

Giving Teachers A Voice Within The Teacher Effectiveness Paradigm

**A Mixed Methods Study Focusing on Teachers'
Perceptions of the Impact of Their Classroom
Practices on Student Outcomes in Mathematics**

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Abstract

The purpose of this research is to add to the teacher effectiveness research paradigm by furthering understanding about how teachers promote student learning and achievement in mathematics. Across the teacher effectiveness paradigm, there has been a great deal of research that quantitatively measures the value added by teachers to student achievement on standardised tests. However, there is a current under-representation of the voices of teachers about how and why certain factors promote student achievement in mathematics. Therefore, in order to address the complexity of the teaching and learning process, this mixed methods study draws upon secondary TIMSS 2011 data, as well as qualitative interview data from fourth class teachers in Ireland and Northern Ireland. Results from this study highlight qualitative teacher insights as an essential tool for understanding the complex process through which teacher-related factors influence student learning and achievement in mathematics. Several factors which were perceived to promote student achievement on fourth class standardised mathematics tests were revealed. These factors include promoting constant revision of mathematics concepts, engaging in a collaborative staff strategic plan for assessing and addressing student underachievement on standardised tests, communicating a strong positive attitude towards mathematics to students, and holding consecutive years of experience at the same grade level. In addition, teacher insights were instrumental for understanding TIMSS score differences between Ireland and Northern Ireland. These findings suggest that researchers within the teacher effectiveness paradigm, as well as educational policymakers, should recognise teachers as experts regarding the teaching and learning process and include their insights in future studies through use of qualitative methodology. Furthermore, quantitative teacher effectiveness studies should consider including qualitative teacher insights in order to gain a deeper understanding of quantitative findings.

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Glossary of terms and abbreviations

BBC: British Broadcasting Corporation.

BERA: British Educational Research Association: <http://www.bera.ac.uk>.

CPD: Continuing Professional Development.

DENI: Department of Education Northern Ireland. DENI is part of the Northern Ireland Executive. <https://www.deni.gov.uk/>.

DEIS: Delivering Equality of Opportunity in Schools. Schools may be classified as disadvantaged by the Social Inclusion Section of the DES using the DEIS Banding categorisation. Band 1 schools have higher levels of educational disadvantage than Band 2 schools.

DES: Department of Education and Skills: <http://www.education.ie>.

Drumcondra Maths Test: The *Drumcondra Primary Mathematics Test-Revised* (DPMT-R) is a group-administered, standardised test of achievement in mathematics, designed for students in Irish primary schools. <http://www.erc.ie/?p=34>.

EAL: English as an Additional Language. <http://www.pdst.ie/EAL>.

ESRC: Economic and Social Research Council. <http://www.esrc.ac.uk/>.

HLM: Hierarchical Linear Modelling.

IEA: International Association for the Evaluation of Educational Achievement.

IEA's TIMSS & PIRLS International Study Centre conducts regular international comparative assessments of student achievement in mathematics and science (TIMSS) and in reading (PIRLS) in more than 60 countries. TIMSS (the Trends in International Mathematics and Science Study) and PIRLS (the Progress in International Reading Literacy Study) together comprise the core cycle of studies for IEA – the International Association for the Evaluation of Educational Achievement.

Learning Support Teacher: provides supplementary teaching for students with high incidence disabilities.

Mainstream class: a class in a regular primary or secondary school.

MICRA-T: Mary Immaculate College Reading Attainment Test – a standardised primary reading test.

NAEP: National Assessment of Educational Progress.

Northern Ireland: For the purposes of this thesis, Ireland and Northern Ireland will be referred to as countries. Unlike Ireland, which is a republic, Northern Ireland is part of the United Kingdom. Northern Ireland is variously described as a country, state, region or province. However, for the purposes of the TIMSS International Study and this thesis it is considered to be a country.

OECD: Organisation for Economic Co-operation and Development.

OLS: Ordinary Least Squares – a statistical method for estimating unknown parameters in linear regression models.

PD: Professional Development.

PiM: Progress in Maths. An assessment that monitors and identifies individuals' strengths and weaknesses in maths.

PIRLS: Progress in International Reading Literacy Study.

QSR International: Research software developer of NVivo 8.

Resource Teacher: In Ireland a resource teacher provides supplementary teaching for students with low-incidence special educational needs.

SAT: Scholastic Assessment Test: A standardised test widely used for college

admissions in the United States.

Sigma-T: The SIGMA-T series of mathematics attainment tests has been specially developed and standardised for use in Irish primary schools.

SPSS: Statistical Package for the Social Sciences – software for statistical analysis.

SSE: School Self Evaluation – process in Ireland whereby schools evaluate their own performance.

Supplementary teaching: extra teaching a student receives from another teacher, e.g. learning support or resource teacher.

TCI: Teaching Council of Ireland. <http://www.teachingcouncil.ie/>.

TDA: Training and Development Agency for Schools.

TIMSS: Trends in International Mathematics and Science Study.

Transfer Test: A test used in Northern Ireland to select students for admission to secondary school. <http://www.thetransfertest.com/>.

VAM: Value Added Modelling – statistical modelling which calculates a teacher's contribution to their students' test scores within a particular time period.

WSE: Whole School Evaluation – an inspection process carried out by the DES Inspectorate in Ireland.

Chapter 1. Introduction

The voices of teachers are missing across the teacher effectiveness evidence base. It has been acknowledged that meaningful teacher input is absent from the literature which informs government policies about effective teaching in mathematics (Skourdoumbis and Gale, 2013). Although teachers are experts regarding the process of teaching and learning (Foreman and Gubbins, 2015), there have been no studies which have included detailed, qualitative teacher insights regarding how teacher-related factors influence student learning and achievement in mathematics. Teacher opinions are therefore the focus of this research, as it is argued that in order to gain a deeper understanding of the hugely complex teaching and learning process, as well as a more balanced understanding of teacher effectiveness, it is necessary to start with an exploration of how teachers believe they can promote student learning and achievement in mathematics.

Across the literature, the term teacher effectiveness is equated to, and by default defined as, the level of success a teacher achieves in promoting student achievement gains, as measured by standardised tests (Goldhaber, 2002; Imig and Imig, 2006; Palardy and Rumberger, 2008; Stronge et al., 2011). However, it is important to acknowledge at the outset that calculating teacher effectiveness through use of a test result which is predominantly impacted by student and other factors outside of a teacher's control is problematic, and this is discussed in detail in Chapter 2. Nevertheless, for clarity, the above definition is considered the working definition of teacher effectiveness for the purposes of this thesis.

Student achievement, and therefore teacher effectiveness, have been found to be influenced by a variety of teacher-related factors which can be divided into three

subclasses, namely teacher qualifications, teacher classroom practices and teacher attitudes and beliefs (Palardy and Rumberger, 2008; Boonen et al., 2014). Teacher qualifications are defined as the credentials a teacher brings to the classroom such as degree level and years of experience (Goe and Stickler, 2008). Teacher classroom practices refer to the practices a teacher uses within the classroom during the teaching and learning process (Palardy and Rumberger, 2008). Teacher attitudes and beliefs refer to the attitudes and beliefs teachers hold in relation to mathematics and mathematics teaching. Many studies use statistical models to link teacher-related factors from these three subclasses to student achievement on standardised tests, in an effort to identify the teacher traits and practices that promote student achievement. However, although a great deal of quantitative research of this type has been carried out, the specific teacher-related factors that optimally promote student outcomes in mathematics remain unclear (Goe and Stickler, 2008).

Situated in the context of fourth class primary school mathematics in Ireland and Northern Ireland, the study aims to offer insight into the views of teachers, with the intention of furthering knowledge and offering explanations with respect to how teachers influence student learning and achievement in mathematics. The starting point of the research was that teachers are the most important asset within schools for promoting student achievement (Wright et al., 1997), and their views about how teachers promote student outcomes in mathematics are therefore of significant importance. However, teacher opinions are under-represented in the literature. Therefore, this mixed methods study focuses on teachers' narratives of teaching and learning in mathematics, in the context of fourth class. This qualitative stage is preceded by a quantitative comparison of teacher factors reported in TIMSS 2011 across the countries of Ireland and Northern Ireland. Teacher participants' opinions on notable quantitative findings were included in the investigation.

This chapter provides a backdrop for the thesis by discussing the importance of research into how teachers influence student learning and achievement in mathematics. The study is considered within the wider global debate regarding teacher effectiveness. The chapter then leads on to the research aims and the research questions which formed the focus of this research project. The research context is outlined before the philosophical assumptions and a brief overview of the methodology are explained.

1.1 Rationale

Global government education policies increasingly seek to improve student learning and achievement in mathematics by improving teacher effectiveness (Akiba et al., 2007). Central to promoting teacher effectiveness is understanding what teachers do within the classroom to improve student outcomes in mathematics (Morgan et al., 2015), as teacher classroom practices are the subclass of teacher effectiveness which has the most proximal impact on student learning and achievement (Palardy and Rumberger, 2008). However, much of the focus has been on the easily measurable teacher effectiveness subclass of teacher qualifications, and comparatively little evidence is available regarding what teachers do within the classroom to influence student outcomes (Hanushek, 2002). The evidence which does exist relating to teacher classroom practices is largely quantitative in nature and preoccupied with ranking teachers (Skourdoumbis, 2013) rather than answering meaningful questions regarding how and why specific teacher factors are important for student achievement in mathematics.

Therefore, the focus of this research was to gain both a qualitative and quantitative understanding of how teachers influence student learning and achievement in mathematics, paying special attention to the subclass of teacher classroom practices,

while at the same time including the subclasses of teacher qualifications and teacher attitudes and beliefs in order to achieve a comprehensive understanding of the teacher effectiveness phenomenon (Palardy and Rumberger, 2008). Secondary analysis of quantitative data from the fourth grade Trends in International Mathematics and Science Study (TIMSS) 2011 for the adjacent countries of Ireland (ranked 17th) and Northern Ireland (ranked 6th) was used as a springboard for a more in-depth qualitative phase of the study. This qualitative phase looked at how and why teachers influence student learning and achievement in mathematics, as very few teacher effectiveness studies include the insights of teachers regarding the teaching and learning process (Campbell et al., 2004; Skourdoumbis and Gale, 2013).

1.2 Research aims and questions

This thesis explored how teachers influence student learning and achievement in mathematics, and the study sought to:

- Compare the similarities and differences between teacher-related factors (teacher classroom practices, teacher qualifications, teacher attitudes and beliefs) with respect to fourth class mathematics teaching, in Ireland and Northern Ireland, as reported in TIMSS 2011, within the context of student learning and achievement on standardised tests
- Explore the perceptions of fourth class teachers, in Ireland and Northern Ireland, regarding how they believe teacher-related factors (teacher qualifications, teacher classroom practices, teacher attitudes and beliefs) influence student learning and achievement in mathematics
- Focus on teachers' understandings of how classroom practices influence student learning and achievement, in an effort to address the research gap that

exists regarding qualitative studies into teacher classroom practices across the teacher effectiveness paradigm

- Explore teacher perceptions of the meaning of teacher effectiveness, and their opinions regarding the factors that help and hinder teachers in promoting student achievement

The research encompassed a mixed methods study drawing on quantitative secondary data from the TIMSS 2011 study, as well as interviews conducted with eleven fourth class teachers across Ireland and Northern Ireland. The following research questions were addressed:

- 1) With respect to mathematics and as reported in TIMSS 2011, what similarities and/or differences exist between fourth class teachers in Ireland and Northern Ireland, with respect to their:
 - a) classroom practices
 - b) qualifications
 - c) attitudes and beliefs?
- 2) How do teachers in Ireland and Northern Ireland describe the role of a range of teacher-related variables from the following teacher effectiveness subclasses, in promoting student learning and achievement in mathematics?
 - a) classroom practices
 - b) qualifications
 - c) attitudes and beliefs
- 3) How do teachers in Ireland and Northern Ireland describe the factors that help and hinder teachers in promoting student achievement?

- 4) How do teachers in Ireland and Northern Ireland conceptualise the term ‘teacher effectiveness’?

1.3 Research context

This study focused on understanding the influence of fourth class teacher-related factors on student learning and achievement in mathematics in Ireland and Northern Ireland. In the TIMSS 2011, Northern Ireland (ranked 6th) was the top performing European country in fourth grade mathematics, while Ireland (ranked 17th) was positioned considerably lower. These results provided an interesting opportunity to conduct the current study into teacher effectiveness across two adjacent countries. A sequential mixed method design was chosen for the study, so as to facilitate a holistic exploration of the complex educational phenomenon of teacher effectiveness. During the quantitative phase, data from the TIMSS 2011 study relating to fourth class mathematics teaching in Ireland and Northern Ireland were drawn upon. Statistically significant findings emerged from data analysis and these were subsequently probed further during the qualitative phase of the study. The qualitative phase also explored teacher perceptions of how and why teacher-related factors influence student learning and achievement in mathematics. Participants for this phase of the study were eleven fourth class primary school teachers across Ireland and Northern Ireland who were selected using a purposive sampling strategy. A brief account of the global teacher effectiveness context is now given in order to situate this research within the wider debate.

1.4 Teacher effectiveness: the wider global context

Teacher effectiveness is a challenging concept within the literature and requires careful consideration. The current dominant definition of teacher effectiveness across the evidence base equates teacher effectiveness with a teacher’s ability to improve

student academic achievement on standardised tests in literacy and mathematics (Nye et al., 2004; Stronge et al., 2011). This emphasises external accountability for teachers (Sahlberg, 2007) and is reflective of an ‘audit society’ which views teachers as resources for achieving measurable outcomes, with little “trust invested in the moral competence of the practitioners to respond to the needs of those they serve.” (Groundwater-Smith and Sachs, 2002, p341).

Increased accountability for teachers and schools, as well as a focus on standardised testing in literacy and numeracy, are evident in global educational policy agendas (Sahlberg, 2007). This can be seen in Irish schools through the Whole School Evaluation (WSE) process and in Northern Irish schools through the School Inspection process, with inspectorates in both countries incorporating an evaluation of student scores on standardised tests in literacy and numeracy into their final published reports. The accountability agenda is also evident in the “unrelenting demand and focus internationally on learning outcomes” in assessments such as the TIMSS and the Programme for International Student Assessment (PISA), with such studies playing an increasingly significant role in evaluating educational performance and influencing educational policy reform in many countries (Sugrue, 2011, p798). For example, in Ireland, the national strategy *Literacy and Numeracy for Learning and Life* noted the disappointing and declining performance of Irish students on international tests in recent years as part of the rationale for implementing the strategy (Department of Education and Skills, 2011).

The composition of the teacher effectiveness literature base may be seen as further evidence of a pervasive global accountability agenda, as it is dominated by quantitative top down studies which feed into government policies (Imig and Imig, , 2006). These studies focus on evaluating teachers by calculating the value that they

add to student outcomes on standardised tests. However, there are moral and philosophical concerns regarding the implications of a sustained focus on standardised testing, such as narrowing of education or schools becoming ‘test factories’ (Imig and Imig, 2006; Lee, 2011).

While the current reality is that teachers are increasingly working in a climate of quality control (Dimarco, 2009), the rhetoric in government policies in Ireland and Northern Ireland highlights the centrality of teachers in moving towards educational improvement (Department of Education, 2009; Inspectorate, 2012). The important role of teachers in these educational improvement policies is supported by evidence from the literature, which shows that teachers have an influence on student achievement that is greater than any other school effect (Wright et al., 1997; Goldhaber, 2002; Schacter and Thum, 2004), such as that of reduced class size (Nye et al., 2004). However, a contradiction currently exists whereby the importance and centrality of teachers are recognised by global educational policies, but the empirical studies that inform these policies fail to include subjective teacher input (Skourdoumbis and Gale, 2013). Thus, in the current climate, meaningful teacher insights about how student learning and achievement in mathematics can be improved are absent across the research and educational policy base, despite teachers’ unique knowledge of student learning based on hundreds of hours of data (Foreman and Gubbins, 2015).

Skourdoumbis and Gale (2013) highlight the need to move away from positivist, quantitative studies within the teacher effectiveness paradigm in order to understand more fully the complex interactions of teaching and learning. Indeed, exploring teacher effectiveness quantitatively using statistical models has proved complex and problematic to date (Imig and Imig, 2006; Welsh, 2011). There is an inherent difficulty associated with utilising quantitative methods to understand the hugely

complex process of teaching and learning, as it does not translate easily into numbers and statistical models (Hikmet et al., 2008; Skourdoumbis and Gale, 2013). The challenge therefore lies in taking a different approach within the teacher effectiveness paradigm by giving teachers, who are often marginalised (Lee, 2011), a meaningful voice. Teachers are in a very strong position to provide knowledge regarding the teaching and learning process (Foreman and Gubbins, 2015) and their insights and professional judgements are necessary to add balance and depth to the current teacher effectiveness evidence base.

1.5 Philosophical approach

This research study focuses on gaining teacher perspectives about how teachers influence student learning and achievement in mathematics, and as such it is subjective. The ontology that informs this work is founded in an orientation that views reality as being multiple, ambiguous and variable (O' Leary, 2004). It is assumed that reality and social phenomena can be observed both objectively and subjectively, resulting in different yet valid insights of reality (Klingner and Boardman, 2011). Epistemologically, there is an assumption that knowledge about educational phenomena cannot be obtained without understanding the perceptions, interpretations and beliefs of social actors within the educational community (Hammersley, 2012). This places the study within the interpretivist paradigm, which seeks to ground social research in people's experiences. In terms of axiology, it is believed that research grounded in polyvocality will "generate more holistic truth about a specific social reality" (Humphrey, 2013, p8). While quantitative methods are not generally associated with the interpretivist paradigm, the use of secondary TIMSS 2011 quantitative data in this study promotes trustworthiness by allowing for triangulation (Bryman, 2012). In addition, the use of a mixed methods design

strengthens scientific inferences (Klingner and Boardman, 2011), and may better determine what is likely to work in relation to the educational phenomena in question.

As a teacher myself, researching teacher effectiveness, it is important for me to acknowledge my positionality, make explicit my values and engage in reflexivity during my research journey so as to continually reflect upon how these aspects influence and shape my research (Hopkins, 2007). Therefore, a brief professional biography is included so as to disclose my position in relation to what is being researched and make any biases or values more transparent (Creswell, 2003).

I am employed as a mainstream class teacher in an urban school in the Republic of Ireland. Throughout my life, I have always had a love for mathematics. Prior to becoming a primary school teacher I completed a Bachelor of Science in Financial and Actuarial Mathematics. As part of this course I worked for over a year in the finance sector as a trainee actuary. Following the completion of this degree, I undertook a Postgraduate Certificate in Education in the UK, before returning to Ireland and taking up my current position as a classroom teacher.

When I began my doctoral journey, I was very interested in exploring what teachers can do within the classroom to promote the success of their students in mathematics. In choosing this as a research topic, I was steered towards the paradigm of teacher effectiveness research, where top down quantitative studies identifying ‘good’ and ‘bad’ teachers dominate the literature (Skourdoumbis, 2013). Although at the outset of my doctoral journey I had intended to conduct a quantitative study, it became clear that there was a notable absence of qualitative studies across teacher effectiveness literature, with teacher voice and professional judgements under-represented across the evidence base (Campbell et al., 2004). I felt that the accountability agenda, which

drives much of the teacher effectiveness evidence base, failed to acknowledge the importance and richness of teacher expertise. Rather than listening to teachers, who are professionals with thousands of hours of data about effective ways in which to help children to learn, complex and contested statistical models are currently being employed across the teacher effectiveness literature to calculate the ‘value added’ by teachers. This supplies little useful information about what teachers can do within the classroom to promote student learning and achievement. Therefore, this study is predicated on gaining teacher perspectives on how teachers can promote student learning and achievement in mathematics.

It is noted that this research is not value-free. My values have had an influence from the beginning of my doctoral journey and throughout every stage of the research process (Bryman, 2008). However, throughout the research project I am committed to maximising researcher objectivity by being conscious of my values and biases and being explicit about my positionality from the outset, which allows the reader to understand my autobiography with respect to the work being presented. Ethically, the study is conducted within the guidelines of the University of Lincoln ethical principles and those of the British Educational Research Association (BERA). Overall, the research project is designed to maximise benefits while minimising risks. Nevertheless, the researcher is committed to engaging in a process of reflexivity throughout the study so as to ensure that any possible harm is anticipated and guarded against (British Sociological Association, 2002).

My doctoral journey has broadened my understanding of the context within which teachers work and influence student learning and achievement in mathematics. Giving teachers a voice and affirming trust in their professional judgement has proved challenging in the current climate of quality control and accountability

(Dimarco, 2009). However, teachers must be at the heart of any efforts for educational improvement (Inspectorate, 2012). The research design of this study affirms the voice of teachers, by exploring their subjective experiences of how and why they influence student learning and achievement in mathematics. A quantitative comparison of teacher effectiveness in Ireland and Northern Ireland using TIMSS 2011 survey data adds empirical strength and credence to the study. This mixed methods approach is optimally suited to exploring educational phenomena of enormous complexity, allowing for a deeper and more holistic investigation of complicated educational issues (Klingner and Boardman, 2011).

1.6 Conclusion

The first chapter of this thesis has introduced the research project, which investigates how teachers influence student learning and achievement in mathematics at the fourth class level in Ireland and Northern Ireland. It outlines the foundations of this research and details the context within which the study was carried out, as well as making explicit the philosophical assumptions underpinning the study and the position of the researcher in relation to the research project. The research originates from the contention that teacher voice is under-represented across the teacher effectiveness evidence base. As such, there is a lack of knowledge regarding what factors are important within the teaching and learning process. Therefore, this study focuses on gaining teacher perspectives in an effort to gain a more holistic understanding of large-scale TIMSS 2011 survey data and the teaching and learning process.

