Reforms include changes to what science is being taught and how it is to be taught (Aikenhead 1996, Atkin and Black 2003). School subject knowledge is extended beyond pure science to applied science, technology and society. Pedagogical practices espouse learner-centred activity-based approaches with an emphasis on developing higher order thinking capacities.

The literature points toward new ways of working within most professions, including teaching (Darling Hammond and Bransford 2005). Competing discourses suggest that teachers either need to be externally managed, through managerial professionalism or they need to take responsibility and engage in eliciting their own professional learning, democratic professionalism (Day and Sachs 2004: 6-7). Within managerial professionalism the needs of the system and external state regulation are paramount with control, compliance and market driven political ends as the main drivers of change. By contrast democratic professionalism is professionally regulated and is collegial and imbued with activism. These two competing discourses are not mutually exclusive and in practice different variations exist side by side.

Democratic professionalism underpins the conception of a school-university partnership as it recognises the need to build alliances that go beyond state and professional control of teaching:

The core of democratic professionalism is an emphasis on collaborative, cooperative action between teachers and other educational stakeholders. It
suggests that the teacher has a wider responsibility than the single classroom and includes contributing to the school, the system, other students, the wider community and collective responsibilities of teachers themselves as a group and the broader profession (Day and Sachs, 2004: 7).

CrossNet Ireland, the subject of this chapter, is an example of boundary crossing in one school-university partnership dedicated to the research and development of innovation in science teacher pedagogical and professional practices. Such innovations involve a complex web of human interaction and activity, argued by Somekh (2007: 49) that go beyond existing traditional boundaries:

Innovation does not simply happen as a result of new policies; it involves people at all levels of human activity in experimentation, boundary crossing, collaborative negotiation and strategic opportunism ... the model is one of praxis – the integration of action with knowledge generation in a cyclical process of experimentation, evaluation and refinement of new practices.

The chapter begins with a preliminary exploration of the background cultural context of science in the lower secondary curriculum in the Republic of Ireland. This is followed by considering our chosen theoretical framework for the study drawn from the international literature on activity theory, boundary crossing and social learning theory. The research methodology is then explored and findings from a number of different sources are analysed. In the final discussion some insights emerge and a number of recommendations are made for the future development of sustainable innovation in the professional learning and pedagogical practices of science teachers.

2. Background and cultural context

CrossNet, set within the Republic of Ireland, has a cultural context that is challenged with regard to science teaching and teacher professional learning. In response to students’ declining interest in science subjects a national report, the Report and Recommendations of the Task Force on the Physical Sciences (2002), led to the revision of the science syllabus in compulsory education and the introduction of a new approach to final assessment. This revision was accompanied by a number of supports including grant assistance for the renewal of school laboratories and guided peer-peer professional support for teachers during the early years, approximately three years, of
implementation. We now consider these reforms under two separate headings: changes to the science syllabus and the changing role of the teacher.

2.1 Changes in the Science Syllabus

The junior cycle is the term given to the lower secondary education system for pupils aged between approximately twelve and fifteen years old. It is a three year programme culminating in an externally marked state examination. The science syllabus is organised according to discipline: biology, physics and chemistry. In 2003 there was a phased introduction of a revised syllabus (Circular Letter 2003). This revision was “activity based in its design and emphasises practical experience of science for each individual student” (Junior Certificate Science Syllabus 2003). This 2003 – 2006 reform saw the assessment change from a 100% written final examination. All pupils were now required to sit a final written examination, worth 65% of the final marks (Coursework C), with 35% of the marks allocated toward a more hands-on experimental approach (Coursework A and B, 2003: 32).

Coursework A, comprised thirty mandatory activities, ten within each domain of physics, chemistry and biology (National Council for Curriculum and Assessment 2007: 62-63). The percentage of marks allotted to this section is 10% for completion of the activities. Coursework B involves investigations. According to the NCCA Guidelines for Teachers, Coursework B serves a dual function, allowing for assessment of learning and revision of knowledge and understanding (National Council for Curriculum and Assessment 2007: 64). Within coursework B, there are two options available. In the first option, pupils conduct two investigations from a prescribed list of three options. In the second option, pupil research an area of science that is of personal interest, in this case only one investigation is necessary. This is worth 25% of the marks and is assessed through a written proforma which is forwarded to external examiners for correction.