Chapter 2 presents a critical analysis of the teacher effectiveness literature. The current conceptualisation of teacher effectiveness is discussed and prevalent methodologies across the teacher effectiveness paradigm are investigated. Three

subclasses of teacher effectiveness are explored, namely, teacher qualifications, teacher classroom practices and teacher attitudes and beliefs.

Chapter 3 provides a detailed account of the methodology employed in this study. The conceptual framework and how it was operationalised are explained. The mixed methods design is outlined in detail and the data analysis procedures are explained.

Chapter 4 reports the findings from the quantitative and qualitative data analysis. An overview of the results is given using the themes from the conceptual framework as headings. These themes link closely to the research questions. Quantitative findings are presented mainly through the use of tables, whereas findings from the qualitative phase of the study are presented descriptively.

These findings are synthesised in Chapter 5 by exploring the results of the research study within the context of the literature.

Finally, Chapter 6 presents the new knowledge that has emerged from this research, along with recommendations for future research.

Chapter 2. Teacher effectiveness

2.1 Introduction

This literature review is structured around three main areas that informed this research project into how teachers influence student learning and achievement in mathematics. The first section traces the path of teacher effectiveness research to date and discusses the current conceptualisation of the term teacher effectiveness, reflecting upon reasons for disagreement across the research base regarding its meaning. The second section then explores the research methodologies that are prevalent across the teacher effectiveness paradigm. This exploration revealed a notable gap regarding qualitative studies into teacher effectiveness (Campbell et al., 2004). The third section of this literature review informs the focus of this research project, in that it explores the literature regarding how teachers influence student learning and achievement in mathematics. The evidence base has identified over 100 teacher-related factors that influence student learning and achievement (Goe and Stickler, 2008). Section three of the literature review divides these teacher-related factors into three subclasses namely; teacher qualifications, teacher classroom practices and teacher attitudes and beliefs. A selection of teacher-related factors that are relevant within the Irish and Northern Irish primary school context are investigated under each subclass, with respect to their impact upon student learning and achievement in mathematics. It is noted that, perhaps due to the absence of subjective teacher input, the process through which these factors influence student learning and achievement in mathematics is unknown. This leads on to the presentation of the conceptual framework (Figure 2.1) which is a synthesis of the entire literature review. Following this, the research aims and questions are discussed. The conclusion draws together key aspects from the literature review to

summarise what the literature reveals about how teachers influence student learning and achievement in mathematics.

Although the literature review shows that the teacher effectiveness evidence base is informative, it also highlights that the literature is limited in several ways. Firstly, the vast majority of studies that were available to inform this literature review were quantitative in nature. However, concerns over the efficacy of current quantitative methods for measuring teacher effectiveness are highlighted (Imig and Imig, 2006; Skourdoumbis and Gale, 2013). In addition, many teacher effectiveness studies have focused on investigating the easily measurable subclass of teacher qualifications. By comparison, research into the subclass of teacher classroom practices is limited, despite teacher classroom practices having the most proximal impact on student learning and achievement (Palardy and Rumberger, 2008). Where knowledge exists regarding teacher classroom practices, it is drawn largely from the positivist, quantitative position. Thus, there is an emerging need for qualitative research within the teacher effectiveness paradigm, which enables teachers to enter the conversation about how teachers can promote student learning and achievement in mathematics.

2.2 The path of teacher effectiveness research to date

This study explores the teacher-related factors that influence student learning and achievement in mathematics, and as such falls within the educational research paradigm of teacher effectiveness. For the purposes of this study, the term ‘teacher effectiveness’ will be defined as the effectiveness of a teacher in promoting student academic achievement on standardised tests (Nye et al., 2004). This working definition is important to articulate at the outset so as to avoid ambiguity throughout the thesis; however, it is not perfect and there are several issues with this definition that will be discussed in section 2.2.1. Although other terms for teacher effectiveness

including ‘good teachers’ and ‘teacher quality’ appear throughout the literature base, this research study will utilise the term teacher effectiveness, as this is the dominant term across the research literature.

Teacher effectiveness represents a paradigm of educational research that has gained much attention from researchers and policymakers alike over the past 90 years. Imig and Imig (2006) trace the path of the teacher effectiveness movement in the US back to the Learned and Bagley (1920) study, which argued that teacher effectiveness should be equated with student learning and achievement (Learned and Bagley, 1920). While the study was met with hostility at the time, 90 years later the global conceptualisation and measurement of teacher effectiveness increasingly aligns with Learned and Bagley’s definition. In a further step towards measuring teacher effectiveness using student achievement data, Sahlberg (2007) identifies the late 1980s as the beginning of a global educational reform movement. This movement marked a rise in educational policies that prescribed frequent high stakes testing of students, an increased focus on literacy and numeracy, and increased school and teacher accountability, and these trends are evident in educational policies in Ireland, the UK and the USA today. The late 1980s also marked the advent and acceptance of new statistical technologies and research methodologies that led a shift towards large-scale quantitative research within the teacher effectiveness paradigm (Imig and Imig, 2006). Three decades later, Exley and Ball (2014) argue that pervasive global educational policies have not only transformed the educational system but also the meaning of being ‘educated’.

Quantitative teacher effectiveness studies that have been conducted to date predominantly use student achievement data in literacy and mathematics as the sole measure of teacher effectiveness (Skourdoumbis and Gale, 2013). By using student attainment scores taken at two or more time points, many researchers identify

effective teachers by regressing student post-test scores on pre-test scores, thus obtaining residual gain scores (Palardy and Rumberger, 2008; Stronge et al., 2011; Konstantopoulos and Chung, 2011). These residual scores show the positive or negative progress in student attainment. This general approach is known as value-added modelling (VAM) (Wright et al., 1997), and it assumes that scores will improve if teachers have been effective (Welsh, 2011). Including test scores at two time points in statistical models is theorised to control for student and school factors that are time invariant (Muijs and Reynolds, 2003) and, unless included, would lead to underestimation of teacher effects on student achievement (Palardy and Rumberger, 2008). Following this, researchers can empirically compare teacher effects from classroom to classroom as well as in relation to other school and student effects.

2.2.1 The current conceptualisation of teacher effectiveness

While the empirical data that value-added modelling produces is attractive to governments and policy makers, there are growing methodological, moral and philosophical concerns associated with this approach for measuring teacher effectiveness (Imig and Imig, 2006). The most important issue regarding equating teacher effectiveness to student achievement on standardised tests is that student achievement is predominantly affected by a myriad of other factors that are outside of a teacher's control (Skourdoumbis, 2013). Hattie (2003) synthesises the teacher effectiveness literature in order to identify the main sources of variance in student achievement and posits that student factors such as socio-economic status, special needs status, etc. account for 50% and thus the majority of variance in student achievement scores. The remainder of variance in student scores is attributed to home factors such as parental encouragement (5–10%), school factors such as class

size and resources (5–10%), peer effects (5–10%) and lastly teacher factors (30%) (Hattie, 2003). It is important to note however, that Hattie’s synthesis refers generally to teacher effectiveness studies and is not specific to mathematics achievement. Nevertheless, Skourdoumbis (2013, p351) strongly critiques the current conceptualisation of teacher effectiveness, due to the accountability it places solely upon teachers for schooling outcomes “to the exclusion of all else”. Similarly, Welsh (2011) points out that student achievement scores as a measure of teacher effectiveness are seriously limited because of the assumption that score improvement is due to classroom instruction rather than experiences outside of school. Despite this, student achievement is the metric that is used to calculate teacher effectiveness by the vast majority of studies across the teacher effectiveness literature base (Creemers, 1999; Goldhaber, 2002; Palardy and Rumberger, 2008; Stronge et al., 2011).

Another major issue with the current conceptualisation of teacher effectiveness is that it fails to recognise the multifaceted nature of teaching and learning by drawing a straight line between teaching and student results on standardised tests (Skourdoumbis and Gale, 2013). The teaching and learning process is dynamic, multidimensional and hugely complex (Hikmet et al., 2008), and despite the development of theories of learning by many prominent twentieth century scholars – notably Lev Vygotsky, Jean Piaget, John Dewey and Paulo Freire to name a few – there is still no consensus on the definition of learning, how learning occurs, or how learning can be measured (Grouws, 1992). While some argue that learning can be identified by measuring acquired knowledge through use of standardised tests, others postulate that learning is “not easily documented, verified or explained” (Skourdoumbis and Gale, 2013). The ambiguity of the process and measurement of student learning thus poses challenges for defining teacher effectiveness. How can a

teacher be deemed as effective in promoting student learning, as measured by their achievement on standardised tests, if there is ambiguity about precisely what constitutes learning to begin with?

A further issue with equating teacher effectiveness to student achievement scores is that this narrow measure does not account for the many other important outcomes of education such as developing socially, developing as a unique individual, and contributing to the good of society (Department of Education and Skills, 2013). Skourdoumbis and Gale's (2013, p892) conceptual critique of teacher effectiveness research argues that equating teacher effectiveness to student outcomes in fact "works against the purposes of education; specifically authentic teaching and learning." Imig and Imig (2006) echo this in their concern that a sustained focus on standardised testing may lead to schools becoming test factories, where teachers teach to the test and education is redefined. Aligning with this view, Lee (2011) posits that education reform is moving education from being conceptualised as the development of individuals as a basis for democratic society to the development of individuals as economic currency.

Aside from issues with the current definition of teacher effectiveness, there is an inherent difficulty with assigning an alternative universal meaning to the term due to the fact that teacher effectiveness is a social construct that varies across time and location. Berliner (2002, p18) emphasises the complexity of educational research due to "the power of contexts, the ubiquity of interactions and the problem of decade by findings interactions." The author argues that broad theories about educational issues, such as student learning and teacher effectiveness, often fail due to the power of contexts. What works in one school may not work in another due to different student populations and local contexts. Similarly, effective teaching in one country

may look different to effective teaching in another country. Hikmet et al. (2008) emphasise this point by positing that “the learning process is complex and not amenable to enterprise-wide standardisation.” This casts doubt upon the efficacy of an emergent trend, in which educational policy makers transplant educational improvement strategies from one country to another (Panayiotou et al., 2014).

Berliner’s “decade by findings” issue, which describes the “short half life” of educational research findings, also impacts the conceptualisation of the term teacher effectiveness (Berliner, 2002, p20). For example, Creemers (1999) posits that effectiveness factors are not stable over time, with some school improvement innovations promoting student achievement initially, but with positive effects diminishing or disappearing totally over time. As such, Schacter and Thum (2004) question the use of evidence from studies in the 1960s and 1970s to define effective teaching in the 21st century. This is because what was considered to be effective teaching several decades ago may not be viewed as effective teaching currently due to changes in social, cultural and educational contexts. Similarly, Stronge et al. (2011) argue that changes in research methodologies and assessment strategies merit a review of how effective teaching is explored. That said, Imig and Imig (2006) posit that older models for exploring teacher effectiveness, such as the professional consensus model, expert consensus building and educational research meta- analyses, provided fairly robust findings.

Echoing Berliner’s (2002) context issue, a further problem in defining teacher effectiveness arises due to the fact that the term means different things to different stakeholders within the education system. At the macro level, governments and economists conceptualise teacher effectiveness differently to the principals, teachers and students operating at the micro level. For example, at the macro level, governments increasingly correlate teacher effectiveness with student scores on

standardised tests in literacy and numeracy. This outcomes-based educational reform trend has been evident since the 1980s and advocates increased accountability for teachers in ensuring that their students achieve expected gains on national standardised tests (Sahlberg, 2007). However, significant statistical, moral and philosophical concerns are raised in this review regarding the equating of student scores on standardised tests to teacher effectiveness. Furthermore, Tucker (2011) argues that policies aimed at improving teacher effectiveness by introducing punitive accountability systems in fact have the opposite effect. These systems erode teacher professionalism and autonomy, leading to lower teacher status and morale and ultimately lower teacher effectiveness (Dimarco, 2009). Nevertheless, greater accountability, as well as a focus on assessing cognition in literacy and numeracy, are evident in policy agendas worldwide, with for example the introduction of School Self Evaluation (SSE) in Ireland (Inspectorate, 2012), as well as national literacy and numeracy improvement strategies in Ireland, Northern Ireland, the UK and the US (U.S. Department of Education, 2002; Department for Education and Skills, 2006; Department of Education and Skills, 2011; Department of Education, 2011).

On the other hand, at the micro level within schools, conceptualising teacher effectiveness may reveal an array of perspectives. While school principals may define teacher effectiveness based upon formal or informal classroom observations, parental reports and/or student achievement (Jacob and Lefgren, 2008), student perspectives about effective teaching reveal an emphasis on the relational aspects of teaching, with students valuing teachers who are creative, empathetic, caring and respectful (Robertson, 2006). Similarly, Sanderse et al.'s (2015, p196) qualitative study of 102 UK teachers suggested that “teachers have a strong ‘moral compass’ and are motivated to make a difference in children’s lives through the pedagogical

relationship.” As such, many teachers disagree with the approach of using student achievement results in standardised tests to define teacher effectiveness (Lee, 2011, p102), and perceive “a disconnect” between this narrow measure and the holistic education of a child. Similarly, those involved in teacher education “insist on a broad array of skills, knowledge, and dispositions to judge teachers and an even wider array of standards to judge student performance” (Imig and Imig, 2006, p175).

However, while stakeholders at the micro level insist that teacher effectiveness is complex, multidimensional and not amenable to being defined singularly by student test scores, those at the macro level continue to use this narrow measure of student achievement gains on standardised tests as the ultimate measure and definition of teacher effectiveness. In addition to this, much of the teacher effectiveness research to date has been driven by macro level stakeholders (Imig and Imig, 2006). Therefore, in order to gain a more balanced understanding of teacher effectiveness, Skourdoumbis and Gale (2013) posit that teachers must reclaim their educational authority, and lead the transformative move away from positivist empirical studies that evaluate teachers towards research studies that focus on understanding the deep complexity of the teaching and learning process.

In summary, although teacher effectiveness has been researched for many decades, a commonly accepted definition for the term is elusive (Imig and Imig, 2006). While teacher effectiveness is defined for the purposes of this study as the effectiveness of a teacher in promoting student academic achievement on standardised tests (Nye et al., 2004), this definition fails to address the multidimensional nature of teacher effectiveness. The strong influence of factors outside of a teacher’s control on student achievement scores (Hattie, 2003), the deeply complex nature of teaching and learning (Hikmet et al., 2008), the power of contexts (Berliner, 2002) and the differing perceptions of teacher effectiveness held by educational stakeholders at

micro and macro levels (Robertson, 2006; Sahlberg, 2007) raise significant issues regarding the current conceptualisation of teacher effectiveness across the evidence base, which equates teacher effectiveness with student achievement on standardised tests. This measurable definition of teacher effectiveness is reflective of the positivist nature of teacher effectiveness research to date (Skourdoumbis, 2013), where qualitative teacher input has been minimal. The foremost objective of this research, therefore, is to gather teacher insights in order to develop a holistic understanding about how teachers can best promote student learning and achievement in mathematics.

2.3 Quantitative methods and the teacher effectiveness paradigm

Despite the issues surrounding the conceptualisation of teacher effectiveness, the reality is that the vast majority of quantitative teacher effectiveness studies across the evidence base draw a straight line between teacher effectiveness and student achievement (Skourdoumbis and Gale, 2013). In this section, therefore, the statistical process in which teacher effectiveness is linked to student achievement is discussed. The limitations of the current quantitative methodologies utilised across the teacher effectiveness evidence base highlight the need for a qualitative approach within the paradigm, which focuses on how to improve student learning and achievement in mathematics, rather than how to evaluate and rank teachers in their effectiveness.

2.3.1 Student achievement gains and value added modelling

In order to identify effective and ineffective teachers, the teacher effectiveness literature base tends to use student achievement gains on standardised tests in literacy and mathematics, and value added modelling. In order for value-added models to work, test scores must be sensitive to teacher instructional practices. Therefore, instructional sensitivity analysis should be carried out to validate results (Welsh,

2011). However, few teacher effectiveness studies include this analysis, and those studies that do so find that test scores do not adequately reflect the instructional efforts of teachers (D'agostino et al., 2007a). In fact, recent evidence has cast doubt over “the ability of standardized tests to accurately reflect school performance” (Lemke et al., 2006, p.246) due to statistical shortcomings when using cut off points to classify schools as performing or underperforming based upon standardised test results. Ho (2008, p351) substantiates this concern in finding that statistics utilising test score cut off points, such as the Percentage of Proficient Students in the USA, are subject to statistical limitations that are “unpredictable, dramatic, and difficult to correct”. In addition, the use of standardised tests may be inadequate to capture the progress of gifted students, as standardised tests are generally designed to capture the skills of average students (Welsh, 2011) and therefore may not show progression in learning for top performing or gifted students.

A further methodological problem regarding the use of test scores and VAM to measure teacher effectiveness is the statistical bias associated with effectiveness estimates for teachers with fewer data (e.g. smaller classes) than others. These estimates were found to be less accurate in Kupermintz's (2003) validity investigation of a value added modelling system in Tennessee. Furthermore, after rigorous statistical testing of VAM error rates, Schochet and Chiang (2010) revealed high type 1 and type 2 error rates for teacher level analyses. Using three years of data, type 1 and 2 errors were estimated at 26 percent, which means, for example, that 1 in 4 average teachers would erroneously be identified as high performing. These findings raise significant questions about the use of VAM as a method for identifying effective teachers, especially in situations where effectiveness rankings are linked to teacher pay.

2.3.2 Teacher effectiveness research – data collection methods

The vast majority of the teacher effectiveness evidence base is quantitative in nature and prevalent data collection methods across the teacher effectiveness paradigm reflect this. Typically, data collection involves gathering student achievement scores at two time points, as well as collecting information about teacher-related factors that may influence student achievement scores. While student achievement data is generally collected through standardised tests in literacy and mathematics, data about teacher-related factors is collected through observations or evaluations of teaching by principals or evaluators, student perceptions of teacher classroom practices, and self-reported teacher survey data. Although teacher qualifications are easily measurable and amenable to survey collection methods, it is evident that teacher classroom practices and attitudes and beliefs are not as simple to measure, with limitations associated with all data collection methods mentioned. This is likely to be because it is difficult to be certain about what teachers do during the thousands of hours they spend teaching each year, or about the attitudes and beliefs that they hold.

Teachers' self-reported surveys are a common instrument for collecting data regarding teacher qualifications, classroom practices, and attitudes and beliefs. For example, a study utilising self-reported instructional practices conducted by Cohen and Hill (2000) used a teacher survey relating to classroom practices to determine teacher influences on student mathematics scores. Only a modest positive relationship was found between self-reported classroom practices and student scores. On the other hand, Wenglinsky's (2000) study, which analysed self-reported teacher survey data from the National Assessment of Educational Progress (NAEP) in the US, found that certain teacher practices, such as being exposed to hands-on learning, had up to 70% of a grade level effect on eighth grade mathematics student attainment

in comparison with their peers (Wenglinsky, 2000). However, Palardy and Rumberger (2008) argue that as a method of gathering data on teacher practices, teacher self-reported surveys are more limited than direct observations, which can show larger effects for teacher practices. A further limitation of survey data is experimenter effect. This is a form of reactivity in which the researcher can inadvertently influence the participant's response. For example, by making participants aware of factors being investigated, their responses may become biased towards what is considered socially acceptable in that area. It also must be considered that teachers' responses may not be related to their actual classroom practices, attitudes or beliefs.

With regard to the teacher effectiveness subclass of teacher classroom practices, classroom observations are widely considered as the optimal quantitative data collection instrument, as they are most proximal to instruction (Welsh, 2011). Teacher effectiveness studies can involve observations which are conducted by principals (Jacob and Lefgren, 2008), evaluators (Van de Grift, 2007) or by coding recorded video evidence (Stipek et al., 2001). The evaluator assigns a score based upon their assessment of the quality of teaching that takes place during the observation. Several studies, involving evaluator observations of teacher classroom practices, have shown positive correlations between student mathematics achievement gains and the teacher evaluation score (Holtzapple, 2003; Gallagher, 2004; Borman and Kimball, 2005). In addition, Kimball et al. (2004) found that teacher evaluation scores are a stronger predictor of student attainment than the qualifications of teacher education or experience. That said, some doubt is cast over this finding due to the use of two-level (student and classroom) hierarchical linear modelling which, according to Palardy and Rumberger (2008), leads to an overestimation of the classroom variance due to the between-school variance in the

outcome being absorbed by the classroom component. Nonetheless, Kimball et al.'s (2004) argument is substantiated by Jacob and Lefgren's (2008) finding that evaluations of teacher effectiveness, conducted through observations by their school principals, are a more robust predictor of student achievement than teacher experience or education, especially with respect to mathematics.

Although direct classroom observation provides valuable teacher classroom practices data that may not otherwise be captured (Cadima et al., 2010), there are some limitations associated with these observations. Firstly, teachers may change their typical instructional practices because they are being observed, which is also known as the Hawthorne effect (Adair, 1984). Halo effects can also cause bias (Welsh, 2011). This occurs when the observer's global perception of the teacher affects all ratings. Observer training as well as multiple observers and observations can reduce bias associated with classroom observations (Welsh, 2011). However, as a method of evaluation, classroom observations are resource intensive and difficult to conduct on a large scale.

Alternatively, student perceptions of teacher classroom practices, as measured by student surveys, can also be linked with student mathematics achievement. According to Busher (2012), students are expert observers of teacher practices. Their views about good teachers correlate closely with the literature on effective teaching (Wragg et al., 2000). Pukleck Levpušček and Zupančič's (2009) study of Slovenian eighth grade students found that their perceptions of mathematics teaching predicted both their motivational beliefs and academic achievement. Similarly, Marcoulides et al. (2005) found a 0.32 correlation between achievement and students' perceptions of their teachers' classroom practices, as measured by student survey. However, this finding is somewhat ambiguous due to lack of controls for prior achievement, which

means that classroom effects are not residualised and therefore are difficult to interpret (Nye et al., 2004). Furthermore, studies in which students rate teachers require careful consideration of ethical issues, as well as statistical controls to address halo effects.

2.3.3 Teacher effectiveness research – data analysis methods

While VAM and student test scores are utilised to identify effective teachers, and various data collection methods elicit information about teacher-related factors, further data analysis models are required to link this data together. Therefore, a variety of statistical methods have been employed to link teacher qualifications, classroom practices, and attitudes and beliefs to their students' achievement scores. Examples of such data analysis approaches include the use of Education Production Functions, Ordinary Least Squares (OLS) regression and multilevel models such as Hierarchical Linear Modelling (HLM). However, due to the multifaceted nature of the teaching and learning process, devising statistical models that disentangle teacher-related factors from the wide range of other factors that influence student achievement has proved problematic (Skourdoumbis and Gale, 2013). Although statistical functions and software packages have been developed that seek to address the statistical complexity of linking teacher variables to student achievement (Rowe, 2003), each statistical approach poses its own set of limitations, and the literature does not reach a consensus regarding the most appropriate statistical model for linking teacher factors to student achievement.

For example, hierarchical linear modelling (HLM) is used by many of the teacher effectiveness studies examined in this literature review (Muijs and Reynolds, 2003; Palardy and Rumberger, 2008). HLM is a complex multilevel modelling system which addresses the hierarchical data structures that exist within schools (Rowe,

2003; Muijs, 2011). Students are nested within teachers' classrooms, which are in turn nested within schools. Failure to consider this can lead to specific teacher effects on student achievement being overlooked, as well as the statistical problems of aggregation bias, the unit of analysis problem and mis-estimated errors (Raudenbush and Bryk, 2002). In recent years, HLM has attracted global interest (Cohen et al., 2011) due to its statistical sophistication and ability to address several statistical issues associated with other single level data analysis approaches (Muñoz et al., 2011). However it has been criticised by some, with Gorard (2007) arguing that it is needlessly complicated with ambiguous empirical and theoretical foundations.

Similarly, various studies within the teacher effectiveness paradigm have utilised education production functions to analyse educational data (Bonesrønning, 2004; Aslam and Kingdon, 2011; Schwerdt and Wuppermann, 2011). Through use of complex process-product equations taken from the economics tradition, education production functions calculate the relationship between school and student inputs and outputs. However, various econometric problems are associated with education production functions, such as omitted variable bias, which is due to correlations between different parts of input vectors, and endogeneity bias which occurs when inputs are endogenous to outputs (Bonesrønning, 2004). In addition, the non-random assignment of teachers to classes can create ambiguity in determining the direction of causality and this has posed a major problem for studies that utilise education production functions (Nye et al., 2004).

In summary, while teacher effectiveness research has led to the development of various quantitative methods that seek to address the complexity of linking teacher factors to student achievement data, there are growing statistical and moral concerns regarding the use of student achievement data or VAM as the ultimate measure of

teacher effectiveness. Furthermore, the multidimensional nature of the teaching and learning process “cannot easily be translated into formulae of mathematical origin and description” (Skourdoumbis and Gale, 2013, p899) and all of the quantitative data collection and analysis methods utilised by studies in this review are subject to numerous statistical limitations. Qualitative research methods would provide a more nuanced, in-depth exploration of the teaching and learning process however, to my knowledge there are no qualitative investigations that utilise teacher subjective opinions, gained through qualitative interviews, to explore how teachers influence student learning and achievement in mathematics. This provides an important gap for this study to address, as teacher insights “make valuable contributions regarding what constitutes ‘quality’ in mathematics education, and how we are to attain it” (Dimarco, 2009, p7).

2.4 The teacher-related factors that influence student achievement

Although the positivist, quantitative methodology that dominates the teacher effectiveness paradigm is contested, evidence from this tradition has nevertheless confirmed the importance of teachers for student learning and achievement in mathematics. Teachers are a key connection between policy, practice and student achievement (Cohen and Hill, 2000). After controlling for student background characteristics, teacher effects explain significant variance across students (Sanders and Horn, 1998; Wenglinsky, 2000; Muijs and Reynolds, 2003; Guarino et al., 2013; Wayne and Youngs, 2003). In fact, teachers are the most influential schooling factor for improving student achievement (Goldhaber, 2002; Hattie, 2003; Schacter and Thum, 2004; Palardy and Rumberger, 2008). Furthermore, the effects of a teacher are cumulative and can persist for years after a student has a teacher (Sanders and Rivers, 1996; Konstantopoulos and Chung, 2011). Because mathematics learning is

developed layer upon layer (Whitburn, 2002), it follows that teachers play an important role in every year of a student's mathematics learning.

The evidence base shows that teachers matter for promoting student achievement. However, as of yet, the specific qualifications, practices or mindsets that are most important for student learning and achievement in mathematics have not been identified with confidence (Bonesrønning, 2004; Goe and Stickler, 2008). Researchers have articulated almost 100 different teacher-related factors which influence student achievement in mathematics (Capraro et al., 2010). The literature (Palardy and Rumberger, 2008; Goe and Stickler, 2008; Boonen et al., 2014) divides these teacher-related factors into three subclasses, namely, teacher background qualifications (referred to as teacher qualifications in this thesis), teacher instructional practices (referred to as classroom practices in this thesis) and teacher attitudes and beliefs. In the following subsections (2.4.1, 2.4.2, 2.4.3) a selection of teacher-related factors relating to each subclass is explored. The selected teacher-related factors are those that are of relevance in the Irish and Northern Irish primary school mathematics contexts.

It is noted that much of the research linking teacher-related factors to student achievement in mathematics has focused on the easily measurable inputs of teacher qualifications (Clotfelter et al., 2007; Akiba et al., 2007; Wayne and Youngs, 2003). More recently researchers have begun to focus on teacher processes that influence student attainment, namely teacher classroom practices (Muijs and Reynolds, 2003; Stronge et al., 2011). Teacher attitudes and beliefs have also received interest from the research community (Askew et al., 1997). According to Palardy and Rumberger (2008), in order to most comprehensively investigate teacher effectiveness, researchers should explore factors relating to all three subclasses of teacher

effectiveness, namely teacher qualifications, teacher classroom practices and teacher attitudes and beliefs. Hence, as mentioned previously, in the following sections the evidence base will be examined under these three headings.

Once again the literature that is drawn on in this section supports concerns that the teacher effectiveness paradigm is dominated by positivist research (Skourdoumbis and Gale, 2013) and as such there are limited sources that arise from qualitative engagement with teachers. The vast majority of studies reviewed here are quantitative in nature. Generally, in quantitative teacher effectiveness studies, as described in detail in section 2.3, teacher-related factors including qualifications, classroom practices and attitudes and beliefs are entered into statistical models to determine their influence on student achievement in the subjects of literacy and mathematics. The literature reviewed in the following three subsections focuses on the mathematics findings from these studies, unless otherwise stated. Where findings from studies focusing on literacy teaching and learning are included, this is nevertheless considered of pertinence to this study due to the fact that teachers have been found to have a larger effect on student achievement in mathematics than in literacy (Hanushek et al., 2005; Clotfelter et al., 2007).

The lack of literature that furthers our understanding of teachers' views about how they influence the teaching and learning process has had a particular impact on this section. There were few studies which explored the process surrounding how the identified teacher-related factors influence student learning and achievement, or why some teacher-related factors are more influential than others. Nevertheless, it has been possible to explore the current knowledge about teacher-related factors which statistically influence student achievement in mathematics. This research project aims to probe this knowledge more deeply by casting a qualitative lens upon the

existing, and largely quantitatively derived, knowledge base relating to how teachers promote student learning and achievement in mathematics.

2.4.1 Teacher qualifications

Across the teacher effectiveness literature base, teacher qualifications refer to easily measurable attributes such as years of experience, certification status, degree level, pedagogical knowledge and academic achievement (Goe and Stickler, 2008). In this section, teacher qualifications including the following will be discussed: teacher experience, teacher degree level, teacher pedagogical and content knowledge, and teacher academic ability. These particular credentials have been chosen as they are most relevant within the Irish and Northern Irish teaching context. In addition, the effects of teacher professional development will be considered.

Teacher experience refers to the number of years that a person has been working as a teacher. Empirical evidence linking student attainment to teacher experience was generally positive in a review of student achievement studies by Wayne and Youngs (2003). However, authors argued that findings regarding teacher experience were too difficult to interpret due to statistical complexities. For example, experience measures would need to control for effectiveness differences between teachers who leave and stay within the profession. Nevertheless, a study by Boonen et al. (2014), utilising data from a longitudinal study in Flemish education (the SiBO Project) found that teacher experience has a significantly positive effect on mathematics achievement at the first grade level. Several other longitudinal studies at the primary school level support these findings that teacher experience positively influences student achievement in mathematics (Clotfelter et al., 2007; Kane et al., 2008). However, a study by Betts et al. (2003) which used a large database from the San Diego Unified School District conversely found that primary students gained higher

improvements in mathematics scores when taught by a teacher with one year or less of experience than a teacher with ten or more years of experience. Alternatively, several studies have found evidence suggesting that the effects of teacher experience are not linear and tend to stabilise after a few years (Sanders and Rivers, 1996; Hanushek et al., 2005; Boyd et al., 2007). For example, Rockoff's (2004) study of more than ten elementary schools across two New Jersey school districts found that for mathematics computation, the effects of teacher experience were most positive for the first few years of teaching. Overall, although the empirical evidence is ambiguous, there seems to be some agreement that experience matters and perhaps most significantly for the first few years of teaching (Akiba et al., 2007).

Degree level refers to whether a teacher holds a bachelor's, master's or doctorate degree, with the latter two degrees also referred to as advanced degrees. A longitudinal study by Rowan et al. (2002) utilised data from the Prospects Study, which included a large sample of US primary schools. Authors counter-intuitively found that students of teachers holding an advanced degree in mathematics performed worse than students of teachers without such degrees. In addition, Clotfelter et al. (2007) found that teacher advanced degrees negatively impacted student mathematics achievement after analysing an administrative dataset for North Carolina spanning ten years. Similarly, Betts et al. (2003) found that a master's degree contributed only marginally to student attainment. These findings call into question many government policies globally that are aimed at promoting teacher quality by monetarily rewarding teachers with advanced degrees, as the empirical evidence continues to show that teacher degree level does not significantly affect student achievement (Hanushek et al., 2005; Carr, 2006).

The literature tends to agree that teacher academic ability, as generally measured by scores on academic tests or exams that a teacher completes, positively contributes to

student attainment. A study by Ball et al. (2005) involving almost 3,000 first and third grade US students and their teachers, found that higher levels of teacher mathematical knowledge led to better student achievement. Conversely, Harris and Sass' (2006) longitudinal study utilising panel data for Florida students from first to tenth grade, found no link between a teacher's own Scholastic Assessment Test (SAT) verbal and quantitative scores and their students' attainment. That said, teacher subject knowledge was positively linked with student attainment in mathematics. Furthermore, Wayne and Youngs' (2003, p100) meta-review of teacher effectiveness research interpreted that "students learn more from teachers with higher test scores." This is consistent with Barber and Mourshed's report (2007), which argues that the best performing education systems in the world are extremely selective when choosing prospective teachers and attract teachers from among the most academically able people within the population.

Pedagogical knowledge refers to knowledge about teaching a subject, whereas content knowledge refers to knowledge about the subject itself. Understanding the kinds of knowledge that teachers draw upon and how they utilise them during classroom teaching are important factors in understanding the complex relationships between teacher knowledge, teacher practice and student learning (Kersting et al., 2012). A qualitative case study by Dimarco (2009) involving four Australian middle school teachers of varying experience found subject pedagogical and content knowledge to be crucial components for student engagement and teacher quality. However, a larger number of research participants would have strengthened this finding. Nevertheless, a larger mixed methods study involving 102 US middle school mathematics teachers found that teacher knowledge of concepts as well as connections was a significant predictor of both student achievement and lesson

quality (Tchoshanov, 2011). This is consistent with findings from a comparative case study in the US by Gilbert and Gilbert (2013), which found that increased content knowledge was a predictor of higher student achievement. However, authors in both studies also observed different pedagogical styles depending on teacher content knowledge, and these were likely a more direct factor in varying student attainment.

Professional development is seen by policymakers worldwide as a tool for improving the pedagogical knowledge of teachers as well as influencing their attitudes, beliefs and classroom practices (Dash et al., 2012). Participating in professional development may be related to increased student achievement in Dodeen et al.'s (2012) comparison of TIMSS data for Taiwan and Saudi Arabia, where the majority of teachers in the highest performing country, Taiwan, had participated in professional development, whereas most teachers in the lower performing country of Saudi Arabia had not. While partaking in professional development was found to impact upon teacher practices in Cohen and Hill's (2000) study involving second to fifth grade Californian students and their teachers, its influence on student achievement is less clear. For example, in their randomised control trial across 79 fifth grade teachers in the US, Dash et al. (2012) found that while online professional development positively affected teacher pedagogical knowledge and practices, this did not translate into increased student achievement. However, Muijs et al. (2014) call for more research in this area, arguing that the effects of teacher professional development are under researched, despite the fact that teacher professional development is considered an important factor in models for school improvement.

Throughout many decades of research, a series of teacher qualifications that predict student achievement has been extensively searched for. Results of the effects of these qualifications on student achievement are mixed (Dodeen et al., 2012), and empirical evidence seems to imply that teacher qualifications alone do not guarantee effective

teaching (Goe and Stickler, 2008). In fact, by aggregating the results of two reviews composing more than four hundred studies, Shachter and Thum (2004) found that academic ability was only significantly positively related to student attainment in more than 40% of studies, teacher years of experience in less than 30% of studies and teacher advanced degrees in less than 10% of studies. Unlike other teacher qualifications, teacher professional development is an aspect of teacher effectiveness that is deemed to be under researched (Muijs et al., 2014), and therefore conclusions about the effects of professional development on student achievement are weak. Overall, while some teacher qualifications may impact student achievement, researchers have called for teacher effectiveness studies to move their focus from teacher qualifications to how teachers behave within the classroom, in order to better understand student learning and achievement (Hanushek, 2002).

2.4.2 Teacher classroom practices

Teacher classroom practices refer to the myriad of interactions that take place during the teaching and learning process, and include, for example, the practices of questioning, assessment and managing student behaviour (Goe and Stickler, 2008). Several terms such as teacher instructional practices, teacher instructional behaviours and teacher classroom behaviours are used interchangeably throughout the evidence base. The literature identifies a vast range of teacher classroom practices that are associated with student learning and achievement. Teacher classroom practices are conceptualised as the only subclass of teacher effectiveness that has a direct influence on student learning (Palardy and Rumberger, 2008). However, a gap exists within the literature with respect to the interplay between teacher classroom practices and student learning (Polly et al., 2013). In this section an array of effective teacher classroom practices that the literature has identified will be examined. Unless

otherwise stated the evidence explored relates to the teaching and learning of mathematics.

2.4.2.1 Classroom and behaviour management

Brophy (1988, p241) argues that classroom management and good teaching are ‘intimately linked’. A study by Van de Grift (2007) involving observations conducted in 854 classrooms by inspectorates across four European countries, including England, Germany, Belgium and The Netherlands supports this idea by finding that effective classroom management positively affected not only student attainment but also student involvement, attitude and behaviour. Similarly, Cadima et al.’s (2010) study across 64 Portuguese first grade classrooms found that classroom organisation played a major role in explaining student maths scores. However, standardised tests were not used and the study would have benefited from more than one observation in each classroom, in order to be more generally representative of daily teacher classroom practices.

Muijs and Reynolds (2011) posit that the main classroom goal of an effective teacher is academic learning, and the environment is managed so that optimum student time is spent on task with smooth transitions between lessons and little time wasted getting organised or dealing with behavioural issues. A mixed methods study by Stronge et al. (2011) involving US fifth grade teachers from top and bottom quartiles of effectiveness, identified through use of hierarchical linear modelling, substantiates this position. Authors found that bottom-quartile teachers had student behavioural disruptions in their classrooms every twenty minutes whereas top-quartile teachers only experienced such disruptions once every hour. As well as this, Stronge et al. (2011) argue that more effective teachers consider students’ academic, social and personal needs. This is supported by Puklek Levpušček and Zupančič (2009) in their study of 365 Slovene eighth graders, which found that when students perceive that

teachers take into account their psychological needs of competence and relatedness, the students' mathematics motivational beliefs and attainment are higher.

2.4.2.2 Teacher expectations

The literature links effective teaching to the communication of high expectations to students of all ability levels about their academic work (Muijs, 2011; Stronge et al., 2011; Newton and Winches, 2013). For example, a US based study by Wentzel (2002) applied multiple regression modelling to data from 452 sixth graders and their teachers and found that high expectations were a consistent positive indicator of student attainment. Similarly, Frome et al.'s (2005) US middle schools study, which tested four aspects of teacher quality against student achievement, found high expectations to have the most significant impact on student attainment. These findings are supported by Kannapel and Clement's (2005) study of eight high performing high poverty elementary schools in Kentucky. A characteristic that set these schools apart from high poverty low performing schools in Kentucky was that teachers had high expectations for student performance and believed every child could succeed. However, it is noted that this study did not focus specifically on mathematics.

Students who perceive that their teachers check their understanding of concepts and would teach a concept again if it was not mastered performed better than their peers in Puklek Levpušek and Zupančič's (2009) study. However, this relationship was mediated by the students' own self-efficacy beliefs. Nevertheless, Rubie-Davies' (2006) study of 256 primary school students and their teachers in Auckland, exploring the relationship between student self-beliefs and teacher expectations, found that the self-beliefs of students of low expectation teachers fell substantially over the course of the year of the study, whereas self-beliefs of students of high

expectation teachers slightly increased. Overall, while the literature shows that high expectations have a positive impact on student achievement in mathematics, the process through which high expectations are communicated by teachers to students requires deeper exploration.

2.4.2.3 Questioning and discussions

Questioning and discussions are forms of interactive teaching and they refer to situations where a teacher and their students interact with each other verbally. A synthesis of the last 35 years of teacher effectiveness evidence base by seminal teacher effectiveness researchers posits that effective questioning is one of the most thoroughly researched aspects of teaching and thus knowledge is available regarding different types of questions, appropriate wait time for questions and the optimum questioning climate (Muijs et al., 2014). Questioning has been linked to student achievement in many studies. For example, Newton and Winches' (2013) study across teachers in 4 US schools, who achieved higher than expected student achievement gains for more than three consecutive years, identified that these teachers continually asked questions to gauge student knowledge and understanding. Furthermore, these teachers also taught their students to ask questions and this is a practice that Capraro et al. (2010) associated with student learning, in their two year study involving video data for two US sixth grade mathematics teachers. Similarly, Aslam and Kingdon's (2011) study across 65 schools in Pakistan found that teachers who asked many questions raised student attainment by 0.21 standard deviations. Additionally, authors found that more experienced teachers tended to ask more questions. This is interesting, as although teacher experience correlated with teacher questioning, student attainment was only significantly linked to the classroom practice of teacher questioning. This shows the importance of teacher classroom practices in mediating the effects of teacher qualifications.

With respect to higher order questioning, a study by Wenglinsky (2000) which utilised data on 7146 American eighth graders who took part in the National Assessment of Academic Progress (NAEP), found that when teachers emphasised higher order thinking skills, their students outperformed their peers by 40% of a grade level. However, it must be noted that the NAEP data involved measurement variability due to students only being administered a subset of questions in the assessment, with their final score being developed through a statistical procedure. Nevertheless, Van de Grift (2007) similarly found that asking process questions and questions that promote higher order thinking skills was positively associated with student attainment, attitude, involvement and behaviour.

In their synthesis of the teacher effectiveness literature, Muijs et al. (2014) posit that effective teachers use a variety of open, closed, lower level, product and process questions. Similarly, Schacter and Thum's (2004) study of 52 primary school teachers in Arizona, which linked a teacher performance rubric to student achievement in mathematics, found that the most effective teachers: asked a variety of question types and provided appropriate wait time for students to think after asking a question. While Muijs and Reynolds (2011) argue that both correct and incorrect responses from students should be acknowledged in a brisk, business-like manner, Panayiotou et al. (2014) posit that effective teachers sustain interaction with respondents who give an incorrect answer by providing clues, so as to facilitate construction of the correct answer. Overall, however, it is agreed that a low risk climate should be established with regards to questioning, in which wrong answers are treated as a natural aspect of learning (Stipek et al., 2001).

2.4.2.4 Lesson planning and delivery

In Aslam and Kingdon's (2011) study, teachers who practised lesson planning were found to raise student achievement by 0.23 standard deviations. Researchers also found that younger and more educated teachers are more inclined to plan their lessons. Furthermore, Newton and Winches' (2013) study, which identified strong teachers of mathematics and then observed them in order to find out what they did within the classroom, found that highly effective teachers continually plan and amend lessons based on their assessments of student learning and, as such, student learning is emphasised over following original plans rigidly.

With respect to lesson delivery, Kannapel and Clements (2005) found that teachers in high performing high poverty schools deliver instruction that is aligned to both learning goals and assessments. Similarly, a study by Panayiotou et al. (2014) involving 10,000 fourth grade students across the countries of Belgium, Cyprus, Germany, Greece, Ireland and Slovenia, found that the teacher classroom practices of orientation (providing lesson objectives) and structuring (providing lessons with a structure involving an overview, modelling of content and reviewing main ideas) had a positive impact on student achievement in mathematics. However, observations rather than student survey reports, would have provided more nuanced data on the teacher classroom practices in question. Nevertheless, Van de Grift's (2007) study involving inspectorates across four European countries found that clear instruction was positively linked to student attainment, attitude, behaviour and involvement. Overall, there appears to be consensus within the literature that clear lesson delivery and the use of modelling and examples positively influence student achievement (Brophy, 1988; Schacter and Thum, 2004; Stronge et al., 2011).