2.2 The Changing Role of the Teacher

From 2006 teachers became members of a statutory self-regulating body, the Teaching Council. Standards and codes of professional conduct for the teaching profession were published by the Teaching Council (2007). The teacher as professional was presented as
a reflective person, a facilitator of learning, a co-operator with colleagues and collaborator with a range of relevant external partners, including parents, support services, inspectorate, universities and higher education institutions:

The teacher as skilled practitioner in the science and art of teaching ... as curriculum maker, researcher, evaluator, and reflective practitioner.

(Report of the Steering Committee on the Establishment of a Teaching Council, 2008: 6)

However, despite the rhetoric of teacher professionalism there is compelling evidence that transmission models of teaching remain the dominant discourse in Irish schools and classrooms, Hogan et al. (2007) and Mooney Simmie (2007). The OECD Teaching and Learning International Study (TALIS), by Shiel et al. (2009), showed little evidence of higher-order co-operation among teachers in the Republic of Ireland. For example there was little evidence of peer observation, peer-peer mentoring and dialogue with regard to pedagogical practices. Assessment of the student teacher during their practicum experience continues to remain the full responsibility of higher education institutes:

The course must include practice in teaching in a recognised second level school. For the purposes of fulfilling this requirement, an applicant must obtain a minimum of 100 hours of personal experience of directly teaching a class, or classes, in one or more approved subjects. The practice in teaching must also have been mentored and supervised by the university or college concerned

(Teaching Council (Registration) Regulations, 2009: 18)

In summary then science teaching, in the lower secondary system in the Republic of Ireland, is wrestling with a number of different challenges during the lifetime of CrossNet Ireland. These challenges include the introduction of activity-based science teaching, a newer type of assessment system and extended roles for science teachers. In addition, analysis of examination papers for Coursework B and C show that cookbook style experiments and rote learning continue to play a significant role in the assessment requirements for the junior cycle science examination.

3. An emerging framework for the study

CrossNet Ireland conceptualised innovation as boundary crossing within a school-university partnership. Boundary crossing as a process of collaborative learning for this project was drawn mostly from activity theory (Engeström et al. 1995), social
learning theory (Wenger 1998, Wenger et al. 2001) and Noddings’s (1992, 2003) theory of care. It conceptualised the school-university partnership as a tool for innovation with the capacity to generate a level of constructive dissonance required to engage teachers in a reconceptualisation of teaching and learning. This challenges traditional views of novice-expert knowledge and learning within vertical top-down reform agendas with their well-defined tasks and competences.

Engeström et al.’s (1995) activity theory regards school-university partnership as a complex web of intersecting communities of practice with cultural dissonance and power differentials. Learning becomes conceptualised as collaborative interaction with shared rules, divisions of labour and mediating artefacts. Key elements of this model are subjects (teachers, teacher educators, researchers and policymakers), boundary objects and tools (agreed documents, videos, etc. whose main purpose is to stimulate the interaction and level the power differential between the various actors), agreed rules of engagement (key questions and agreed protocols) and different communities (school and university).

Activity theory broadens the concept of knowledge using horizontal axes as well as vertical axes for different forms of knowledge, for example, e.g. academic knowledge, professional knowledge and professional practice knowledge. Cochran Smith and Lytle (1999) understand teacher professional knowledge as knowledge for practice, knowledge in practice and knowledge of practice. While the former may be construed as vertical knowledge, the latter forms of knowledge are examples of horizontal knowledge. School-university partnership is set within different contexts, poly-contextuality, and forms a complex social network of insiders and outsiders with a common purpose sharing arenas of overlap as well as arenas of dissonance:

Boundary crossing entails stepping into unfamiliar domains. It is essentially a creative endeavour which requires new conceptual resources. In this sense, boundary crossing involves collective concept formation…and learning that attempts to combine theory and practice

(Engeström et al. 1995: 333)

Within activity theory we discern three strands that develop an emerging framework for the project. These three strands include: the educative strand, the relational strand and the contextually responsive strand. We will now consider these in turn.
3.1 The educative strand