2.4.2.5 Assessment and feedback

Assessment and feedback are both associated with effective teaching and student attainment (Schacter and Thum, 2004; Kannapel et al., 2005; Stronge et al., 2011). Assessment results allow teachers to match instruction to student needs and, by extension, to improve student achievement (Martinez et al., 2009). Wenglinsky's (2000) large scale quantitative study of US eighth graders, found that frequent use of written assessments by teachers led to mathematics students outperforming their peers by almost half of a grade level. Similarly, in their study of 100 eighth grade teachers and their 1410 students in Pakistan, Aslam and Kingdon (2011) found that quizzing on past lessons raised student attainment. However, this study utilised across-subject variance to control for student background factors influencing achievement and therefore findings may be statistically biased if students were sorted to teachers based upon subject-specific rather than general ability. Nevertheless, Dodeen et al. (2012) found that 89.9% of teachers in the top performing country for eighth grade mathematics in TIMSS 2007 (Taiwan) conducted a weekly mathematics test.

Providing meaningful and corrective feedback on assessments and schoolwork has been found to raise student attainment in mathematics (Westerhof, 1992; Muijs and Reynolds, 2003; Kannapel et al., 2005). Teachers who give frequent, high quality academic feedback and promote students giving feedback to one another are associated with improved student performance (Schacter and Thum, 2004). Furthermore, a large scale longitudinal study of 4724 third to seventh grade Belgian students by Pinxten et al. (2014) found that teacher feedback that promotes student self-concept beliefs is associated with increased student achievement. That said, based upon a comprehensive analysis of research into feedback, Hattie and Timperly

(2007) caution that while feedback is a critical influence on student learning, the manner and situation in which it is given is of vital importance. However, this analysis is not specifically related to mathematics feedback and refers only to general teaching and learning. That said, a Norwegian study by Bonesrønning (2004) supports this idea within the mathematics education field, by finding that easy grading can negatively affect student attainment, although statistical bias problems limited this finding.

2.4.2.6 Maths vocabulary

The “language of mathematics encompasses more than just numbers and symbols; it includes specific vocabulary that should be developed through instruction and experience” (Firmender et al., 2014, p218). Because maths vocabulary provides access to mathematics concepts, it requires careful instruction by teachers (Monroe, 1997). High stakes mathematical assessments regularly feature complex word problems (Pierce and Fontaine, 2009). Maths vocabulary can pose problems for students in several ways. Some words such as volume are sub-technical and have different meanings in mathematical and non-mathematical contexts (Pierce and Fontaine, 2009). Other words, such as third, have different meanings when considered under different mathematical headings (Firmender et al., 2014). As such, teachers who repeatedly expose students to mathematics vocabulary are likely to improve their students’ mathematics achievement (Hea-Jin Lee and Herner-Patnode, 2007; Firmender et al., 2014). For example, Firmender et al.’s (2014) quantitative study found that when US kindergarden, grade one and grade two teachers used appropriate mathematical vocabulary, as well as engaging their students in verbal communication in mathematics, their students’ attainment scores were higher. However, as observations by multiple observers were utilised to collect the data on

teacher classroom practices, the inclusion of inter-rater reliability tests would have added further credence to findings.

2.4.2.7 Problem solving

A study by Schwerdt and Wuppermann (2011), using eighth grade TIMSS 2003 data for the US, found that a 10 percentage point shift towards lecture style teaching from problem solving style was associated with an increase in student attainment of 1% of a standard deviation. However, the fact that only one variable was used in the study may have led to omitted variable bias (Palardy and Rumberger, 2008). Nevertheless, the authors maintain that their result was robust due to assessment of results for selectivity bias using a technique pioneered by Altonji et al. (2005). Following from Schwerdt and Wuppermann's (2011) findings, Westwood (2013) argues against focusing on problem solving in early primary school years and for struggling learners, due to a lack of evidence confirming that students acquire essential mathematical skills by participating in problem solving activities. On the other hand, Panayiotou et al.'s (2014) large scale European study involving fourth grade students, found that the teacher classroom practice of aiding students in using and developing strategies to solve different kinds of problems was associated with higher student achievement. Similarly, a study conducted in three fifth grade Singapore schools found that when teachers taught students a four phase problem approach, their students' scores on a problem solving test improved (Ho and Hedberg, 2005). However, this may have been due to familiarity with the test, as students had completed it previously during the pre-test phase of the study. Therefore, causal links between student achievement gain and the teaching of the four phase problem approach cannot be made with confidence.

2.4.2.8 Teacher use of ICT

ICT infrastructure investments in schools and educational institutions have been high on global educational policy agendas since the early 2000s (De Witte and Rogge, 2014); however, evidence of the effectiveness of ICT in improving student performance remains inconclusive (Hikmet et al., 2008; Román Carrasco and Murillo Torrecilla, 2012). For example, De Witte and Rogge's (2014, p178) large-scale study using Mahalanobis matching of TIMSS 2011 data, pertaining to fourth grade students in The Netherlands, found that while there were differences in student performance based upon teacher use of ICT, these differences vanished when student, school and teacher level characteristics were controlled for. Similarly, Thorvaldsen et al.'s (2012) control case study of Norwegian ninth grade teachers and students found that the ICT teacher guided activity was a more important predictor of mathematics achievement than the ICT tools used. Alternatively, Eyyam and Yaratan's (2014) quasi-experimental study of seventh grade mathematics students in Cyprus found that the use of technology in mathematics lessons led to significantly improved performance for the experimental group in comparison with the control group. However, a sample larger than 5 groups within the same school would have allowed for greater generalisability of findings. Overall, Hikmet et al. (2008) argue that the idiosyncrasy of teaching and learning coupled with a disproportionate amount of opinion related research have led to inconclusive findings about the impact of ICT on student achievement.

2.4.2.9 Teacher classroom practices summary

The research base has identified a large number of teacher classroom practices that are associated with effective teaching and learning. However, as a subclass of teacher effectiveness, teacher classroom practices are under researched in comparison to teacher qualifications. Because researchers view teacher classroom practices as

having the most proximal association with student achievement (Stigler and Hiebert, 1999; Palardy and Rumberger, 2008), calls resound across the research base for more studies to be conducted within this subclass of teacher effects, especially within different socio-cultural contexts (Cadima et al., 2010). Furthermore, much of the research into teacher classroom practices to date has been quantitative. However, quantitative studies fail to address the complexity of classroom interactions and fall short in answering questions about how classroom practices influence student learning and achievement. Therefore, the current study builds on the quantitative findings discussed in this literature review by qualitatively exploring how teachers believe the classroom practices identified by the literature impact student learning and achievement in mathematics. The study initially focused on the practices of questioning, conducting assessments and holding high expectations; however, due to the semi-structured nature of the interviews, many other teacher classroom practices were discussed and are thus explored in this literature review.

2.4.3 Teacher beliefs and attitudes

A body of literature suggests that teachers' educational attitudes and beliefs affect their classroom instructional practices (Askew et al., 1997; Charalambous et al., 2009). Manouchehri's (2004) five month study of autonomy supportive and controlling US high school mathematics teachers found that teachers' attitudes and beliefs about their role in the classroom influenced their interactions with students as well as how they taught mathematics. Research has also found that a teacher's belief system and instructional practices have a dynamic two-way relationship, where beliefs influence practice and reflection on practice influences beliefs (Thompson, 1992). In contrast, however, a study by Stronge et al. (2011) found that there were no significant differences between highly effective and ineffective teachers' beliefs

about their capabilities regarding student engagement, classroom management and instructional strategies. However, this could be explained by ineffective teachers having inflated self-belief based on unfounded self-appraisal. This was found to be disabling in a Canadian mixed methods study by Bruce et al. (2010), as teachers with inflated self-beliefs felt that they had nothing new to learn. In this section the influence of teacher beliefs, efficacy and attitudes on student achievement will be explored.

2.4.3.1 Teacher beliefs

A teacher's belief system can influence their teaching and therefore indirectly affect student achievement (Muijs and Reynolds, 2003). Askew et al. (1997) describe a teacher belief framework related to teaching and learning by distinguishing between connectionist, transmission and discovery orientations. Connectionist orientated teachers value students' problem solving methods and emphasise making connections within mathematics, whereas transmission orientated teachers place most value on teaching separate procedures and routines. Alternatively, discovery orientated teachers place most value on children learning mathematics by discovery. However, Askew et al. (1997) advise that no teacher fits exactly into just one of the three orientations. Nonetheless, in their mixed methods UK study of 90 teachers, it was found that teachers with strongly connectionist orientations were more likely to have classes with better mathematics gains than teachers with strongly discovery or transmission orientations. However, Askew et al.'s (1997) study also showed that having connectionist beliefs does not always translate into connectionist teaching practices and one teacher with strongly connectionist beliefs in fact displayed a transmission orientation in their teaching practices. Similar inconsistencies were found between what teachers believed and what they did in the classroom in a review of teacher beliefs and practices by Fang (1996). That said, this review did not focus

specifically on mathematics and instead referred to studies about general teacher beliefs and practices.

Although there is ambiguity about how teacher beliefs translate into classroom practices and thus student achievement, a connectionist belief orientation has nevertheless been found to be most positively associated with student attainment (Askew et al., 1997; Muijs and Reynolds, 2003), and therefore merits further discussion. A fundamental connectionist belief is that most students can achieve in mathematics given sufficient instruction and that this instruction should emphasise the links between different aspects of mathematics (Askew et al., 1997). This aligns with the teacher classroom practice of holding high expectations, reviewed in section 2.4.2.2. In fact, teachers with a strongly connectionist belief orientation tend to adopt many instructional practices that the literature in the teacher classroom practices section of this review (section 2.4.2) finds to be effective. For example, with respect to questioning and interactive teaching, connectionist orientated teachers view numeracy teaching as being based on a dialogue between teacher and students (Askew et al., 1997). In addition, connectionist orientated teachers work actively with student explanations, differentiating between methods and looking for the most efficient one. Such classroom practices have been found to positively affect student learning and achievement in several studies across the teacher effectiveness literature base (Muijs and Reynolds, 2011; Newton and Winches, 2013; Panayiotou et al., 2014).

As well as beliefs about teaching and learning, teacher goal orientation beliefs have been found to affect teachers' classroom practices and, by extension, student achievement. Goal theory relates to a social-cognitive approach to motivation (Thronsen and Turmo, 2013) and goal orientation refers to a pattern of beliefs that

lead to different approaches to, engagement in and response to achievement. While mastery goals refer to engaging with an academic task in order to master a new skill, performance goals are based upon a desire to outperform others. A large-scale study of 500 Norwegian second and third grade teachers and 9980 students by Throndsen and Turmo (2013) found strong correlations between performance goal orientation and performance instructional practices and similarly between mastery goal orientation and mastery instructional practices. Examples of mastery classroom practices include: creating situations where students feel that they can succeed; emphasising effort; promoting individual improvement; and communicating that mistakes are part of learning. Many of these practices have been highlighted in the teacher classroom practices section (section 2.4.2) of this review as having a positive effect on student achievement. In contrast, performance classroom practices emphasise competition between students, point out ability differences and show the work of the best students to their classmates. Throndsen and Turmo's (2013) study found teacher mastery goal orientation to be positively associated with mastery classroom practices and in turn student achievement.

Bandura (1997) defines self efficacy as a person's perceived ability to execute tasks and achieve particular goals. Following from this theory, teacher self efficacy beliefs relate to their perception about their ability to bring about student learning effectively (Charalambous et al., 2009). Teacher efficacy has been found to be associated with mathematics gain in several studies (Palardy and Rumberger, 2008; Throndsen and Turmo, 2013). Similarly, a recent US study by Usher (2009) found that student self-efficacy beliefs can be enhanced by teachers using effective classroom structures, such as delivering instruction that consistently provides mastery opportunities for students. Alternatively, Bruce et al.'s (2010) mixed-methods study, conducted at the primary school level, found that teacher efficacy was a mediator rather than a cause

of higher student attainment, due to its influence on teacher goal setting and persistence. Authors also found that without the condition of a teacher's previous professional learning experience, teacher efficacy alone has a minimal impact on student achievement. This would appear to support some findings explored in the teacher qualifications section that argue that teacher experience *does* matter. Collective Teacher Efficacy (CTE) is a term that describes the collective perception of teachers within a school that they can make an educational impact upon their students, regardless of the students' social circumstances (Parker et al., 2006). In their mixed methods study involving 66 teachers in a UK local authority, authors found that at the school level all schools with increased student attainment had higher than average values for CTE. However, due to an overall response rate of only fifty percent in participating schools, positive bias may have been a factor in these findings.

2.4.3.2 Teacher attitudes

A three year case study by Boaler (1997) of a mathematics department in the UK which taught in streamed groups, found that mathematics learners held negative attitudes toward mathematics that were uncorrelated with their performance. As mathematics attainment is more strongly impacted upon by teachers than literacy attainment (Muijs and Reynolds, 2011), it follows that teachers who openly demonstrate negative attitudes towards mathematics are likely to negatively influence their students' views towards the subject (Charalambous et al., 2009). This is supported by Stipek et al.'s (2001) study which assessed the mathematics beliefs and practices of 21 US fourth to sixth grade teachers. Findings showed that teachers' self-confidence as mathematics teachers was significantly correlated with their students' self-confidence as mathematical learners, although whether this was

because teachers modelled self-confidence during mathematics lessons or were in fact more confident because they were better teachers and produced better learning outcomes for students was not explored. Following from this, however, Hadley and Dorward's (2011) study of 692 primary schools across the US found that teacher anxiety about teaching mathematics had a negative impact on student achievement, although general anxiety about mathematics as a subject did not affect student attainment. Similarly, Polly et al.'s (2013) study, involving 35 US primary school teachers and their students, found that teacher beliefs about the pedagogy of mathematics affected their instructional practices, whereas their beliefs about mathematics as a subject did not. This suggests that teacher attitudes and beliefs about the teaching and learning of mathematics, as opposed to beliefs and attitudes about mathematics as a subject, are what affect teacher instructional practices and in turn student achievement.

Although positive teacher beliefs and attitudes are seen to correlate with student achievement, there is some ambiguity across the evidence base about the process by which these factors influence firstly teacher classroom practices and in turn student attainment. With Stronge et al.'s (2011) finding that there were no significant differences between the classroom capability beliefs of effective and ineffective teachers, and both Fang (1996) and Askew et al.'s (1997) studies uncovering inconsistencies in the alignment of teacher belief orientations and their actual classroom practices, it is difficult to make robust assumptions about the effects of teacher beliefs on either their classroom practices or in turn their students' attainment. Similarly, with respect to efficacy beliefs, Bruce et al. (2010) posit that teacher efficacy beliefs can only affect student attainment when they are based upon prior professional learning and reflection. Therefore, according to Palardy and Rumberger (2008), further research is needed in this area.

2.5 Conceptual Framework

In order to synthesise the findings from the literature review, a conceptual framework was developed and is shown below in Figure 2.1. The framework was adapted for this study from Palardy and Rumberger's (2008, p118) "A multilevel theoretical framework of classroom and school effects". In order to make the framework relevant to this study many of the sections, especially those relating to the three subclasses of teacher effectiveness, were expanded to include evidence from the literature review. Additionally, the three teacher subclasses are coloured in pink in the conceptual framework while all other elements are coloured in blue.

The framework highlights the complexity of the teaching and learning process, illuminating the range of student, classroom and school level factors that impact upon student achievement (explored in Section 2.2 of this literature review). In doing so, the framework also illustrates the inherent statistical difficulties that are likely arise when endeavouring to numerically link teacher level factors to student achievement (discussed in Section 2.3 of this literature review). As this study focuses on how teachers influence student learning and achievement in mathematics, the three teacher effectiveness subclasses (teacher qualifications, teacher classroom practices, teacher attitudes and beliefs) are highlighted in pink. Each subclass is expanded utilising evidence from Section 2.4 of the literature review.

The arrows in the conceptual framework signify conceptualised relationships between different stages and levels of the schooling process where "solid arrows indicate a potential causal influence, and the dashed arrows indicate an association due to aggregation". (Palardy and Rumberger, 2008, p117). For example, solid arrows are used between the teacher attitudes and beliefs and the teacher classroom practices sections, as the literature has shown evidence of links between these

2.6 Conclusion

This literature review explored the conceptualisation and quantitative measurement of teacher effectiveness, as well as the three subclasses of teacher effectiveness, namely, teacher qualifications, teacher classroom practices and teacher attitudes and beliefs. Many decades into the search into what constitutes teacher effectiveness, an agreed definition for such is still obscure (Rowe, 2003), with teacher effectiveness being labelled as a mystery by Goldhaber (2002) and an inexplicable phenomenon by Lewis et al. (1999). Intrinsic to the deep complexity of teacher effectiveness is the elusive nature of the learning process (Grouws, 1992), coupled with the fact that, as a social construct, the meaning of teacher effectiveness varies across time and contexts (Schacter and Thum, 2004; Hikmet et al., 2008). Furthermore, teacher effectiveness is conceptualised dichotomously by various educational stakeholders. While at the macro level, policymakers seek to define teacher effectiveness by equating it with student achievement, stakeholders at the micro level hold the contention that the teaching and learning process is too complex and multidimensional to be defined by a single, narrow measure of student learning (Imig and Imig, 2006).

The evidence base almost exclusively measures, and by default defines, teacher effectiveness by equating it with student gains on standardised tests (Muijs and Reynolds, 2003; Schacter and Thum, 2004; Akiba et al., 2007; Palardy and Rumberger, 2008). However, this review highlighted significant methodological, moral and philosophical concerns regarding the use of VAM as a single measure for teacher effectiveness. Firstly, the statistical accuracy of VAM in identifying effective teachers is contested by a growing number of studies (Kupermintz, 2003; Lemke et al., 2006; Schochet and Chiang, 2010). Additionally, moral and philosophical concerns have been voiced regarding the implications of a sustained focus on

standardised testing, such as the narrowing of education or schools becoming test factories (Imig and Imig, 2006; Lee, 2011; Skourdoumbis and Gale, 2013). Furthermore, the competitive ranking of students, teachers or schools “is not an aim of active and authentic teaching and learning” (Skourdoumbis and Gale, 2013, p903), and is therefore of little assistance to teachers and other stakeholders who wish to enhance student learning at the micro level.

Positivist, quantitative studies investigating teacher effectiveness to date have utilised a variety of quantitative data collection and analysis instruments, including direct observations, surveys, HLM and education production functions. However, teaching and learning do not translate easily into numbers and statistical models (Skourdoumbis and Gale, 2013) and, as such, all of the quantitative methods employed by the literature are subject to statistical bias and limitations. This literature review highlighted a paucity of qualitative investigations of teacher effectiveness, with teachers’ subjective opinions about how their classroom practices influence student learning and achievement largely absent across the evidence base. This provided an important focus for this study, as teachers “have unique knowledge, based on hundreds of hours of accumulated data” (Foreman and Gubbins, 2015, p19).

While the positivist, quantitative, methodologies of teacher effectiveness studies are increasingly contested, research evidence from this tradition has nevertheless confirmed the importance of teachers in promoting student achievement. Statistically, teacher effects on student attainment have been found to be profound (Goldhaber, 2002) and greater than any other school effect (Wright et al., 1997). In addition, teacher effects are cumulative and can persist for years after a student has a teacher (Konstantopoulos and Chung, 2011). However, while the literature confirms the importance of teachers, the specific teacher traits that are important for promoting

student learning and achievement in mathematics are still uncertain (Goe and Stickler, 2008).

In fact, the teacher effectiveness literature base has identified over 100 factors that influence teacher effectiveness (Capraro et al., 2010). Palardy and Rumberger (2008) identify three subclasses of teacher-related factors that impact upon teacher effectiveness, namely, teacher qualifications, teacher classroom practices and teacher attitudes and beliefs. Extensive research has been conducted into the effects of teacher qualifications on student attainment. Despite this, findings are inconsistent (Schacter and Thum, 2004; Dodeen et al., 2012), and calls resound across the research community for more focus on teacher classroom practices, the subclass of teacher effectiveness that has the most proximal effect on student learning and achievement (Rockoff, 2004; Akiba et al., 2007; Palardy and Rumberger, 2008).

Existing research studies investigating teacher classroom practices recognise a multitude of factors that promote student achievement in mathematics, including good classroom and behaviour management skills, high expectations for student performance including clear goal setting, frequent questioning using a variety of forms, structured clear and coherent lesson delivery that involves numerous instructional strategies, and frequent formal and informal assessment and feedback (Westerhof, 1992; Wentzel, 2002; Muijs and Reynolds, 2003; Schacter and Thum, 2004; Frome et al., 2005; Stronge et al., 2011). However, as a subclass of teacher effectiveness, teacher classroom practices are under researched. Therefore, repeated calls have been made across the literature for further research to be conducted in this area (Hanushek, 2002; Palardy and Rumberger, 2008). Research focusing on teacher classroom practices is of interest to stakeholders at the micro level, as they value knowledge about what occurs within the classroom. However, so far, questions

regarding how and why certain teacher classroom practices promote student learning and achievement remain unanswered. Therefore, this study addressed this gap by focusing on gaining in-depth knowledge about teacher classroom practices in a variety of school contexts across two adjacent countries: Ireland and Northern Ireland.

While the teacher effectiveness subclass of teacher beliefs and attitudes was also revealed as being under researched across the literature base, the empirical evidence was ambiguous, with many studies finding that teacher beliefs did not align with their classroom instructional practices (Fang, 1996; Askew et al., 1997). This study aims to address this ambiguity by considering the influence of teacher attitudes and beliefs on teacher classroom practices and in turn student achievement.

2.7 Research aims and questions

This research project focuses on exploring the perceptions of primary fourth class teachers in Ireland and Northern Ireland regarding their opinions about how teachers influence student learning and achievement in mathematics. The study aims to:

- focus on the perceptions of teachers, who are expert professionals, but whose voice is largely absent across the teacher effectiveness literature base
- explore how teachers believe they impact student learning and achievement in mathematics, with a focus on their classroom practices
- investigate how teachers view ‘teacher effectiveness’ and how they view the use of standardised tests as a measure of teacher effectiveness
- explore how teachers believe student learning and achievement in mathematics is helped and hindered

- examine the similarities and differences between teacher qualifications, classroom practices, and attitudes and beliefs in Ireland and Northern Ireland as reported in TIMSS 2011

The literature review highlights the importance of teachers in promoting student learning and achievement (Goldhaber, 2002; Schacter and Thum, 2004), but reveals a lack of subjective teacher input in studies across the teacher effectiveness paradigm (Campbell et al., 2004; Skourdoumbis and Gale, 2013). In addition, there is a comparable lack of studies examining teacher classroom practices (Hanushek, 2002). The research questions emerged from the literature review and seek to address the highlighted research gaps. They are as follows:

- 1) With respect to mathematics and as reported in TIMSS 2011, what similarities and/or differences exist between fourth class teachers in Ireland and Northern Ireland, with respect to their:
 - a) classroom practices
 - b) qualifications
 - c) attitudes and beliefs?
- 2) How do teachers in Ireland and Northern Ireland describe the role of a range of teacher-related variables from the following teacher effectiveness subclasses, in promoting student learning and achievement in mathematics?
 - a) classroom practices
 - b) qualifications
 - c) attitudes and beliefs

- 3) How do teachers in Ireland and Northern Ireland describe the factors that help and hinder teachers in promoting student achievement?
- 4) How do teachers in Ireland and Northern Ireland conceptualise the term ‘teacher effectiveness’?

The need for teacher effectiveness research to move from evaluating teachers to understanding how teachers can help to promote student learning and achievement in mathematics is highlighted by the literature review. Therefore, question 2 looks at teachers’ perceptions and opinions about how teacher-related factors influence student learning and achievement, while question 3 explores factors that help or hinder student achievement. The literature also draws attention to the need for more research into teacher classroom practices, due to the direct influence of teacher classroom practices on student learning (Rockoff, 2004). Therefore, questions 1a and 2a examine teacher classroom practices both qualitatively and quantitatively.

A call to move the focus away from positivist, quantitative studies is made by Skourdoumbis and Gale (2013) in order to address the significant research gap regarding qualitative studies into teacher effectiveness (Campbell et al., 2004). Hence, questions 2–4 explore aspects of teacher effectiveness qualitatively. In addition, the importance of context when considering teacher effectiveness is highlighted by Berliner (2002), with a need for research to take cognisance of the variety of socio-cultural contexts in which teachers work (Cadima et al., 2010). Therefore, questions 1–4 explore aspects of teacher effectiveness across a variety of school contexts in two different countries – Ireland and Northern Ireland. The next chapter follows with a description of the methodology employed by this study.

Chapter 3. Methodology

3.1 Introduction

An interpretive approach was used to carry out this mixed methods research study, in order to answer the research questions posed in section 2.7. Identifying the teacher-related factors that most significantly influence student learning and achievement has been problematic (Goe and Stickler, 2008). Much of the teacher effectiveness literature consists of large-scale quantitative studies that fail to address the deep complexity of classroom interactions (Campbell et al., 2004). In addition, many of the existing studies have focused on the impact of teacher qualifications on student outcomes, despite the fact that teacher classroom practices influence student outcomes more directly (Rockoff, 2004; Akiba et al., 2007). This study addresses the identified gaps in the literature by qualitatively exploring teachers' interpretations regarding how teacher-related factors impact upon student outcomes. Teacher classroom practices formed the focus of the study; however, teacher qualifications and teacher attitudes and beliefs were also explored, so as to provide a comprehensive perspective on teacher effectiveness (Palardy and Rumberger, 2008).

This chapter examines the philosophical paradigm that underpinned and influenced the research process. Within this, my ontological and epistemological views are made explicit and their influence on the research methodology is explained. This follows on from the reflexive account of my position in the investigation, which was detailed in Chapter 1. The research methodology is outlined and strategies for data collection and analysis are described in detail. In addition, ethical considerations, as well as researcher positionality, are discussed.

3.2 Philosophical underpinnings

The sense that researchers “make of the world is reflected in, and affected by the norms and values that have been absorbed as part of life experience” (Morrison, 2007, p32). It is essential, therefore, to “acknowledge that research cannot be value free but to ensure that there is no untrammelled incursion of values in the research process and to be self-reflective and so exhibit reflexivity about the part played by such factors” (Bryman, 2008, p25). This process was aided by being explicit about the philosophical assumptions that underpinned my research.

The metaphysical philosophies of ontology and epistemology fundamentally influence the entire research process, including methodological choices, use of instruments and data collection methods (Willis, 2007). While ontology is concerned with social reality (Hammersley, 2012), epistemology questions the relationship between the knower and what can be known (Guba and Lincoln, 1994). How researchers view social reality influences how they acquire, interpret and communicate knowledge relating to that reality (Cohen et al., 2000; Morrison, 2007) and, as such, epistemological and ontological assumptions should be consistent (Andrade, 2009). In the current study, the ontological assumption is that reality is multiple, ambiguous and variable (O' Leary, 2004). Following from this, it is assumed that reality and social phenomena can be observed both objectively and subjectively, resulting in different yet valid insights of reality (Klingner and Boardman, 2011). These ontological and epistemological viewpoints formed the foundation of the research methodology and influenced the choice of paradigm.

Paradigms are described by Willis (2007) as comprehensive belief systems that provide a guiding framework for the entire research process. Research paradigms have proliferated into a variety of interpretations in recent years (Humphrey, 2013),

due in part to the fact that they tend to be used by researchers in socially situated ways (Hammersley, 2012). Much of the research undertaken to date within the teacher effectiveness paradigm has been conducted within the positivist tradition. However, the literature review in Chapter 2 highlighted a need for an alternative interpretive philosophical lens to be cast upon teacher effectiveness phenomena. Therefore, these two main philosophical paradigms in social research, ‘interpretivism’ and ‘positivism’, merit further discussion. The positivist and interpretivist paradigms are founded upon dichotomous philosophical perspectives regarding social reality, and each perspective has led to a myriad of offshoots and methodologies linked to the contrasting schools of thought.

“The virtues of positivist research reside in the promise of securing objective knowledge” (Humphrey, 2013, p5). Positivists hold the ontological assumption that reality exists externally to social actors, and epistemologically researchers are concerned ultimately with the explanation of observable phenomena (Cohen et al., 2000; Morrison, 2007). Traditionally, positivism reflects a philosophy where causes most likely determine effects (Creswell, 2003) and researchers are concerned ultimately with the explanation of observable phenomena (Cohen et al., 2000). However, this approach is criticised for failing to take into account the complexity of human nature (Cohen et al., 2000) and, as a result, being dehumanising, treating people in aggregate or numerical terms (Hammersley, 2012). These criticisms align with my own beliefs, which have evolved throughout my research journey. Although I initially identified with the positivist paradigm due to my interest in mathematics, both the literature review and my own reflections highlighted that objective research approaches alone do not address the depth of human experiences or the complexity of classroom interactions. The positivist approach recognises no factors behind “facts” (Giroux, 1983, p32) and, as such, was not a good fit for this research project.

The interpretive philosophy, by contrast, embraces subjectivity, contexts and human constructions of reality. The interpretivist paradigm is predicated on the belief that research emphasising polyvocality will “generate more holistic truth about a specific social reality” (Humphrey, 2013). As a result, interpretive research is grounded in people’s experience and a key aim is to gain insight into the person’s perspective on the meaning of events and phenomena (Morrison, 2007). Words take precedence over measures and numbers. The researcher does not claim objectivity; rather, their interpretations, in addition to those of the research participants, are seen as playing a key role in the research process (Andrade, 2009). While research conducted within the interpretivist paradigm has been criticised for its lack of generalisability, this is not considered the focus; rather, the emphasis is on gaining deep understandings of complex social phenomena by exploring the intentions and meanings behind human behaviour (Cohen et al., 2000). The interpretivist paradigm therefore provided a framework through which I could achieve my research aims, which focused on understanding how teachers influence student outcomes in mathematics. There is an emphasis on subjective interpretations of reality, as it is my contention that these interpretations are vital for understanding the deep complexity of classroom interactions. Furthermore, gaining subjective insights allows for exploration of behaviour-with-meaning (Cohen et al., 2011), which focuses on the intentions behind human actions, a missing piece of the puzzle in teacher effectiveness research.

3.3 Research approach

The current study used a mixed methods approach, premised on interpretivist ontologies and epistemologies, as outlined above. The mixed methods approach allowed for an in-depth, holistic exploration of complex educational phenomena (Klingner and Boardman, 2011), and facilitated both ‘what’ and ‘how’ research questions to be answered in detail (Cohen et al., 2011). The chosen approach

emphasised subjective teacher experiences, while also benefiting from the strength of empirical data. Previous research into teacher effectiveness has most commonly been conducted on a large-scale quantitative basis, through use of questionnaire surveys and student test score data (Skourdoumbis and Gale, 2013). In contrast, this project aimed to cast a subjective lens on teacher effectiveness by giving a voice to teachers. Qualitative interviews were regarded by the researcher as the most appropriate way in which to represent teachers' views, allowing for their unique expertise regarding classroom interactions and student learning to be explored through spoken word. The use of qualitative interviews also added coherence between epistemology and ontology and aligned well with the interpretive approach (Willis, 2007). The small number of interviews allowed for in-depth explorations to be conducted with teachers in Ireland and Northern Ireland (Denscombe, 2003; Polkinghorne, 2005). This was considered vital for understanding the contexts and cultures within which teachers lived and worked (Creswell, 2003).

While qualitative data formed the focus of this study, the use of secondary quantitative data provided a starting point for the research approach. Creswell (2003, p16) describes this as a sequential procedure within the mixed methods approach, where "the researcher seeks to elaborate on or expand the findings of one method with another method." The TIMSS 2011 study highlighted Northern Ireland as being the highest achieving European country in fourth class mathematics, with a scale score of 562 in comparison to Ireland's scale score of 527 (Eivers and Clerkin, 2012; Sturman et al., 2012). Phase one of this study investigated these results and involved a quantitative comparison of fourth class teachers and teaching in Ireland and Northern Ireland, as measured by the TIMSS 2011 teacher self-reported survey. This was undertaken in order to ascertain whether differences in teacher-related factors existed between the two countries, which could account for the varying achievement

scores across the two populations. This use of this quantitative data allowed for an objective perspective to be gained which supported the qualitative data (Mackenzie and Knipe, 2006) in a manner that complemented and aligned with the interpretive tradition. This mixed methods approach was optimally suited to address the research questions of this study, allowing for a deeper and more holistic investigation than either a purely quantitative or qualitative approach, which Klingner and Boardman (2011) argue supports stronger inferences regarding educational phenomena.

3.4 Methods

A conceptual framework (see Figure 2.1) was used to guide research design and acted as an anchor for the entire research project. Conceptual frameworks are considered to be “the current version of the researcher’s map of the territory being investigated” (Miles et al., 2014, p20). In the case of this research project, the conceptual framework went further than Miles et al.’s (2014) definition, in that it synthesised findings from the literature review and served as a bridge between the quantitative and qualitative phases of the study, where it guided variable selection during the quantitative phase and the creation of the interview schedule during the qualitative phase. In addition, the conceptual framework provided a structure from which to present and discuss my findings in Chapters 4 and 5. This aligns with Smyth’s (2004, p2) articulation that the conceptual framework can become the “heart” of the study, by scaffolding and strengthening research, and informing research design, methodology and data analysis.

3.5 Linking the framework to research questions and data sources

In order to show the links between the framework and the research questions, and from the research questions to the data sources, Table 3.1 and Table 3.2 were drawn up. Table 3.1 centres around the first research question, which pertains to the

quantitative phase of the study. Table 3.2 focuses on research questions 2, 3 and 4, which relate to the qualitative phase of the study. Research questions pertaining to the three subclasses of teacher effectiveness (*Teacher Qualifications*, *Teacher Classroom Practices*, *Teacher Attitudes and Beliefs*) are investigated both quantitatively – using TIMSS 2011 survey data, and qualitatively – through use of data collected from semi-structured interviews with teachers in Ireland and Northern Ireland. For example, the subclass of *Teacher Qualifications* is explored through research questions 1b and 2b respectively. Similarly, *Teacher Attitudes and Beliefs* are investigated in research questions 1c and 2c. *Teacher Classroom Practices* are the main focus of this study and they are considered in research questions 1a and 2a.

Teacher perceptions relating to *Student Outcomes* are addressed specifically in research questions 2 and 3. *Student Outcomes* are also considered in research question 1, in that if large differences are highlighted between certain teacher-related factors in Ireland and Northern Ireland, the higher student achievement outcomes for Northern Ireland TIMSS 2011 may suggest that these teacher-related factors impact upon student achievement. Teacher perceptions regarding *Teacher Effectiveness* are explored in research question 4.

Table 3.1 Linking framework to research questions and quantitative data sources

Themes from Framework	Research Questions	Data Source
Teacher Classroom Practices (Student Outcomes)	1a What similarities and/or differences exist between mathematics teacher classroom practices in Ireland and Northern Ireland as reported in TIMSS 2011?	Quantitative TIMSS 2011 Teacher Questionnaire: G6d, G15a, G15b, G15c, G15d, G15e, G15f, M1, M3a, M3b, M3c, M3d, M3e, M3f, M3g, M3h, M4a, M4b, M4c, M4d, M10a, M10b, M10c
Teacher Qualifications (Student Outcomes)	1b What similarities and/or differences exist between mathematics teacher qualifications in Ireland and Northern Ireland as reported in TIMSS 2011?	Quantitative TIMSS 2011 Teacher Questionnaire: G1, G3, G4, G5A, G5B, G10a, G10b, G10c, G10d, G10e, M11a, M11b, M11c, M11d, M11e, M11f
Teacher Attitudes and Beliefs (Student Outcomes)	1c What similarities and/or differences exist between mathematics teacher attitudes and beliefs in Ireland and Northern Ireland as reported in TIMSS 2011?	Quantitative TIMSS 2011 Teacher Questionnaire: M2a, M2b, M2c, M2d, M2e, M12Ad, M12Bb, M12Bd, M12Be, M12Bg

Table 3.2 Linking framework to research questions and qualitative data sources

Themes from Framework	Research Questions	Data Source
Teacher Classroom Practices Student Outcomes	2a How do teachers in Ireland and Northern Ireland describe the role of a range of teacher classroom practices in student learning and achievement in mathematics?	Qualitative Semi-Structured Interviews Teachers were asked their opinions on the role of a variety of classroom practices on student learning and achievement. The practices of questioning, assessment and holding high expectations were focused on in detail
Teacher Qualifications Student Outcomes	2b How do teachers in Ireland and Northern Ireland describe the role of teacher qualifications in student learning and achievement in mathematics?	Qualitative Semi-Structured Interviews The role of teachers' background knowledge of maths and teacher experience were explored with respect to their influence on student outcomes
Teacher Attitudes and Beliefs Student Outcomes	2c How do teachers in Ireland and Northern Ireland describe the role of teacher attitudes and beliefs in student learning and achievement in mathematics?	Qualitative Semi-Structured Interviews The roles of positive attitudes towards maths, interest levels in maths, and maths confidence were discussed in relation to their influence on student outcomes
Teacher Effectiveness Student Outcomes School Level Classroom Level Student Level	3. How do teachers in Ireland and Northern Ireland describe the factors that help and hinder student learning and achievement in mathematics?	Qualitative Semi-Structured Interviews Teachers were asked about factors that helped and hindered student achievement on standardised tests. Factors at the school, classroom and student level were explored
Teacher Effectiveness	4. What do teachers in Ireland and Northern Ireland understand by the term 'teacher effectiveness'?	Qualitative Semi-Structured Interviews What the term 'teacher effectiveness' meant to teachers was explored through semi-structured interviews, as well as factors that teachers perceive to affect it

3.6 Data collection strategies

Data collection for this study comprised two phases. Secondary data from the Trends in International Mathematics and Science Study (TIMSS) 2011 was downloaded from the TIMSS and PIRLS website (TIMSS & PIRLS International Study Centre, 2013), and analysed during the first phase of the study. Following this, semi-structured interviews were conducted with eleven fourth class teachers of mathematics in both Ireland and Northern Ireland.

The 2011 TIMSS study collected data on teacher, student, school and home level variables by means of self-completion survey questionnaires. The use of secondary survey data from the TIMSS 2011 dataset was highly suitable for answering the first research question of this study, as it allowed for comparisons to be made between teacher-related factors in Ireland and Northern Ireland, as well as allowing for consideration of patterns or effects of these factors on student achievement (Bryman, 2008; Muijs, 2011; Cohen et al., 2011; Foy et al., 2013). However, there was a worry that variables would be limited due to the use of secondary data (Gorard, 2001; Muijs, 2011). While this was a limitation, there was nevertheless a considerable range of variables of pertinence available for each teacher effectiveness subclass under investigation, as shown in Tables 3.3, 3.4 and 3.5 in the next section.

The TIMSS 2011 dataset provided answers to the research questions, based upon generalisable data from a large and representative sample of Irish and Northern Irish teachers and students, on a scale that would have been impossible for me to collect for the purposes of this doctoral study (Smith, 2011). However, quantitative survey questionnaires capture only surface information, and therefore a qualitative approach was required to explore the “vertical depth” of human experience (Polkinghorne, 2005, p138). Hence, during phase two of the study, qualitative interviews were

considered the most appropriate data collection method, as they allowed for teachers to “discuss their interpretations of the world in which they live ... from their own point of view (Cohen et al., 2011, p409). Interview forms can vary from heavily structured to unstructured, depending on the research aims (Hitchcock and Hughes, 1995). As this research project had a clear focus, in that it sought to gain teachers’ expert opinions regarding the phenomenon of how teachers influence student outcomes, semi-structured interviews were chosen, because they facilitated specific issues being addressed (Bryman, 2012). An interview guide allowed for the research questions to be explored, while also providing the interviewer with the opportunity “to probe and expand the respondent’s responses” (Hitchcock and Hughes, 1995, p157). In this way, rich and detailed answers were emphasised (Miles et al., 2014), allowing the researcher to access more fully the complexities and depth of classroom situations (Campbell et al., 2004). Additionally, the flexibility of semi-structured interviews allowed the researcher to probe and discuss some of the more notable findings from the quantitative phase of the study, in an effort to explain and understand them (Klingner and Boardman, 2011). The use of qualitative semi-structured interviews aligned with the interpretivist approach, allowing for the clarification and understanding of lived experience through first-hand subjective accounts (Polkinghorne, 2005).

3.7 Variable selection

The main purpose of using the TIMSS 2011 dataset was to gain nationally representative data on student achievement and teacher-related factors in Ireland and Northern Ireland for comparison purposes. Because secondary data was being utilised, it was important to ensure that suitable variables were selected in order to answer the research questions. A thorough knowledge of the literature, as well as use

of the conceptual framework (Figure 2.1), guided variable selection. Tables 3.3, 3.4 and 3.5 were drawn up to show the TIMSS 2011 teacher survey questions that aligned with the subclasses of teacher effectiveness which were included in the conceptual framework. For example, Table 3.3 lists the questions on the TIMSS 2011 teacher self-reported survey that are related to the teacher effectiveness subclass of *Teacher Qualifications*. A description of each question is also included. In the same manner, Table 3.4 and Table 3.5 detail TIMSS 2011 questions from the teacher survey that were linked to the subclasses of *Teacher Attitudes and Beliefs* and *Teacher Classroom Practices* respectively.

Table 3.3 Teacher qualifications variables

Teacher Effectiveness Subclass	TIMSS Teacher Survey Question	Description of TIMSS Teacher Survey Question
Teacher Qualifications	G1	Teacher Experience: Years teaching
	G4	Highest Level of Education
	G5b	Maths Major
	M11a	PD Participation in Past 2 Years: Maths content
	M11b	PD Participation in Past 2 Years: Maths pedagogy/instruction
	M11c	PD Participation in Past 2 Years: Maths curriculum
	M11d	PD Participation in Past 2 Years: Integrating IT into maths
	M11e	PD Participation in Past 2 Years: Maths assessment
	M11f	PD Participation in Past 2 Years: Addressing individual students' needs

Table 3.4 Teacher attitudes and beliefs variables

Teacher Effectiveness Subclass	TIMSS Teacher Survey Question	Description of TIMSS Teacher Survey Question
Teacher Attitudes and Beliefs	M2a	Maths Confidence: Answer students' questions
	M2b	Maths Confidence: Show variety of problem solving strategies
	M2c	Maths Confidence: Provide challenging tasks for capable students
	M2d	Maths Confidence: Adapt teaching to engage students' interest
	M2e	Maths Confidence: Help students appreciate value of learning maths
	M12Ad	How Well Prepared to Teach: Add and subtract fractions
	M12Bb	How Well Prepared to Teach: Compute and draw angles
	M12Bd	How Well Prepared to Teach: Geometric shapes
	M12Be	How Well Prepared to Teach: Reflections and rotations
	M12 Bg	How Well Prepared to Teach: Area, perimeter, volume

Table 3.5 Teacher classroom practices variables

Teacher Effectiveness Subclass	TIMSS Teacher Survey Question	Description of TIMSS Teacher Survey Question
Teacher Classroom Practices	G6d	Perception of Collective Teacher Expectations for Student Achievement
	G9c	Use of Computers in Classroom Instruction
	G15a	How Often: Summarise what students should have learned from lessons
	G15c	How Often: Use questioning to elicit reasons and explanations
	G15d	How Often: Encourage all students to improve performance
	M1	Time Teaching Maths Per Week
	M3a	How Often: Listen to teacher explain how to solve problems
	M3b	How Often: Memorise rules, procedures, facts
	M3c	How Often: Work problems (individually or with peers) with teacher guidance
	M3d	How Often: Work problems with whole class with direct teacher guidance
	M3e	How Often: Work problems (individually or with peers) with teacher occupied
	M3f	How Often: Explain answers
	M3h	How Often: Take a written test or quiz
	M4b	How Teacher Uses Resources: concretes
	M4d	How Teacher Uses Resources: computer software
	M10a	Teacher Emphasis on forms of Assessment: Evaluation on ongoing work
	M10b	Teacher Emphasis on forms of Assessment: Classroom tests
	M10c	Teacher Emphasis on forms of Assessment: National Achievement Tests

3.8 Focusing the interview questions

Careful planning was required for focusing interview questions and administering the semi-structured interviews. Initially, designing an interview schedule that ensured that the interview questions adequately reflected what was required by the research questions was vital (Cohen et al., 2011). The conceptual framework (Figure 2.1) was therefore used to focus the interview questions during the creation of the interview schedule (see Appendix 2). While it was necessary to formulate interview questions that were focused on answering the research questions, it was important at the same time not to be too specific (Bryman, 2012). In this way, the researcher could gain insight on what the interviewee subjectively perceived as being significant in relation to the focus of the research. This helped in ensuring that the interview process elicited the views and perspectives of the interviewee, which was important ethically (Polkinghorne, 2005).