It is the educative strand of a school-university partnership that provides the intellectual milieu to lead innovation in teaching, learning and professional practice. It is here that research, theory and professional practice achieve confluence. Mezirow and Associates (1990) argue for the role of a critical friend, an *empathic provocateur*, in the learning process. In this project as the two university personnel involved in the project we aspired to play the role of *empathic provocateur* to the school communities. A critical friend role by the university can listen and offer timely questions and alternatives to teachers and the school community and assist them as they seek to push beyond their boundaries of professional practice and learning. Friere (1970) argues for the development of knowledge through acquisition models. He speaks of the need for the student-teacher contradiction in the learning process. This contradiction is exemplified by the juxtaposition of roles with at times the teacher as student and the student at teacher. This student-teacher contradiction is equally faced by the teacher-teacher educator in the process of an educative learning relationship within a school-university partnership. The teacher educator is called upon to model the theories of teaching and learning that they espouse. The educative strand is therefore equally challenging to both social groups in such as partnership.

3.2 The relational strand

A school-university partnership involves relationships of care. We were influenced in this aspect of the project by the theory of professional development posited by Day and Sachs (2004) and the theory of care espoused by Noddings’s (1992, 2003). Day and Sachs (2004: 16) distilled the features for a fully functioning school-university partnership and found relational aspects dominated: *collaborative discourse, negotiated expectations, sharing of expertise, development of trust, respect for difference and generation of new knowledge*. The development of each of these relational aspects requires a high level of care, trust and respect. Noddings’s (1992: 23) goes further and argues that dialogue, the hallmark of a caring relationship such as found in teaching, is based more on an open-ended exchange more than an outcome-based approach:

Dialogue is open-ended; that is, in a genuine dialogue, neither party knows at the outset what the outcome or decision will be…Dialogue is a common search for understanding, empathy, or appreciation. It can be playful or
serious, logical or imaginative, goal or process oriented, but it is always a
genuine quest for something undetermined at the beginning.

3.3 The contextually responsive strand

The third strand that we discern under the broad umbrella of activity theory is the con-
textual strand of social and cultural responsiveness. Wenger (1998) views learning as
taking place within social constructivist models that lead to the development of change in
perspective and practice and the interdependence of learners. He is particularly interested
in defining the complex role of the broker in the crossing of boundaries:

Brokering involves processes of translation, coordination, and alignment
between perspectives. It requires enough legitimacy to influence the
development of a practice, mobilise attention, and address conflicting interests.
It also requires the ability to link practices by facilitating transactions between
them, and to cause learning by introducing into a practice elements of another.

(Wenger, 1998: 109)

The school-university partnership in CrossNet Ireland became an action with the
potential to support innovation among the participating three case study schools. The
challenge for each social grouping was to move toward newer types of meaning-making:

Multiple contexts demand and afford different, complementary but also
conflicting cognitive tools, rules and patterns of social integration. The
criteria of expert knowledge and skill are different in the various contexts.
Experts face the challenge of negotiating and combining ingredients from
different contexts to achieve hybrid solutions. The vertical master-novice
relationship, and with it, in some cases, the professional monopoly on
expertise, is problematised as demands for dialogical problem solving
increase

(Engeström et al. 1995: 333)

All actors in the partnership face the challenge of learning and leaving aside their
authoritative stance, their specialist scholarship and decision-making powers. One
successful example of this approach is given by Lang et al. (2007) where a
Curriculum Workshop (CW), in the European EUDIST project, was used to negotiate
raising teachers’ voices while holding the voice of the expert in abeyance. The CW
offered a public space for questioning existing standards and practices and generating
possibilities for sustainable innovative pedagogical practices with science teachers.

CrossNet Ireland used the concept of the Curriculum Workshop as the public
space to open the debate on pedagogical innovation with teachers and policymakers.
These public spaces were offered three times during the project. The rules of engagement were negotiated and developments were shared and examined. Interchange between teachers and teacher educators, across a European dimension, was further supported by two CrossNet teacher exchange networks, in Speyer, 2008 (Mooney Simmie and Power 2008) and Vienna, 2009 (Power and Mooney Simmie 2009). At each of these teacher exchange networks teachers were proactively encouraged to transcend disciplinary knowledge to work within a broader social context:

Collaboration in educational reform assumes an atmosphere of professional autonomy realised through discourse, decentralisation, and professional self-improvement in communities of practice. This implies a participatory process in a common information space that is different from the traditional view in a bureaucratic or expert hierarchy. It has to be discussed and justified in a social context ... with shared meaning, values and rules (Lang et al. 2007: 8).