Initially, general information, which aligned with the *Teacher Qualifications* section of the conceptual framework, was gathered regarding, for example, the teacher's name, the class they were teaching, their educational background, their number of years teaching, etc. In addition, school demographic information was collected. This opening stage of each interview was useful for contextualising interviewee answers (Bryman, 2012), while also allowing both the interviewee and interviewer to settle into the interview experience. The main body of the interview focused upon gaining information relating to *Teacher Classroom Practices*, *Teacher Attitudes and Beliefs* and *Teacher Qualifications*. A variety of questions were asked where appropriate, including open-ended, specific, non-specific, direct and indirect questions (Cohen et al., 2011). I was conscious to avoid the use of complicated vocabulary or leading questions (Silverman, 2004; Cohen et al., 2011; Bryman, 2012). The flexibility associated with semi-structured interviews allowed me to probe and interpret or

follow up on interviewee answers where necessary (Bryman, 2012). However, in order to do this successfully it was important to listen to interviewee answers actively and alertly, while at the same time not being intrusive or showing agreement or disagreement (Silverman, 2004).

3.9 The pilot study

Prior to beginning the mixed methods research project outlined in this thesis, a pilot study was conducted in order to examine the effectiveness of the research instruments. The pilot study was conducted in July 2014 and consisted of a quantitative and qualitative phase. During the quantitative phase, bivariate analysis of secondary TIMSS 2011 data, relating to teacher classroom practices (Question M3 on the TIMSS 2011 teacher survey) in Ireland and Northern Ireland, was carried out. This was done to investigate whether there was a significant difference in teacher classroom practices in both of these countries, which could explain the difference in student achievement scores in the two countries. Statistical Package for the Social Sciences (SPSS) was used to conduct the bivariate analysis, which involved the use of crosstabs and the chi squared test (Muijs, 2011). This process ascertained the statistical significance of the relationship between variables through use of the null hypothesis, and actual and expected values. The quantitative stage of the pilot study allowed me to familiarise myself with the TIMSS 2011 dataset. It also highlighted the need to select and investigate a larger array of variables pertaining to teacher classroom practices, as there were few statistically significant differences between the practices reported by teachers in Ireland and Northern Ireland with respect to question M3. Hence, the variable selection strategy for the main study was amended accordingly.

Subsequently, the qualitative phase was conducted, which involved a semi-structured interview carried out with an Irish primary school teacher. The teacher chosen for the interview was a willing fourth class teacher in a school that was known to me, as well as being geographically accessible. The pilot interview was a worthwhile and illuminating endeavour, which affirmed confidence in the rich data that could be collected by the use of the semi-structured interview instrument. It also allowed for improvement of the instrument, in that it drew attention to several minor issues that were associated with the interview schedule. These issues were revealed by listening to and transcribing the interview recording. Notes were made simultaneously, which informed subtle revisions to the interview schedule. For example, in order to probe central themes more effectively, open ended questions, such as ‘Can you tell me a little more about that?’ were included. Also, terms that were unfamiliar to the interviewee in the pilot study were clarified in the amended interview schedule (Kvale, 1996). In this manner, the pilot interview allowed for critical reflection and provided me with insights, which were used to make revisions for subsequent interviews (Bryman, 2012).

3.10 Sampling strategy

Sampling is a crucial aspect of research and it is important to carefully determine the population of interest and assess the suitability of the chosen sampling strategy so as to ensure research design rigour. As this was a mixed methods study, two forms of sampling featured, namely, two-stage random sampling and stratified purposive sampling. In both the quantitative and qualitative phases of the study, samples were chosen from the adjacent countries of Ireland and Northern Ireland. The decision to include samples from these particular countries was made due to the fact that Northern Ireland was the top performing European country in fourth class mathematics in TIMSS 2011, whereas Ireland, the country in which I live myself,

ranked considerably lower. A comparison of teachers and teaching practices in both countries, both quantitatively and qualitatively, offered nuanced insights, which provided rich, detailed answers to my research questions. As well as this, conducting research in these two countries answered the call for more research on the link between classroom interactions and student achievement in different countries (Cadima et al., 2010). Practically, I am familiar with the education systems in both countries, which ensured that I understood the phenomenon under investigation (Silverman, 2004).

With respect to the quantitative phase of the study, it was important that an unbiased sample of the population was included in the research design, so as to allow for generalisation (Muijs, 2011). TIMSS 2011 employed “rigorous school and classroom sampling techniques” (TIMSS & PIRLS International Study Centre, 2011, p1), which included two-stage random sampling and national sampling plans that were implemented by National Research Coordinators and TIMSS sampling experts. In Ireland, a nationally representative sample of 151 schools and 220 teachers took part in the TIMSS 2011 study, and a total of 4560 students completed the TIMSS assessment. The large sample means that “the data are likely to be an accurate reflection of the achievements, attitudes and environment of Fourth class students” (Eivers and Clerkin, 2012, p6). Similarly, in Northern Ireland 136 schools and 184 teachers took part in the TIMSS 2011 study, and a total of 3571 students were assessed (Sturman et al., 2012). Statistically, the large samples for Ireland and Northern Ireland reduced “the extent to which noise of error variance influences observations” (Tolmie et al., 2011, p55) and, as such, provided a more dependable picture of effects with decreased possibility of type I and type II statistical errors (Muijs, 2011).

The qualitative phase of the study involved a smaller sample of just 11 interviewees. This smaller sample is typical of the number of informants included in qualitative research, as it allows for greater depth to be achieved within the data (Hitchcock and Hughes, 1995). Although the sample was small, it was nonetheless important to engage in a transparent sampling strategy. Stratified purposive sampling was employed in the second phase of this study and this is a common feature of qualitative research (Cohen et al., 2011). This non-random form of sampling allowed me to strategically choose research participants from subgroups of interest (Bryman, 2012), which was important, as I wanted to integrate the quantitative TIMSS 2011 data with the qualitative interviews conducted in 2015, insofar as was possible (Day et al., 2008). It was not possible to select teachers who had taken part in TIMSS 2011 for reasons of anonymity; therefore, research participants were selected instead from categories of schools that mirrored the categories used in TIMSS 2011. This sampling strategy is typical in sequential mixed methods research, where one sample precedes and influences another (Teddlie and Tashakkori, 2009). For example, the TIMSS 2011 school questionnaire categorised schools into five areas including urban, suburban, medium size city or large town, small town or village, and remote rural (5B, schools questionnaire). Schools with populations that were highly disadvantaged, highly affluent and with high numbers of English as an Additional Language (EAL) status children were also categorised. In addition, fourth class was the primary school grade level studied. Hence, I selected fourth class teachers who worked in schools that fell within each of the aforementioned categories as research participants for the qualitative phase of the study. This is depicted in Table 3.6. While the use of stratified purposive sampling in this manner allowed for integration of the qualitative and quantitative phases of the study, it also ensured the inclusion of teachers working within a variety of school settings in the study, which takes

cognisance of Campbell et al.'s (2004) assertion that context matters for teacher effectiveness.

Table 3.6 below summarises the details of the eleven interviewee participants of this study and also provides information on their schools' size and the TIMSS categories that the schools would fall under if the schools had been involved in TIMSS 2011. Pseudonyms are used to ensure interviewee anonymity.

Table 3.6 Interviewee and school details

Interviewee	School Identifier Code	School Location (TIMSS Classification)	School Population (TIMSS Classification)	Years of Experience	Maths Major	School Student Number (Approx.)	Years teaching Fourth Class or Primary 6
Finola	Ireland, School A	Suburban	Highly Affluent	11	Yes	250	1
Alison	Ireland, School B	Medium Size City/Large Town	High EAL	9	No	400	3 (non - consecutive)
Una	Ireland, School C	Urban	Highly Disadvantaged	5	Yes + Master's	400	1
Patricia	Ireland, School D	Small Town/Village		23	No	230	4 (2 consecutive)
Ciara	Ireland, School E	Remote Rural		12	No	12	4 (composite class setting)
Phyll	Ireland, School F	Small Town/Village		9	No	350	3 (non - consecutive)
Majella	N. Ireland, School A	Small Town/Village	Highly Disadvantaged	16	No	250	6 consecutive
Gareth	N. Ireland, School B	Remote Rural		16	Yes	190	9 (consecutive blocks)
Geraldine	N. Ireland, School C	Suburban	Highly Affluent	25	Yes	350	5 consecutive (20 years in P7)
Michael	N. Ireland, School D	Small Town/Village		5	No	190	3 (2 consecutive)
Dervla	N. Ireland, School E	Medium Size City/Large Town		22	No	420	16 (consecutive blocks)

Although a sample size of six teachers in Ireland and Northern Ireland was posited at the outset, the final sample size was six teachers in Ireland and five teachers in Northern Ireland. The sixth interview in Northern Ireland was cancelled by the participant due to unforeseen circumstances. While over twenty schools were contacted in June 2015 in order to secure a replacement interview, these attempts were not successful. However, this was not considered to be a significant limitation, as data saturation had been achieved prior to this point and the variability of themes had become stagnant (Bryman, 2012). The sixth interview in Ireland confirmed the researcher's assumption regarding data saturation, as it did not reveal any new themes.

3.11 Ethical considerations and access

According to Hammersley and Traianou (2012, p5), "the prime ethical responsibility of the researcher is to pursue worthwhile knowledge". Following from this, however, ethical considerations are vital (Gorard, 2001) so as to ensure a balance is set between the researcher's quest for knowledge and their subjects' values and rights, which may be affected by the research (Cohen et al., 2011). This study was conducted within the guidelines of the University of Lincoln ethical principles and those of the British Educational Research Association (BERA). An 'Ethical Approval Form' (Appendix 1), 'Interview Schedule' (Appendix 2), and 'Interview Permission Form' (Appendix 3) were submitted and approved by the University of Lincoln Ethics Committee in July 2014. Furthermore, I was committed to engaging in a process of reflexivity throughout the study so as to ensure that any possible harm was anticipated and guarded against (British Sociological Association, 2002).

With respect to the use of secondary TIMSS 2011 data, ethical concerns were fewer than those relating to the qualitative phase of the study. However, noted concerns

were addressed by referencing and acknowledging TIMSS as the owners of the dataset, as well as analysing the data in accordance with the guidelines set out in “TIMSS 2011 User Guide for the International Database” (Foy et al., 2013). Semi-structured interviews, on the other hand, demanded more personal interaction and were therefore more predisposed to risks. At the outset, I was aware that ethically I needed to be sensitive to the hierarchy of schools when gaining access to interview participants (Hitchcock and Hughes, 1995). Therefore, firstly, contact was made with the principal of each school through a telephone conversation. A request for an interview with the fourth class teacher (or Primary 6 (P6) teacher in Northern Ireland) was made, and the research aims were explained verbally. In one case, an outline of the research aims and interview topics was emailed to the participant, at their request. Interviews with willing participants were subsequently arranged and conducted within their respective schools. Participant autonomy was respected and only those teachers who were happy to take part in the study were included.

In order to uphold the principle of respect for persons (University of Lincoln, undated), written informed consent was gained from each participant prior to commencing the interviews. This was done by use of an ‘Information Permission Form’ (Appendix 3), which outlined the purpose of the research project and the rights of the interview participant, and provided assurance of confidentiality and anonymity. Protecting interviewee and school privacy (Hammersley and Traianou, 2012) was of the highest importance throughout the research project, and information was treated with the utmost confidentiality. Interview recordings were kept in a locked cabinet until transcribed, after which they were destroyed. Pseudonyms replaced individual and school names in the written transcriptions (Bryman, 2012), and identifier codes for the pseudonyms were locked away separately (Holmes, 2004). The research participants and their schools are only identifiable through their

country (Ireland or Northern Ireland) and school context (urban, suburban, medium size city or large town, small town or village, remote rural, highly disadvantaged, highly affluent, high numbers of EAL status children). Each type of school context included exists numerously in both Ireland and Northern Ireland. In this way, the confidentiality and anonymity of participants is ensured, with no school or interviewee being identifiable or identified in the written publication, or throughout any stage of the study, by anyone but myself.

3.12 Positionality

“Truth, or what is real and thus meaningful and ‘right’, for researchers and participants, depends on how they have experienced the world” (Milner IV, 2007, p395).

The positionality of the researcher influences and shapes both the research processes and outcomes (Hopkins, 2007). From the outset, I was aware of “multiple, flexible and changing” identities that I embodied (McNess et al., 2015, p295), which moved along a multidimensional continuum, from insider to outsider (Mercer, 2007). For example, with respect to the quantitative phase of the study, I was very much an outsider in that I was working with secondary data from the TIMSS 2011 study, which had been conducted four years previously. However, as an Irish teacher exploring teacher responses to the TIMSS teacher survey data in Ireland (and Northern Ireland), I was able to relate to the education system under investigation (McNess et al., 2015) and, as such, experienced a level of ‘insiderness’ too (Mercer, 2007, p1).

In contrast, during the qualitative phase of the study, I, for the most part, perceived myself to be an insider. Although I was unknown to the research participants, as a teacher I was their peer and a member of the same collective group (Merton, 1972).

These aspects, coupled with the absence of power relationships, seemed to elicit candid responses from interviewees and therefore may have reduced informant bias (Mercer, 2007). Nevertheless, my positionality as an insider was never fixed, and it was important too for me to examine this reflexively so as to bring into “consciousness explicit, hidden, or unexpected matters” (Milner IV, 2007, p395). For example, with respect to conducting interviews with teachers in Northern Ireland, I was cognisant that I was an outsider, coming from a different education system. It was therefore important to me, as a researcher, to gain an understanding of the contexts in which the interview participants worked. This process unveiled influences arising from “different historical and cultural traditions” (McNess et al., 2015, p310).

3.13 Administering the interviews

All interviews, with the exception of one, were conducted in schools between January and June of the year 2015, and were scheduled to last for one hour. One interview was conducted over the telephone at the request of the interviewee. An interview “as a social encounter, has to take account of, and plan for, the whole range of other possibly non-cognitive factors that form part of everyday conduct” (Cohen et al., 2011, p424). I worked towards making each interview a positive and beneficial experience in several ways. For all interviews, a setting that was quiet and free from interruptions was used (Bryman, 2012). Before interviews began, I endeavoured to put the interviewee at ease by introducing myself and explaining the purpose and scope of the interview. I considered this to be important as “some teachers being interviewed may feel that evaluation or criticism is implied” (Hitchcock and Hughes, 1995, p165). I was aware of this throughout the interviews and remained “attuned and responsive” to the body language of the interviewee, being prepared to divert

from a question if it was causing undue stress to the interviewee (Bryman, 2012, p479). Semi-structured interviews facilitated this aspect, due to their flexible nature. Similarly, I was cognisant of my own body language and ensured that it was non-threatening and conveyed interest in what the interviewee had to say (Cohen et al., 2011).

Permission was sought to voice record the interviews and, although all participants agreed without hesitation, several authors had posited that some interviewees find this constraining (Hitchcock and Hughes, 1995; Cohen et al., 2011; Bryman, 2012). Therefore, I assured each participant that the recorded data would be stored securely and confidentially on an external hard drive and destroyed after its use in the research project. In addition, I explained that their, as well as their schools' identities would be made anonymous in both the interview transcripts and research publications. Lastly, participants were made aware that they could withdraw from the interview at any stage and request that their data not be used.

3.14 Data analysis

As this was a mixed methods study, two forms of data analysis were required. The quantitative data that pertains to the first phase of this study was analysed using the computer software package SPSS. Alternatively, the qualitative interview data was analysed through the researcher's interpretations with the assistance of the computer software package NVivo 8.

During the quantitative data analysis phase of this study, TIMSS 2011 data for both Ireland and Northern Ireland were analysed using the SPSS computer software package. The first research question in this study required comparisons to be made between teacher-related factors in Ireland and Northern Ireland. An approach was chosen that mirrored one used in a similar research project by Dodeen et al. (2012).

Their study compared teacher-related factors in Saudi and Taiwanese schools using data from the eighth grade TIMSS (2007) teacher background questionnaire. Bivariate analysis using the chi-square test was employed to compare teacher-related factors in the context of student achievement scores. Bivariate analysis is the statistical process by which the relationship between two variables is investigated (Muijs, 2011). The chi-square test tests the statistical significance of the relationship between two variables through use of actual and expected values and the null hypothesis (Denscombe, 2003).

The teacher-related variables of interest in this study (see tables 3.3, 3.4, 3.5) were nominal or ordinal, and hence cross-tabulation was carried out to compare the responses of Irish and Northern Irish teachers to selected questions from the TIMSS 2011 teacher background questionnaire (Muijs, 2011). Actual and expected counts for each response were included so as to check that the necessary conditions for the chi-square test were met. These conditions included no cell having an expected value of less than 1 and no more than 20% of the cells having expected values of less than 5. The large samples for Ireland and Northern Ireland in TIMSS 2011 increased the chances of meeting these conditions (Denscombe, 2003). Upon applying the chi-square test, p-values lower than 0.05 indicated a statistically significant result (Muijs, 2011).

The second phase of the study involved exploring teacher effectiveness phenomena from an alternative, qualitative viewpoint. Qualitative data analysis involves managing, analysing, explaining and interpreting data (Cohen et al., 2011). Data collected during the interviews was funnelled through the researcher and, as such, data analysis took place simultaneously both during and after interviews (Hitchcock and Hughes, 1995). I therefore felt that it was essential to have a strong knowledge of

the relevant literature, as this ensured theoretical sensitivity, which enabled me to recognise important factors within the data and to give them meaning. Similarly, as this was a sequential mixed methods study, it was important for the researcher to be aware of findings that had emerged during the quantitative phase so that I could integrate them into the qualitative phase from the outset, rather than just during data analysis.

The first stage of manual data analysis during the qualitative phase involved transcribing interview recordings. Errors are an issue associated with transcriptions (Gibbs, 2007) and needed to be addressed by carrying out frequent accuracy checks. In addition, transcription conventions outlined by Cohen et al. (2011, p537-538) were followed so as to ensure all data was transferred. In order to be aware of emergent themes as the research project progressed, data analysis including transcription and coding was conducted shortly after each interview took place, so as to maintain a close relationship with the data. For example, after each transcript was completed, it was printed and read through several times, with some initial codes pencilled in. This eased the issue of data overload (Cohen et al., 2011), while the iterative relationship between data analysis and collection aligned well with the researcher's selected form of data analysis, namely, thematic analysis. Engaging in continual interactions with the data also highlighted when theoretical saturation had been achieved (Bryman, 2012).

Following the transcription of all of the interview recordings, data was organised, stored and analysed with the assistance of the computer software package, QSR NVivo 8. While the use of this computer software allowed for large amounts of rich data to be managed effectively by use of memos, codes, selective retrieval, quantitative counts and code linkage (Kelle, 1995), it could not analyse the data in the same manner as SPSS processes quantitative data. The researcher was therefore

required to decide upon codes and categories that would interpret the data (Cohen et al., 2011). Coding translated interview question responses into categorised data that was amenable to analysis (Kerlinger, 1970), and the conceptual framework as well as a thorough knowledge of existing literature aided this process (Hitchcock and Hughes, 1995).

Initially, large sections of the transcripts were coded under the headings of classroom practices, attitudes and beliefs, qualifications, teacher effectiveness and factors which help and hinder teachers in promoting student achievement on standardised tests. Following this, subcodes were created and this process was repeated where necessary. The node system in NVivo 8 was a useful tool for carrying out this process, as it allowed for codes to branch into subcodes and for subcodes to branch into further subcodes and so on. For example, classroom practices branched into the subcodes of assessment, questioning, use of ICT, building confidence, planning and high expectations. These subcodes then branched out further. For example, assessment branched into the codes of benefits of assessment, assessment and achievement on standardised tests, role of informal assessment and how often assessment. Once again these subcodes branched out further and the subcode benefits of assessment, divided into the subcodes of parental partnership, revision, differentiation importance, more valuable than standardised tests and informs teaching. Codes were assigned and re-assigned in an iterative manner so as to ensure the consistency and suitability of codes and categories used (Miles and Huberman, 1994).

Thematic analysis moved on further from coding the data by grouping codes into central themes and subthemes, which made “a theoretical contribution to the literature relating to the research focus” (Bryman, 2012, p580). For example,

constant revision emerged as a recurrent theme and it was referred to at several stages throughout many of the interviews. Data extracts where teachers referred to the importance of revising or revisiting mathematical concepts were grouped under the theme of constant revision. An example of a data extract that fell within this theme was Phyll's (School F, Ireland) comment that written tests facilitated *"constant revision..because...they [the students] forget stuff. They need constantly to be reminded."* Another theme that emerged from the data was the interconnectedness of teacher related factors. On occasions where interviewee participants linked one teacher related factor to another, such extracts were grouped under this theme. For example, a data extract which fell under this theme was when Majella (School A, Northern Ireland) linked questioning with the informal assessment of student understanding, by noting that *"Questioning does determine what they [the students] are getting from the lesson and how much they are understanding."* Emergent themes were then compared and integrated with findings from the quantitative phase, providing a nuanced and holistic picture of how teachers influence student outcomes in Ireland and Northern Ireland.

3.15 Quality of research

A criticism of some mixed methods research studies is the failure to integrate quantitative and qualitative data (Klingner and Boardman, 2011). I was especially aware of this with respect to the current study, due to the fact that the quantitative phase involved secondary data that had been collected four years previous to data collected during the qualitative phase. Therefore, I was careful to integrate both phases of the study from the outset. The conceptual framework was instrumental in linking quantitative and qualitative aspects of the study, as it provided a clear focus for data sourcing that was predicated on findings from the literature. Following from this, the sequential mixed methods design of the study allowed for the qualitative

phase to build upon and investigate findings from the quantitative phase. In this way, the qualitative phase provided a “context for understanding broad-brush quantitative findings” (Bryman, 2012, p645). The mirroring of the quantitative sampling strategy during the qualitative phase also integrated both phases of the study and ensured teachers in a range of school contexts were included. This was important, as the “validity and trustworthiness of qualitative research is related to the selection of viable sources that promote a deepening of the understanding of the experience inquired about” (Polkinghorne, 2005, p141).

While a key strength of mixed methods research lies in the fact that the limitations of one approach can be compensated for by the benefits of the other, it was nevertheless important to consider carefully the validity and reliability of each approach, so as to ensure design rigour. In quantitative research, validity refers to the degree to which an instrument measures what it purports to measure (Cohen et al., 2011), whereas reliability refers to how consistent a measure or concept is over time, or across different observers (Bryman, 2012). The quantitative phase of this study involved secondary analysis of the TIMSS 2011 dataset. TIMSS 2011 was “designed to provide valid and reliable measurement of trends in student achievement” (Joncas and Foy, 2013, p1) and, as such, there can be strong confidence in the reliability of the data collected. Despite the high quality of the TIMSS 2011 dataset, it was nevertheless important to consider validity and reliability with respect to the variables and instruments chosen for secondary data analysis in the current study. For example, theoretical knowledge was considered essential in guiding variable selection (see tables 3.1–3.5) so as to ensure content validity (Muijs, 2011). Similarly, theory deduced from the literature review guided the selection of appropriate statistical tests for analysing the secondary data (Cohen et al., 2011), and this process is detailed in section 3.14 of this chapter. The need for generalisability is

another important aspect of quantitative research. Initially, sampling determines generalisability of research (Tolmie et al., 2011). The large random samples for Ireland and Northern Ireland included in the TIMSS 2011 study give confidence to the generalisability of results to the general population. In addition, significance testing and use of confidence intervals during the data analysis stage lead to greater generalisability (Muijs, 2011).

Qualitative research, on the other hand, which formed the focus of this study, has been criticised by those within the quantitative tradition for its lack of validity and reliability (Bryman, 2008). However, while external validity and reliability are not generally relevant concerns for qualitative researchers – as their research usually does not set out to measure variables or generalise findings (Cohen et al., 2011) – striving towards trustworthiness, as specified by Guba and Lincoln (1994), can ensure research rigour. In this study, the four criteria of trustworthiness, which are credibility, transferability, dependability and confirmability, were addressed as follows:

- Credibility – gaining multiple accounts of social reality and triangulation of methods through use of eleven qualitative interviews and secondary TIMSS 2011 quantitative data (Bryman, 2008)
- Transferability – gathering in-depth data on and rich descriptions of teacher effectiveness through use of semi-structured interviews (Lincoln and Guba, 1985)
- Dependability – keeping a transparent audit trail by storing recordings and transcriptions as well as using NVivo and researcher notes to record coding and theory generation processes (Bryman, 2008)

- Confirmability – being reflexive about researcher values and bias, so as to maximise research objectivity while acknowledging the researcher as the main research instrument

3.16 Conclusion

In this chapter a detailed account of the philosophical underpinnings, research approach, methodology and analytical processes of the research study was presented. As has been explained, a mixed methods interpretive approach was taken in order to address the research questions. Qualitative, semi-structured interviews with fourth class teachers in Ireland and Northern Ireland were integrated with findings from secondary data relating to the TIMSS 2011 study, in a dynamic and iterative manner. The research approach aligned with the ontological and epistemological assumptions that underpinned the study, in that the subjective opinions of teachers were emphasised, while empirical evidence also provided an objective perspective on the phenomena. This mixed methods approach generated dependable, rich and nuanced data from which to answer the research questions. The findings are presented in Chapter 4 and discussed more analytically in Chapter 5.

Chapter 4. Findings

This chapter presents the findings from data collected and analysed during the quantitative and qualitative phases of this study. The research questions posed in Chapter 1 are answered through integration of both the quantitative and qualitative data. How fourth class teachers influence student learning and achievement in mathematics in Ireland and Northern Ireland was explored by firstly comparing the similarities and differences between teacher-related factors with respect to fourth class mathematics teaching in Ireland and Northern Ireland, as reported in TIMSS 2011, in the context of student achievement. Following this, the perceptions of fourth class teachers in Ireland and Northern Ireland were gathered, regarding how teacher-related factors (teacher qualifications, teacher classroom practices, teacher attitudes and beliefs) influence student learning and achievement in mathematics. There was a focus on teachers' understandings of how classroom practices influence student learning and achievement, in an effort to address the research gap that exists regarding qualitative studies into teacher classroom practices and teacher effectiveness.

Data analysed in the first phase of this study were the responses of both Irish and Northern Irish fourth class primary school teachers to the TIMSS 2011 Teacher Questionnaire for Fourth Grade. In Ireland, fourth grade is referred to as fourth class, and in Northern Ireland the equivalent of fourth grade is Primary 6 (P6). The Irish sample consisted of 220 teachers (71% female, 29% male) who completed the questionnaire and whose students took the TIMSS 2011 mathematics achievement test. Similarly, the Northern Irish sample consisted of 184 teachers (64% female, 36% male).

In order to explore the TIMSS data further, evidence from the second phase of the study is based on interviews with eleven participants who were teaching at the fourth class level at the time of the interviews. Six interviewees were teaching in Ireland and five were teaching in Northern Ireland. The qualitative data probed the surface level findings from the quantitative TIMSS 2011 data more deeply. Although the data in the second phase was collected four years after the TIMSS 2011 data, the qualitative data nevertheless facilitated a deeper understanding of the TIMSS data, highlighting the benefits of using qualitative data to complement and support quantitative data. Perhaps more importantly, the qualitative phase of the study investigated unanswered how and why questions about how teacher variables influence student learning and achievement in mathematics, and why certain teacher variables are considered important for promoting student attainment. These questions were answered through use of interview participant narratives, which provided rich and detailed explanations.

4.1 Structure of reporting findings

The conceptual framework (Figure 2.1), which evolved from an extensive literature review, provided a structure for organising and analysing data and, following this, reporting findings. Mirroring the framework, this chapter is structured around five main themes, namely, Teacher Qualifications, Teacher Classroom Practices, Teacher Attitudes and Beliefs, Promoting Student Achievement and Teacher Effectiveness. Student Outcomes are considered with respect to each of the main themes. Several subthemes are discussed under each theme. The subthemes are arranged by presenting the relevant quantitative data first, followed by exploration of the qualitative data.

4.2 Teacher qualifications

Research questions 1b and 2b investigated the teacher effectiveness subclass of teacher qualifications and were as follows:

Q.1b With respect to mathematics, what similarities and/or differences exist between fourth class teacher qualifications in Ireland and Northern Ireland, as reported in TIMSS 2011?

Q.2b How do teachers in Ireland and Northern Ireland describe the role of teacher qualifications in student learning and achievement in mathematics?

The TIMSS 2011 teacher background questionnaire collected data regarding several teacher qualifications including years of experience, level of education, holding a mathematics major and participation in mathematics-related professional development. Teacher responses to survey questions G1, G4, G5b, M11a, M11b, M11c, M11d, M11e and M11f (described in table 3.3) were compared for Ireland and Northern Ireland. In addition, during qualitative interviews, interviewees were asked for their opinions on the impact of a range of teacher qualifications on teaching and learning. The quantitative and qualitative findings are presented below.

4.2.1 Teacher experience

Table 4.1 Percentage of students taught by teachers with different levels of experience (G1)

Years of Experience	Ireland	Northern Ireland
0–5 years	34.3%	9.7%
6–10 years	30.9%	19.3%
11 or more years	34.8%	71.0%

Question G1 on the TIMSS 2011 Teacher Questionnaire asked teachers to indicate how many years altogether that they had been teaching. There were surprising

differences between fourth class teacher experience levels in Ireland and Northern Ireland. For example, in Ireland 65.7% of fourth class students were taught by teachers with over five years of teaching experience. In Northern Ireland, 90.3% of fourth class students were taught by teachers with more than five years of teaching experience. In order to statistically ascertain whether teacher experience was similar in both countries, the chi-square test was conducted. The result was highly statistically significant, ($\chi^2 = 1988.671$; $p = < .001$, $df = 38$). This means that there was a significant difference between the two countries regarding teachers' levels of experience, which is unlikely to be due to chance. The large value for chi-square suggests that there are unusual differences in the data.

The qualitative phase probed the surprising quantitative finding that a significantly higher number of Northern Irish fourth class teachers had more than five years of teaching experience, in comparison with the experience levels of their Irish counterparts. In addition, teacher perceptions about the impact of teacher experience on student learning and achievement in mathematics were explored.

The TIMSS 2011 finding that Northern Irish fourth class teachers had significantly more teaching experience than Irish fourth class teachers was echoed during qualitative interviews, in that three of the five Northern Irish teachers interviewed had more than fifteen years of teaching experience and only one of the teachers was in their first five years of teaching. Furthermore, four out of the five Northern Irish teachers had more than five consecutive years of experience in teaching fourth class (P6). The semi-structured interviews as well as the iterative nature of the data analysis process facilitated exploration of this finding. An explanation for this trend was provided by Dervla (School E, Northern Ireland), and it highlighted the importance of context in understanding the quantitative TIMSS 2011 data. Dervla

explained that teachers in Northern Ireland tend to teach P6 for many consecutive years “*because of the transfer procedure ... we do need some continuity ... we are preparing children for a non-regulated test ... Primary 6 is where you start at the very beginning to prepare for that.*” In summary, Dervla highlighted that striking the balance between teaching the primary curriculum, while also preparing P6 students for the transfer test, was “*quite a specialism*” and, as such, teachers required special experience for this role.

The transfer test is an entrance exam that children in Northern Ireland are required to complete in their final year of primary school education (P7) in order to be accepted to some post primary grammar schools. The impact of the transfer test upon P6 teaching and learning may be significant for explaining many of the TIMSS 2011 quantitative findings, including the significant differences noted between Ireland and Northern Ireland regarding teacher experience (G1, TIMSS 2011 Teacher Questionnaire), teacher confidence (M2a-e, TIMSS 2011 Teacher Questionnaire), teacher expectations (G6d, TIMSS 2011 Teacher Questionnaire) and time spent teaching mathematics (M1, TIMSS 2011 Teacher Questionnaire). This substantiates Wang’s (2001) concern over the validity of TIMSS rankings due to different levels of exposure to content across different countries.

Similarly, the existence of the transfer test in Northern Ireland highlights a notable difference between the context of fourth class in Ireland and P6 in Northern Ireland. Although both class groups are on a par according to TIMSS 2011 categories (in that they are of the same age range and are equivalent to the fourth grade), the schooling context of P6 in Northern Ireland is very different to that of fourth class in Ireland. Children in P6 (Northern Ireland) are in their second last year of primary school education. They are preparing intensively for a numeracy transfer test which impacts upon their school choices for post primary education. Many children get extra tuition

in order to achieve an A grade and there is high stress and anxiety associated with the transfer exam (Gareth, School B, Northern Ireland). On the other hand, in Ireland, fourth class students are not yet at the senior stage of their primary schooling and have both fifth and sixth class to complete before entering secondary school. There are no external exams and fourth class is in general free from exam related academic pressure.

The richer understanding of school contexts gained in the semi-structured interviews highlights the importance of qualitative data in explaining quantitative findings, by emphasising context and probing surface level quantitative findings more deeply. In addition, the comparison of context across two countries facilitates an understanding of how educational culture and “policies affect student outcomes in different settings” (Panayiotou et al., 2014, p75).

The qualitative phase of the study also invited participants to provide their expert opinions on how teacher experience influences student outcomes. Teachers in Ireland and Northern Ireland generally viewed teacher experience as having a positive influence on student outcomes, especially with respect to their lesson delivery, as is evident in what Dervla (School E, Northern Ireland) says: “...*You are self evaluating all of the time and over the years you learn better methods and new approaches*”, and is also reflected by Finola (School A, Ireland): “... *as you have more experiences, you have more ways you know to get a concept across to children, you know what works and what doesn’t work ... you learn tricks and ways to get something across from experience.*” This is in contrast to the literature regarding teacher experience, which, although mixed, suggests that the influence of teacher experience on student achievement levels off after a few years (Rockoff, 2004; Hanushek et al., 2005; Boyd et al., 2007; Goe and Stickler, 2008).

A notable finding was the reporting by interviewees of the benefits of having teaching experience at the same grade level. This has not been considered across the teacher effectiveness literature base; however, the teachers in this study perceived it to have a positive impact on teaching and learning. Interestingly, four out of the five qualitative interviewees in Northern Ireland had been teaching at fourth class or P6 level for five or more consecutive years, whereas in Ireland only one interviewee had more than five years of experience in teaching fourth class and this was non-consecutive. The benefits of gaining teaching experience at the same grade level were noted by Alison (School B, Ireland), who described:

I've had fourth a few times ... I know what they find difficult ... so what I would do is I'd place more emphasis on the things they're finding more difficult, where you could spend more time, and I know when to do it during the year ... to give that little bit extra.

Similarly, Majella (School A, Northern Ireland) added:

It [teaching experience at the same grade level] definitely does help ... you build up the resources and you're familiar with the curriculum, you're familiar with what needs to be taught.

In addition, Gareth (School B, Northern Ireland) reflected:

You don't really know the nuts and bolts of teaching [a particular grade level] until you're put in front of the class.

These extracts highlight the benefit of having experience at the same grade level in relation to having a thorough knowledge of the curriculum for that particular grade level. This, as Alison mentioned, can promote an awareness of the concepts that students find difficult within the curriculum so that steps can be taken by the teacher to address this. Teachers also saw a benefit in having teaching experience at the same grade level regarding the perception that self-evaluation of the teaching of particular concepts could lead to improved lesson delivery of these concepts in future teaching. For example, Geraldine (School C, Northern Ireland) noted:

Every year you learn, you learn from your own mistakes, and how to make things as simple as possible for them [the students], especially in numeracy actually. Because you want to get the concepts really clear in their head.

The above-mentioned benefits of having consecutive years of experience at the same grade level are indicative of a link between teacher experience at the same grade level and improved teacher pedagogical knowledge. This link is exciting, as pedagogical knowledge is the type of knowledge most likely to influence student learning (Schulman, 1986). Overall, the evidence from this study suggests that the pedagogical knowledge gained from experience, rather than teacher experience in isolation, has a more direct effect on teaching and learning in mathematics.

4.2.2 Holding advanced degrees (master's or doctorate level)

Question G4 on the TIMSS Teacher Questionnaire asked teachers to indicate the highest level of education that they had achieved. In Northern Ireland, 24.8% of students were taught by teachers with a master's degree or higher, whereas 16.8% of Irish students were taught by teachers with a master's degree or higher. The result was statistically significant ($\chi^2 = 100.175$, $p = < .001$, $df = 2$). The fact that a large proportion of teachers in Ireland were in the first five years of their teaching career (34.3%) may explain why there were fewer Irish than Northern Irish students being taught by teachers holding advanced degrees.

The qualitative interviews investigated how holding an advanced degree influences teaching and learning. Only one of the eleven interviewees (Una, School C, Ireland) held an advanced degree. Una had recently completed a master's degree in mathematics education. She spoke very positively about the experience. What was interesting was the link that was evident between her research and her enthusiasm for her research topic in the classroom:

Doing my master's is something that's on my CV ... but it has changed me completely as a teacher ... I'm very passionate about my word problems [focus of master's] and teaching the children about it and seeing if they actually get it or not, and seeing them progress. That's because I did the master's, mainly. I suppose it's in the classroom you really see it, but ... going studying is amazing.

The literature is unclear about the impact of holding advanced degrees upon teaching and student learning (Goe and Stickler, 2008). However, Una's experience suggests that research that is closely linked to classroom teaching and learning may have a positive impact on teacher motivation and enthusiasm within the classroom, which in turn may influence student outcomes. That said, further research in this area would be required to confirm this deduction, as it is based on the experience of only one research participant.

4.2.3 Maths background/holding a mathematics major

Question G5b on the TIMSS 2011 teacher questionnaire collected data regarding whether teachers whose main area of study at third level was education had specialised with a mathematics major. In Northern Ireland 8.2% of fourth class students were taught by a teacher who specialised in mathematics at third level, whereas 4.1% of Irish fourth class students were taught by a teacher who specialised in mathematics at third level. The result was statistically significant ($\chi^2 = 56.352$, $p = <.001$, $df = 1$).

During the qualitative phase, interviewees were asked about their mathematics background. Four out of the eleven interviewees held mathematics majors or degrees. Two of these teachers were Irish and two were Northern Irish. These four teachers described positive mathematics backgrounds and past experiences with mathematics. For example, Gareth (School B, Northern Ireland) noted: *"I always loved maths in school."* Similarly, Geraldine (School C, Northern Ireland) described how she often tells students *"I love maths, I really love maths."* Una reflected: *"It (maths) would*

have been my strongest subject in school the whole way through” and Finola noted: “... *(I) always enjoyed maths ... I enjoy teaching it as well.*” Phyll (School F, Ireland) did not have a specific mathematics background, but was “*interested in maths.*” On the other hand, Alison (School B, Ireland) noted having a negative mathematics background due to past school experiences: “*Maths was probably one of my least favourite subjects in school.*” Other interviewees did not describe either strongly positive or negative mathematics backgrounds.

Interviewees were asked for their perceptions regarding how a teacher’s mathematics background influences student achievement. Analysis of the data revealed an interesting link between six interview participants’ mathematics background, their attitude to maths, their classroom practices and in turn their students’ attitudes and outcomes with respect to mathematics. Negative mathematics past experiences had a different impact upon teacher attitudes and classroom practices in comparison with positive past mathematics experiences. A noteworthy factor, which was reported by teachers who had indicated having positive mathematics backgrounds, was that when a teacher communicates enthusiasm for mathematics, this positively influences their students. For example, Una (School C, Ireland, Mathematics Major) noted that: “... *the person’s ability and the person’s enthusiasm about maths will certainly affect the children*” and Gareth (School B, Northern Ireland, Mathematics Degree) reflected that “*children pick up on whether a teacher likes the subject or not.*” Similarly, Geraldine (School C, Northern Ireland, Mathematics Major) perceived that a teacher’s mathematics background influenced student learning in mathematics by describing:

I think – you have enthusiasm for it ... I say [to the class] “I love maths, I really love maths.” And some of the parents say to me “I believe you love maths” and some of them said that their child has learnt more because of my enthusiasm for it.

It is interesting that all of the above examples are teachers with strong mathematics backgrounds and past experiences. This links with Geist's (2015, p333) finding that "the more mathematics that a teacher feels they know the more confident they are in their ability at mathematics and the better they like mathematics." Moreover, the above examples highlight the powerful positive effect that communicating enthusiasm about mathematics to students has on student outcomes. There is very little in the literature about the influence of communicating a positive attitude towards mathematics on student achievement. However, Charalambous et al. (2009) hypothesise that because teachers often act as models for their students, it follows that the attitude that they communicate towards mathematics is likely to influence their students' attitudes towards the subject. Similarly, a study by Geist (2015) found that teachers who have 'maths anxiety' inadvertently pass it on to their students, as early as at the preschool level.

With respect to the effect of a negative background in mathematics, Alison (School B, Ireland) reflected that, in her opinion, this made her a better teacher of the subject due to her understanding of the need to explain concepts clearly:

I wouldn't put a huge emphasis on it [the influence of a teacher's mathematics background]. Maths was probably one of my least favourite subjects in school, but I find now it nearly makes me a better teacher of it because I nearly try harder to explain, because I found it difficult. So I don't think it matters.

Phyll (School F, Ireland) noted a similar experience regarding teaching a subject with which she had a negative background:

I would have had a very negative attitude towards Irish always ... and even in primary school I just hated it ... now you know, I feel I'm so conscious of that, I make Irish as good and interesting and exciting as I can because I don't want to have that opinion for them.

Both Alison and Phyll described a negative background with a subject, which resulted in the attitude that they did not want their own students to have a similar

negative experience. This in turn influenced their classroom practices, as they aimed to make their lessons in that subject both clear and enjoyable. The classroom practices of clear instruction and a stimulating learning climate were found to positively influence student attainment in a study by Van de Grift (2007). This suggests that negative past experiences with mathematics can lead to teachers adopting the opposite (and more positive) classroom practices themselves. However, further research is required to substantiate this finding as it is based only on the experiences of two teachers.

Overall, analysis of the interview data highlighted a distinct link between a teacher's mathematics background (specifically past schooling experiences), their attitudes, their classroom practices, and in turn their students' outcomes. This reveals an interesting, dynamic interaction that occurs between the different levels of the conceptual framework, namely, *Teacher Qualifications*, *Teacher Classroom Practices*, *Teacher Attitudes and Beliefs* and *Student Outcomes*. It also highlights the importance of considering all three sublevels of teacher effectiveness (teacher qualifications, teacher classroom practices and teacher attitudes and beliefs) when conducting studies of this nature, as is posited by Palardy and Rumberger (2008).