Using this theoretical rubric, the school-university partnership was conceptualised as a complex interlocking activity system with a number of communities of practice, where cultural dissonance and power differentials were continuously negotiated and mediated through agreed key questions and a range of boundary objects, including agreed documents, rules for engagement and protocols. The emerging framework based largely on the work of Engeström et al. (1995), Nodding’s (1992, 2003), Wenger (1998), and Wenger et al. (2001) with its educative, caring and contextually responsive strands became the lens for the analysis of findings. Throughout the three years of CrossNet Ireland these communities engaged in a mutual creative, collaborative and critical discourse to improve pedagogical innovation and teacher professional learning.

4. Research Methodology

CrossNet Ireland was viewed as a single exploratory case study design and research strategy according to the arguments of Yin (2003). Case study research has great strengths in seeking to understand complex social phenomena. The complex social phenomenon under study in this project was the use of a school-university research and development project to assist pedagogical innovation and teacher professional learning. The project was set within an interpretative paradigm with a variety of qualitative data collection methods employed over the lifetime of the project. These
included a variety of different sources. There was video footage from the first two curriculum workshops and field note evidence from the third curriculum workshop (CWs). The field note evidence was the final agreed note, negotiated with all participants, as the agreed outcomes from the meeting. Other instruments included the documents written as preparation, again negotiated with all participants, in advance of these workshops. As the two university personnel involved in the project, University A and University B, we also developed a number of field notes which we added to the data trail. This included notes we made in the early stages of the project with regard to our reactions to schools becoming involved. It included our ongoing dialogue with regard to where we positioned ourselves reflexively and reflectively. Positioning ourselves reflexively allowed us the opportunity to share what in each of our life scripts had lead to us both becoming involved in this type of research and development project. Positioning ourselves reflectively involved an ongoing dialogue with regard to our values and the arenas of overlap and difference, in our opinion, between schools and the university sector. We concluded the project by recording a final dialogue which charted the evidence we observed for successful outcomes and learning from the project.

The theoretical framework for the study became the basis for the analysis and critical interpretation of the outcomes and pointed to areas for future research and development. Data analysis involved a series of iterations between each of the data sources to seek themes, explore rival explanations and leave space for new knowledge to emerge. Assessment of the trustworthiness of the approach taken was based on the validity criteria for practitioner research argued by Zeichner and Noffke (2001) as cited in Hansen (2008). This suggested the use of three validity tests to ensure the robustness of the findings and emerging insights: democratic validity, process validity and outcome validity.

Democratic validity was concerned with the equity of participation and common ownership of the outcomes by the teachers, teacher educator and researcher. The claim that CrossNet Ireland was trustworthy in terms of democratic validity stems from the continually negotiated processes engaged in with regard to ownership of the project and the mutually agreed key questions driving the curriculum workshops. Hansen (2008: 496) states that the successful search for a compromise indicates the democratic validity of this stage. Process validity concerned itself with the extent to
which the espoused *curriculum workshop* approach and the enacted *curriculum workshop* followed its own stated standards. A range of efforts were made to ensure that the standards were followed. Key questions for each workshop were agreed beforehand, there was a document trail produced at each workshop with evidence of pre-planning. Outcomes were circulated after each workshop to check for agreed validity. The national coordinator assumed the role of the moderator of the *curriculum workshop*, instead of an external moderator, explaining this on the basis of her capacity and experience to ‘broker’ the worlds of the school and university. However the use of an external moderator might have been a more appropriate choice and could have led to a strengthening of *process validity*. *Outcome validity* focused on practical improvements resulting from the ongoing activities of this school-university partnership. The teachers themselves argued that the project had contributed to improved collaborative work, pedagogical dialogue and pupil motivation.

5. Findings from CrossNet Ireland

Findings from *CrossNet* Ireland come from a number of sources: initial visits to schools, the three curriculum workshops and our observations and reflections. It is to these findings that we now turn.

5.1 Findings from initial visits to schools

Cultural dissonance between the world of the school and university was most evident in the early start-up phase of the project. Part of this early phase involved visiting schools, talking with teachers and explaining what the project involved. The clash of cultures was more acute in schools that remained unconvinced of the value of the project based on innovation and collaboration. Science teachers had busy and stressful lives in school and some were dismayed at the suggestion of becoming involved in a project that might increase their existing workload:

> the impression was given that this project would lead to more work and so was greeted with negativity straight away from all concerned…I felt that the teachers thought perhaps that we were questioning their ability to teach by asking them to take part in the project

(*University A* respondent, 17th September 2007)
One school that had initially agreed to become involved in the project found that, after six weeks, they were unable to sustain interest. These teachers agreed to engage with the authors in a collective debriefing session for an hour. They appeared weary and wary of change and were stressed from the technical workload involved in keeping laboratories fully functioning for all their junior cycle student experiments:

Look around you, see all that equipment, we are supposed to get all that ready and tidied away before the next class. Do you know how long that takes?

(Teacher respondent, 28th February 2008)

As the project progressed with the teachers that had self-selected the theme of teacher busyness and exertion remained and raised questions for us about the conceptualisation of the role and functions of the teacher. Is the teacher perceived more as a technician in the current system of schooling rather than as a public intellectual and professional?

5.2 Findings from the curriculum workshops

At the first Curriculum Workshop the teachers, teacher educators and researchers assembled with the intention of sharing the aims of the European projects and to listen to early feedback from a number of policymakers and key stakeholders. Cross-net Ireland was focusing on the school-university partnership while the school-based part of this project was part of another Comenius 2.1 teacher education and training project: Gender, Innovation and Mentoring in Science and Mathematics Education (GIMMS). The Curriculum Workshop offered an opportunity for early dissemination and feedback:

(We are) looking for feedback, we are in very much a listening mode…Is there something we need to be paying more attention to, is there something you’d like to see coming out of the project and is there some help you can give us as we (progress the project).

(University B respondent, 14th January 2008)

The authors felt that ownership of the project by the teachers themselves was a critical factor for the success of the project:

Gaining ownership of a reform is very important and has been given centre-stage in the OECD report Teachers Matter. It suggests that teachers must grapple with the topic they want to work on themselves and if it is handed
down as a top-down reform it has not much chance of becoming the innovative process it can become.

(University B respondent, 14th January 2008)

The science teachers present from each of the schools, we assigned the pseudonyms Maple, Alder and Chestnut. Science teachers at Maple, pondered about why they became involved and arrived at a number of carefully considered benefits and constraints (Table 1). They identified their teaching styles as largely transmission approaches. While they fear change they were willing to move beyond their comfort zones. Their new laboratories appeared to give them an impetus to begin to work together, and with the university, to improve science teaching. They decided, in consultation with the university, to develop micro-scale eco-friendly pupil experiments and progress this concept beyond junior cycle into senior cycle. The preoccupation with ‘right answers’ and ‘acceptable answers’ for the state examinations remained an underlying concern:

It comes back to the examination questions...we have to remember to constantly tell the students the difference between these diagrams, their experiments. Maybe UL (university) and the Exams Commission (State Examinations Commission) can work on this.

(Teacher Maple, 14th January 2008)

Science teachers at Alder, decided to work with first year pupils on understanding and analysing graphing skills and learning introductory principles of mechanics. They decided to use the project to collaboratively develop their ICT skills to make better use of their data logging equipment:

We plan to develop an innovative approach to teaching graphs to junior cycle science ... to use data logging and ICT as a pedagogical tool to improve the teaching and learning of graphing skills and to develop a series of lessons to teach introductory mechanics (distance, time, velocity, acceleration) using discovery learning and activity learning for the pupils

(Teacher Alder, 14th January 2008).

Science teachers at Chestnut, decided that they would use extensive ICT with one half of their first year class grouping and more traditional approaches with the other half. They did this with 138 students, divided into six class groupings and involving five of their science teachers. They decided to teach the topics, forces in physics and acids,
bases and pH in chemistry and then assess the learning through standard testing and marking. The rationale for the project was explained thus:

The ICT method of presenting material has to embrace more traditional methods as well because that’s how we relate to the pupils, by questioning, by talking and by explaining but predominantly the difference in the delivery will be in the fairly significant PowerPoint input to the ICT, including tests, handouts and worksheets, that are word-processed, we’re also using data-loggers for two investigations. (we note) the extent to which we are leaving a comfort zone, the level of ICT-literacy would vary quite a bit among the five of us.

(Teacher Chestnut, 14th January 2008)

Table 1: Benefits and constraints of a school-university partnership identified by science teachers at Maple

<table>
<thead>
<tr>
<th>Constraints</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Already busy</td>
<td>Excellent management support</td>
</tr>
<tr>
<td>Traditional approaches currently used</td>
<td>New Facilities (four new laboratories, a preparation room and a small meeting room for science teachers)</td>
</tr>
<tr>
<td>Comfort zone in this regard</td>
<td>A part-time Laboratory Technician</td>
</tr>
<tr>
<td>Currently using an exam focused and questioning style of teaching science</td>
<td>We have already experienced doing some work together</td>
</tr>
<tr>
<td>Fear change, pupils fear change, parents fear change</td>
<td>Overall the staff attitude is to be open to new thinking</td>
</tr>
<tr>
<td>This new approach requires staff co-operation of a higher order</td>
<td>Let’s get out of our comfort zone</td>
</tr>
<tr>
<td>Where does this programme fit into whole school evaluation, inspection, subject planning?</td>
<td>Change can be good</td>
</tr>
<tr>
<td></td>
<td>This will help us think about our teaching</td>
</tr>
<tr>
<td></td>
<td>Why should we stop at junior cycle, let’s take this thinking through to our senior cycle classes also</td>
</tr>
</tbody>
</table>

All science teachers in the project brought the dilemma between being pedagogically innovative and preparing pupils for a public state examination to our attention. Three different national policymakers at the workshop, which we labelled X, Y and Z, to protect their identity, offered to assist with dissemination and made a number of suggestions:
A useful outcome of the project will be the increased collaboration and interaction of the teachers as they engage in a dialogue of teaching, learning and assessment.

(Policymaker X, 14th January 2008)

The work you are now doing has allowed you to engage in differentiated teaching this will be a very helpful result for the project

(Policymaker Y, 14th January 2008)

All of this has to be assessed. It might be interesting to make the questions that bit more interpretive so that pupils can get involved in more critical questions. That could be a role for the project as this is where our pupils appear to be falling down.

(Policymaker Z, 14th January 2008)

In these first early months of the project there was a considerable need for sustained support and challenge to scaffold teachers’ thinking and willingness to engage with imagined practices that they had not tried before. The project offered considerable challenge to teachers in a system that was very traditional and offered few incentives to experiment explore and take risks in teaching, learning and assessment.

The second Curriculum Workshop was held in June 2008, among a number of transnational partners (TP), local (LP) and national policymakers (NP). It focused on the emerging need for school-university partnership to scaffold the continuing professional learning and innovation of the teaching force. Table 2 gives a summary of some of the key observations made during this workshop. The respondents are identified by the codes above, TP, LP and NP.

The third and final Curriculum Workshop held on 26th September 2009, among teachers, student teachers and local and national policymakers, focused on the emerging need for school-university partnership to scaffold teacher pedagogical innovations and teacher professional learning. Key questions were negotiated in advance. The discourse considered the key contextual factors required in the Republic of Ireland to facilitate this type of school-university collaboration. The following factors were collaboratively agreed as the most significant:
- The school-university partnership to be successful needs to work in egalitarian and democratic ways focused on learning and change for all.
- It is imperative that an atmosphere of professional trust is generated within the partnership so that problems could be aired in productive ways.
- A designated public space is needed for this type of dialogue.
- The partnership needs to be sufficiently open to acknowledge problems. There was agreement that this might pose a cultural difficulty in Ireland.

While the final state examination had changed to a 65% written examination, with 25% being acknowledged for evidence of experimental work, the key focus of teachers in this project continued to remain on preparing pupils for the test rather than developing more innovative approaches to teach for understanding and higher levels of analysis.

Table 2: Using school-university partnership as a tool for innovation.

<table>
<thead>
<tr>
<th>School-University Partnership</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationale</td>
<td>Twenty years ago innovation in science education simply meant (introducing) experimental practical work...(in this project) there is an ICT strand and a professional collaboration strand. They are both about communication. We are now seeing that as very central to science and very central to the way we construct knowledge about science – we do not see a simple correlation anymore between constructivism and discovery learning, we do not see that pupils will discover the principles of science if they just do the experiments, we now see that consultation, collaboration, communication as central to the construction of meaning (NP)</td>
</tr>
<tr>
<td>Benefits</td>
<td>There is a need for a change in teacher education and pre-service teacher education. (They) should come closer together in settings where learning from each other is more possible (TP)</td>
</tr>
<tr>
<td>Constraints</td>
<td>In my country there are constraints (to this type of innovation), constraints in terms of PISA, standards, competencies, narrowing down the liberal education (agenda) into a more constrained education (TP)</td>
</tr>
</tbody>
</table>

At the third curriculum workshop the question of school-based assessment and the value of considering an alternative approach to examining the Junior Certificate were debated. The consensus of opinion was that it was timely to re-open this as a policy
debate and to again ask the following rhetorical question of our policymakers: *Is it really necessary to have all pupils in all schools sitting externally marked examinations in all subjects at the end of lower secondary education?* Finally some suggestions were proposed during the workshop to extend and sustain this network of innovative teachers, including connecting teachers to the *National Centre for Excellence in Science and Mathematics Teaching and Learning* at the University of Limerick.

### 5.3 Findings from observations and reflections

The authors reflected on what, in their opinion, had gone well and what could have been improved in this research and development study. There was evidence that teachers had worked well together and with the university and policymakers to develop better collaborative structures at the school site. Further information on the specific outputs from the school based side of the project may be accessed through the web-site [www.gimms.eu/](http://www.gimms.eu/). We contend that the development of professional trust and having teachers take ownership of the project were key aspects that had been reason-ably successful. However, we underestimated the workload of the project and the time and continuing effort it would take to bring teachers together to develop collaboratively (Mooney Simmie and Moles, 2012). Greater clarity and better use of a variety of forms of communication were required:

> We were very tentative in the way we initially approached schools, we went in knowing that it had to be a level playing field for it to work, this approach worked well for two out of three schools, we planned with them, we took their viewpoints into account, we were respecting that the teachers were also curriculum makers, they were bringing their intelligence to the table, sharing was done informally, all of this lead to the development of trust, we listened but we asked a lot of questions and challenged them also, we did play the role of the *empathic provocateur*

*(University B, 28th February 2010)*

> The third school just did what we asked of them and no more … they did not stay with us … they were not able to continue giving us time, they were burdened with examinations and did not get enthused enough to stay with us for the longer journey. We were partly to blame for the way we described the project in the first instance … we were saying weeks when we meant many months

*(University A, 28th February 2010).*

A number of unexpected outcomes emerged from our observations. At the start of the project, only one of the three schools had a part-time laboratory technician. By the end
of the project this had increased to two schools with the third school advocating for change from their Board of Management. The science teachers informed us that this happened directly as a result of giving them an opportunity to see into each other’s ways of working. This coincided with our own espoused professional values. We felt that teachers’ needed to spend more time thinking and planning together, rather than doing routine tasks of setting up experiments for their pupils, if they were to progress and sustain innovative pedagogical practices.

After the project concluded some science teachers progressed to academic accreditation programmes at the University. It was considered that the expenditure of time and energy for this type of development would have resource implications for scaling up the project to national level:

we gave them a lot of time, we couldn’t change this, time and a lot of time and energy is needed to develop this type of innovation. It also took place at the school setting. This is both a strength and a resource limitation for the project

(University A, 28th February 2010)

6. Discussion and future directions

Innovation in CrossNet Ireland was concerned with engaging teachers in an extended network through boundary crossing between school and university within a distributed community of practice (Engeström et al. 1995, Hansen 2008, Lang et al. 2007). We now return to the key questions driving this research and development project: Does a school-university partnership in the Republic of Ireland have the capacity to generate the constructive dissonance required for the development of innovative pedagogical practices and professional learning? What evidence is there to suggest it does? What limitations were found? What implications have these findings for the future policy process? Analysis of the findings, from this small scale exploratory case study, reveals a number of insights from which some recommendations emerge:

- In CrossNet Ireland a culture of professional learning, among the science teachers, was successfully implemented in the schools. As the project developed teachers began to engage in more regular formal and collaborative study circles with each other and with the university. The dialogue was totally
focused on pedagogy. The project not only provided the ‘formal time’ and ‘public spaces’ for this type of work it also provided the cultural dissonance, through boundary crossing, required to extend teachers beyond their comfort zones. The findings are in agreement with Engeström et al.’s 1995 activity theory and its’ capacity to regard teaching as a continual learning and relearning process. A sustained model of school-university partnership would acknowledge the complex non-linear nature of teacher professional learning and the need to continually integrate theoretical with professional practical knowledge (Cochran Smith and Lytle, 1999 and Somekh, 2007).

- In CrossNet Ireland pedagogical innovations were successfully implemented by science teachers. Teachers needed the support of the university to move across boundaries from traditional inherited practices to more ICT-enhanced and activity-based learner-centred pedagogical approaches in their teaching. Over the lifetime of the project the science teachers developed the confidence and capacity to share in a pedagogical dialogue with colleagues, teacher educators and policymakers. This is the type of higher order co-operation found to be generally lacking in Ireland in the OECD TALIS report, published by Shiel et al (2009). In CrossNet Ireland teachers argued that to uplift their dialogue toward pedagogical matters required an external stimulus. Teachers do not feel that they can do this on their own within the cultural constraints of their school environments. The university can bring research findings to the school and play the role of critical friend empathic provocateur, argued by Mezirow and Associates (1990), to generate the necessary cognitive dissonance and educative relationship that might otherwise be more difficult in a teacher-only setting.

- Over the lifetime of this project teacher educators in this school-university partnership gained a deeper understanding of the ‘dilemmas’ that experienced science teachers continually manage in their everyday practice. Teaching is a complex activity and teachers’ extended role is always caught in that in-between ground of trying to balance a number of paradoxes: whole class needs versus individual need, scholarship needs with the needs of school managers, parents and the wider society. Science teacher’s professional lives in these schools were busy, stressful and demanding. There was little energy left for co-
planning or critical co-inquiry. The focus on ‘teaching for the test’ was in relentless opposition to the development of more innovative and imaginative teaching and learning approaches. The need for a reflective inquiry-oriented co-professional approach to teaching was acutely experienced in this school-university partnership. This has recently been identified as the hallmarks of the teacher as a professional and lifelong learner, Teaching Council Draft Policy on the Continuum of Teacher Education (2010). CrossNet Ireland raises the rhetorical question for policymakers, about the need for all pupils in all subject areas, to be required to sit an external examination at the end of lower secondary education. This national debate has already started with a revision document presented by the National Council for Curriculum and Assessment, www.ncca.ie/juniorcycle

- A limitation of the project was that one school in the project appeared less interested after an enthusiastic initial involvement. While at school level some cultural constraints may have operated, there was some early miscommunication by the university team. This appears to account for the difference. Clarity with regard to goals and outcomes needed to be communicated, especially at an early stage in the partnership. This evidence is consistent with Wenger’s (1998) argument in favour of social and cultural responsiveness.

*CrossNet Ireland’s* strengths were found to lie in its capacity to generate teacher collaborative pedagogical discourse. The project challenged the more traditional essentialist conception of science teaching and vertical conceptions of knowledge. It offered a much improved teacher voice. Findings show that changing pedagogical practices of experienced science teachers involves deep cultural challenge. It requires extended social networks, such as school-university partnerships, that have the boundary crossing capacity to support sustainable and critical change of this magnitude.

While many different types of reform measures are advocated none on their own appear sufficient to provide the complex interconnecting mesh required for sustainable innovation networks. Fullan’s (2010) new focus on system wide reform advocates that all agents and agencies work together to nurture and support change.
Findings and insights from CrossNet Ireland suggest that for pedagogical innovation to be sustained study circles of teachers working alongside teacher educators and policymakers are required. Teachers’ in the project expressed their fear of change and, in keeping with Nodding’s (2003, 1992) care theory, they required trust to be developed before they are willing to engage with this type of boundary crossing. The development of professional trust and ownership, especially in the early stages of this school-university partnership, was found to be a significant factor in the overall success of this research and development project. Teachers when developing pedagogical innovation require the broader networks that school-university partnerships can provide if the inherited practices of teaching to the test are going to change to learner-centred approaches:

The prevalent rationalistic conception of curriculum planning is giving way to a view of curriculum planning as ongoing, multivoiced discourse and experimentation in a network that brings together actors representing various interests, types of expertise, and cultural backgrounds

(Miettinen 1999: 342)

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