4.2.4 Professional development

Question M11 on the TIMSS 2011 Teacher Questionnaire asked teachers to indicate whether they had participated in Professional Development in a range of mathematics-related areas over the past two years. Table 4.2 below shows results from statistical analysis. Significantly more teachers of fourth class students in Northern Ireland participated in mathematics-related professional development than teachers of fourth class students in Ireland. This was true for all six professional development topics included in question M11. Similarly, a comparison of TIMSS

data for Taiwan and Saudi Arabia by Dodeen et al. (2012), found that teachers in the higher performing country (Taiwan) had participated in more professional development than had their Saudi Arabian counterparts.

Table 4.2 Percentage of students taught by teachers who participated in professional development in past 2 years (M11a-f)

Professional Development Topic	Ireland		Northern Ireland		Statistical Significance		
	Yes	No	Yes	No	Chi – Square	p value	df
Mathematics Content	33.9 %	66.1 %	57.9 %	42.1 %	426.874	<.001	1
Mathematics Pedagogy/Instruction	31.4 %	68.6 %	64.2 %	35.8 %	785.852	<.001	1
Mathematics Curriculum	37.0 %	63.0 %	61.6 %	38.4 %	440.827	<.001	1
Integrating information technology into mathematics	29.9 %	70.1 %	56.1 %	43.9 %	517.605	<.001	1
Mathematics Assessment	25.5 %	74.5 %	62.0 %	38.0 %	1008.028	<.001	1
Addressing individual student's needs	30.7 %	69.3 %	44.0 %	56.0 %	140.334	<.001	1

In line with the TIMSS 2011 findings in Table 4.2, qualitative interviews indicated that professional development was attended frequently by Northern Irish teachers in the past. However, interviewees described how the current climate in Northern Ireland is somewhat different, in that only the numeracy co-ordinators tend to participate in professional development courses and subsequently they give feedback to school staff. The extracts below reflect this:

Years ago they were throwing courses at us like they were going out of fashion because the education boards were full of money and you would come away enthused and excited and ready to go. Now it's a bit more difficult because if you want to go on a course you're not going to get any sub cover ...

(Gareth, School B, Northern Ireland)

Well the professional development comes through me to be honest with you, through me going every year to a coordinators course.

(Geraldine, School C, Northern Ireland)

Well we are lucky, we have a really great coordinator who does feed back to us ... she would report back as to what the course was about and then she'd maybe do some practical examples or powerpoints or worksheets.

(Michael, School D, Northern Ireland)

Overall, teachers in Ireland and Northern Ireland viewed professional development positively and felt it gave them new ideas, resources or initiatives to use in their teaching of mathematics.

I do find doing the online courses, you get some great ideas, there's some really good websites and games.

(Alison, School B, Ireland)

Certainly the CPD would be great, you know, any problem-solving courses that I've gone on and we've come back with loads of ideas that we're trying to implement in the school, like, doing "Maths Eyes" and using the environment. They are all things that I certainly wouldn't be aware of without the CPD, so it's been fabulous.

(Patricia, School D, Ireland)

The School Board are fantastic at giving us resources and workbooks and discs with lots of activities which I put in the public folder so therefore then all the teachers have access to it ... There are so many activities, you could never get through them.

(Geraldine, School C, Northern Ireland)

Some teachers viewed professional development as being an important factor for improving teacher effectiveness. However, there was a sense among several interviewees that there were not enough professional development opportunities in mathematics.

I suppose in service and continuing professional development [would shape teacher effectiveness], because I don't think teachers get enough of that, especially in maths.

(Finola, School A, Ireland)

CPD definitely could play a role [in shaping teacher effectiveness] for the teachers that are out [qualified/teaching] longer.

(Ciara, School E, Ireland)

Well with regard to professional development there doesn't be ... there seems to be a lot of courses and things for numeracy leaders in the school but trickling down there doesn't seem to be. I'm trying to think if I've been on many recently. I suppose it's important to be able to have the option of going away on professional development courses.

(Michael, School D, Northern Ireland)

While professional development was considered important by teachers, it is interesting that it was not linked by the interviewees to teacher classroom practices as distinctly as other teacher qualifications such as teacher experience or teacher mathematics background. This may be due to the nature of professional development available to teacher participants. A large-scale study by Garet et al. (2001) found that professional development is more likely to have an impact when it is sustained, intensive, content focused, coherent with school daily life and when it involves collective participation and active learning. Evidence from participants in this study suggests that they are not engaging in the professional development that Garet et al. (2001) highlight as being effective. For example, many interviewees cited that they were currently not getting opportunities to personally attend mathematics professional development courses; rather, they were just receiving feedback from courses from another member of staff. This practice does not appear to be as effective as the teacher personally attending the course, with Michael (School D, Northern Ireland) citing “... no matter how good something like that [getting feedback from a member of staff who has attended a professional development

course] is, it doesn't beat you being away on it [the professional development course] yourself."

4.3 Teacher classroom practices

Research questions 1a and 2a explored the teacher effectiveness subclass of teacher classroom practices quantitatively and qualitatively and were as follows:

Q.1a With respect to mathematics, what similarities and/or differences exist between fourth class teacher classroom practices in Ireland and Northern Ireland, as reported in TIMSS 2011?

Q.2a How do teachers in Ireland and Northern Ireland describe the role of a range of teacher classroom practices in student learning and achievement in mathematics?

The TIMSS 2011 teacher background questionnaire collected data regarding several teacher classroom practices including the use of ICT and other teaching resources, assessment and lesson delivery. Teacher responses to survey questions G6d, G9c, G15a, G15c, G15d, M1, M3a-f, M3h, M4b, M4d and M10a-c (described in table 3.5) were compared for Ireland and Northern Ireland. Overall, there were less dramatic differences between teacher reports of classroom practices in Ireland and Northern Ireland than there were between teacher reports of qualifications, discussed in the previous section of this chapter.

Qualitative interviews focused upon three classroom practices in detail. These were teacher expectations, teacher questioning and teacher assessment. However, in order to gather information on other classroom practices that teachers felt were important, while not being too specific, interviewees were asked to describe the structure of a good mathematics lesson. This provided data on a range of classroom practices and

also allowed for a comparison to be made between teacher accounts of good mathematics lesson structure in Ireland and Northern Ireland. Twelve components of a good lesson were identified by interviewees, including: **mental mathematics revision, introduction to topic**, introduction of learning objectives, **teacher modelling of examples**, teacher questioning, **student tasks**, word problems, group work, **use of resources, teacher informal assessment**, help for struggling children and **summarising through a plenary**. The components of good lessons that were identified by five or more interviewees are highlighted in bold and are discussed under the appropriate headings below.

4.3.1 Teacher expectations

Question G6d on the TIMSS 2011 Teacher Questionnaire asked teachers to characterise general teacher expectations for student achievement within their school. A five point Likert scale was used, with options ranging from very high to very low. Results are shown below in Table 4.3. While this question was not specifically related to mathematics, it was included as teacher expectations were identified as being important by the literature and were also focused on during the qualitative interviews. A higher proportion of Northern Irish teachers worked in schools where they characterised teacher expectations for student achievement to be very high (51.5% in comparison to 35.2% of Irish teachers). The result was statistically significant ($\chi^2 = 391.962$, $p = <.001$, $df = 3$).

Table 4.3 How teachers characterise overall teacher expectations for student achievement in their school

How would you characterise teacher expectations for student achievement within your school?	Ireland	Northern Ireland
Very High	35.3%	51.5%
High	52.7%	46.9%
Medium	11.2%	1.6%
Low	0.8%	0.0%
Very Low	0.0%	0.0%

In addition, question G15d provided information about how teachers in Ireland and Northern Ireland communicate their expectations for students' performance. Results are shown below in Table 4.4. Teachers were asked to indicate how often they encouraged all students to improve performance. A four point Likert scale was used with options ranging from every/almost every lesson to never. Like question G6d, this question referred to general teacher classroom practices that would be applied across all areas of the curriculum. Slightly more Northern Irish students were taught by teachers who encouraged them to improve performance in every or almost every lesson. The result was statistically significant ($\chi^2 = 70.495$, $p = <.001$, $df = 3$).

Table 4.4 How often teachers encourage all students to improve their performance (G16d)

How often do you encourage all students to improve their performance in teaching this class?	Ireland	Northern Ireland
Every or almost every lesson	88.0%	90.6%
About half of the lessons	9.0%	7.0%
Some Lessons	3.0%	1.5%
Never	0.0%	0.9%

Qualitative data analysis showed that different approaches to monitoring and evaluating student achievement were evident across the two countries. This may explain the differences in teacher expectations for student achievement across the

two countries. Evidence from throughout the interviews with Northern Irish teachers suggested that there was a whole school approach and focus on student achievement within their schools, especially in relation to standardised tests. Interventions to target students underachieving on standardised tests were described by all of the participants from Northern Ireland. For example, Dervla (School E, Northern Ireland) discussed how standardised test data was analysed “*at least four times per year*” in her school in order to track and monitor the progress of “*under achievers*”. Underachievers were explained to be those students whose scores on standardised tests were lower than their scores on an intelligence test. Dervla described the “*special measures*” her school put in place for underachievers, citing:

An expert classroom assistant comes to your classroom and works with target groups, students who need that extra little, those are not special needs pupils, those are mid band pupils who we are helping to bring up a level to reach their full potential ... It is an extra pair of hands where they can go to a carpeted area and work with a small group and make sure that everything they're learning in a new topic is taken in, so it's confidence and morale boosting too.

The strong focus on standardised tests in Northern Ireland may be evidence of the impact of the current global accountability agenda described by Sahlberg (2007). There was a very strong sense of a strategic, whole school and team approach to student underachievement throughout the interviews in Northern Ireland, and this was not apparent from the Irish interview data. In Northern Ireland, classroom assistants were described as being trained specifically to address underachieving students' needs and this was separate to the learning support programme for children with special needs. Numeracy teams and co-ordinators tracked mathematics progress and learning throughout the whole school over the course of each year. These collaborative practices suggest that the class teacher is not a ‘lone ranger’ in promoting and holding high expectations for their students' achievement. Rather, the whole school team, from management to numeracy co-ordinator to classroom

assistants, have a vested interest and involvement in the achievement of students. Although the whole school strategic approach to addressing underachievement on standardised tests, outlined by Northern Irish teachers, was reported to improve student achievement on standardised tests, Imig and Imig (2006) and Lee (2011) voice concerns about the implications of a sustained focus on standardised tests, namely, the narrowing of education or schools becoming test factories.

Aside from this, the whole school and team approach to addressing student underachievement in Northern Ireland may be a reason for teachers perceiving high expectations for student achievement within their schools in TIMSS 2011. Furthermore, the fact that P6 teachers spend time preparing their students for a transfer test may also lead to them focusing more closely on student achievement than do Irish fourth class teachers.

The qualitative interviews also explored the role of holding high expectations for student learning and achievement. Analysis of the data revealed a consensus among teachers in both Ireland and Northern Ireland that holding and communicating high expectations for student learning has a positive effect on student outcomes, in the sense that students tend to rise to their teacher's expectations. This supports evidence that communicating high expectations to students about their academic work positively influences student self-beliefs (Rubie-Davies, 2006) and student achievement (Wentzel, 2002). Michael (School D, Northern Ireland) provided an example of this in citing:

I find that they [the students] react well to your encouragement ... I think if they think that you have an expectation that they can get to a certain level then they will try their darndest to get to that one.

Una (School C, Ireland), who teaches in a highly disadvantaged DEIS (Delivering Equality of Opportunity in Schools) Band 1 school, echoed this in stating:

I think it's the enthusiasm, if you expect the children are going to do very well, you tell them they are going to do very well, they think they are themselves. I tell my children that they are amazing at maths. Their maths are the lower end of the bell curve, overall they are weaker than the average, but I tell them they are great and they think they are great. And sure they'll make a bigger effort, they'll try the sums and I think it does have such an influence on it.

Similarly, Patricia (School D, Ireland) reflected that holding high expectations for student achievement “... encourages them [the students] ... and it gives them a bit of self-belief”, although she noted that there shouldn't be “... great pressure on them.” This idea that undue pressure should not be placed upon students also resonated among other teachers, with Phyll and Geraldine noting that teacher expectations should be for students to achieve at the “... best of their ability” (Phyll, School F, Ireland; Geraldine, School C, Northern Ireland).

4.3.2 Questioning

Question G15c on the TIMSS 2011 Teacher Questionnaire asked teachers to indicate how often they used questioning to elicit reasons and explanations from students. A four point Likert scale was used with options ranging from every/almost every lesson to never. Results are shown below in Table 4.5. Although this question was not specifically related to mathematics, it was included due to the fact that variables regarding teacher classroom practices were limited and teacher questioning was identified as one of the most prominent activities of effective teachers in the literature (Brophy, 1988; Muijs and Reynolds, 2011; Newton and Winches, 2013). More Irish students were taught by teachers who used questioning to elicit reasons and explanations in every or almost every lesson (91.2% in comparison with 84.2% of Northern Irish students). The result was statistically significant ($\chi^2 = 113.976$, $p = <.001$, $df = 3$).

Table 4.5 How often teachers use questioning to elicit reasons and explanations

How often do you use questioning to elicit reasons and explanations in teaching this class?	Ireland	Northern Ireland
Every or almost every lesson	91.2%	84.2%
About half of the lessons	7.8%	14.9%
Some Lessons	0.4%	0.0%
Never	0.6%	0.9%

Question M4f referred specifically to mathematics teaching and asked teachers to indicate how often they asked students to explain their answers. A four point Likert scale was used with options ranging from every/almost every lesson to never. A similar number of students in Ireland and Northern Ireland were taught by teachers who asked them to explain answers in every or almost every lesson (61.30% in Ireland and 61.40% in Northern Ireland).

Qualitative interviews explored classroom questioning in detail and, echoing the quantitative data, teachers in Ireland and Northern Ireland held very similar views regarding the classroom practice of questioning. Three types of question were considered, namely, product, process and higher order questions. Teachers were also asked for their opinions on the role of teacher questioning in promoting student achievement on standardised tests. All teachers viewed questioning as an important and integral classroom practice. In line with findings by Heritage and Heritage (2013), seven teachers viewed teacher questioning as a tool for informally assessing student learning and understanding of concepts. For example, Ciara (School E, Ireland) reported:

You can see who is listening, you can see if they are following ... You can figure out “Yeah they know the process”, ... Yes it’s a way of assessing how a lesson is going really for your own reflections as well as their learning.

Similarly, Michael (School D, Northern Ireland) noted:

It reinforces if they are understanding a topic,

and Majella added:

Questioning does determine what they [the students] are getting from the lesson and how much they are understanding, and also what you're giving as well.

Phyll (School F, Ireland) also noted:

You know straight away from the child if you can push them a little more.

The above extracts reveal an interesting synergy between teacher questioning and teacher informal assessment of both the teaching of the mathematics lesson and student learning.

When interviewees were asked for their opinions about product, process and higher order questions, six teachers were of the opinion that process questions were the most important question type for student learning, as these questions were perceived to facilitate as well as show a student's understanding regarding the process of working through a mathematics problem. This aligns with evidence from the literature that links process questions with effective teaching and student achievement (Frome et al., 2005; Aslam and Kingdon, 2011; Muijs and Reynolds, 2011). For example, Una (School C, Ireland) noted that process questions show “*a very strong understanding with a child.*” Similarly, Finola (School A, Ireland) emphasised the importance of process questions: “*... so they [the students] understand what it is they're doing and why they're doing it*” and Patricia (School D, Ireland) reflected that process questions encourage students to “*clarify and state exactly what they mean.*”

A number of teachers linked the verbalising of answers to process questions with student achievement on standardised tests. Geraldine (School C, Northern Ireland) for example, noted that:

... you're drawing out of them [the students] what they need to be processing I suppose, so when they read it [the standardised test question], they should think "Well when I did that in class, this is what we did." I suppose you're just getting them to think things through.

Similarly, Finola (School A, Ireland) added:

If they're used to going through a process of questioning things and thinking about how to go about approaching a maths question, then when they come to something that they mightn't necessarily have seen before in a standardised test they hopefully will go through that process themselves.

In response to the researcher asking how questioning influences student achievement on standardised tests, Phyll (School F, Ireland) reflected:

If the children are able to explain exactly how they got the answer, they're more likely to be able to understand the concept of it.

In response to the same question, Patricia (School D, Ireland) noted:

I think it should help them [the students] ... because they are verbalising what they are actually doing.

In addition, interviewees highlighted the importance of process questions in showing students that there are different ways to solve any given mathematics question. This was an important factor for many of the interviewees. For example, Alison (School B, Ireland) noted that she asks students *"How did you get the answer? Did somebody else get it a different way?"* In this way, the other students are hearing *"different ways of getting the same answer."* Similarly, Gareth (School B, Northern Ireland) added:

I think for children to see that there are different ways of getting it [the answer] and that there may be two, three, four or five in the class who got it in a different way, is important. It really makes them feel much happier with their maths.

With respect to product style questions, many interviewees saw a role for these questions during the mental mathematics session at the beginning of mathematics lessons. For example, Phyll (School F, Ireland) noted *"... mental maths covers an*

awful lot of that.” Finola (School A, Ireland) substantiated this in citing: *“they [product questions] do have their place, I think for the mental maths section at the beginning of a lesson, you know when you’re doing real rapid fire questioning session, then they’re used a lot.”* On the other hand, higher order questions were seen as playing a role towards the end of mathematics lessons, to stretch and extend students’ learning, especially the more able students. This extract from Majella’s (School A, Northern Ireland) interview gives a clear example of this view:

They [higher order questions] would be for your really strong pupils now. I would use them as an extension exercise as I would call it. The children that are kind of the high flyers at maths can work through that.

Patricia (School D, Ireland) and Phyll (School F, Ireland) also pointed out that while higher order questions are important, not all children may be able to do them. Interestingly, however, Ciara (School E, Ireland) cited that in posing higher order questions to the whole class *“... you get those who aren’t quite as able thinking more and I guess wanting to answer the next time you have a higher-order question.”* This suggests that students learn and are motivated by hearing other students’ answers to higher order questions.

Overall, teachers associated the three types of question with very specific stages of mathematics lessons, with product questions at the beginning during the mental maths stage, process questions during the main body of the lesson, and higher order questions towards the end of the lesson. In addition, an interesting link between teacher assessment and teacher questioning was described by **seven** of the interviewees.

4.3.3 Assessment

Question M3h on the TIMSS 2011 Teacher Questionnaire required teachers to indicate how often they asked their students to take a written test or quiz. A four

point Likert scale was used, with options ranging from every or almost every lesson to never. Table 4.6 below shows the results. Teachers in Ireland asked their students to take a written test more often, with 25% of students taught by teachers who asked them to take a written test in about half or more of their mathematics lessons. This was in comparison to 19.7% of Northern Irish students. The result was statistically significant ($\chi^2 = 95.161$, $p = <.001$, $df = 3$).

Table 4.6 How often teachers ask students to take a written test or quiz (M3h)

In teaching mathematics to this class, how often do you usually ask students to take a written test or quiz?	Ireland	Northern Ireland
Every or almost every lesson	6.1%	4.4%
About half of the lessons	18.9%	15.3%
Some Lessons	74.9%	78.6%
Never	0.1%	1.7%

Questions M10a, M10b and M10c on the TIMSS 2011 Teacher Questionnaire also pertained to assessment and were analysed during the quantitative phase of the study. These questions required teachers to indicate how much emphasis they put on various forms of assessment to monitor student progress in mathematics. A three point Likert scale was used for each question, with options ranging from major emphasis to little or no emphasis. Table 4.7 below shows the results. Students in Ireland and Northern Ireland were taught by teachers who put a similar emphasis on the evaluation of ongoing work to monitor student progress (92.8% and 94.4% of students respectively). On the other hand, more Irish students were taught by teachers who put a major emphasis on classroom tests to monitor student progress (52.3% in comparison to 42.3% of Northern Irish students). However, slightly more Northern Irish teachers placed a major emphasis on national or regional achievement tests to monitor student progress (37.0% in comparison to 32% of Irish Students).

Results for questions M10a, M10b and M10c were statistically significant (M10a: $\chi^2 = 7.851$, $p = .005$, $df = 1$), (M10b: $\chi^2 = 73.835$, $p = <.001$, $df = 2$), (M10c: $\chi^2 = 19.736$, $p = <.001$, $df = 2$).

Table 4.7 How much emphasis teachers put on various forms of assessment to monitor students' progress in mathematics (M10a, M10b, M10c)

Form Of Assessment	Ireland			Northern Ireland		
	Major Emphasis	Some Emphasis	Little/No Emphasis	Major Emphasis	Some Emphasis	Little/No Emphasis
M10a: Evaluation of Ongoing Work	92.8%	7.2%	0.0%	94.4%	5.6%	0.0%
M10b: Classroom Tests	52.3%	47.0%	0.7%	42.3%	57.1%	0.6%
M10c: National Achievement Tests	32.0%	65.1%	2.9%	37.0%	60.3%	2.7%

During the qualitative interviews, teachers in Ireland and Northern Ireland were asked how often they felt written classroom tests in mathematics should be conducted. Most interviewees reported that they conducted tests regularly, either weekly or at the end of teaching a topic or concept. There were no notable differences in the frequency of testing reported by interviewees in Ireland and Northern Ireland. However, Dervla (School E, Northern Ireland) did note that the revised curriculum, which was introduced in 2007 in Northern Ireland, advocates “*more learning as you go*” and, as such, she reported conducting written tests less frequently than in the past. Additionally, Dervla described an “*obsession*” with standardised tests within her school, and reported that test data was revisited four times per year. Dervla revealed that this was partly due to the fact that education inspectors looked closely at student achievement data when awarding grades to schools. This evidence appears to correlate with the TIMSS 2011 data where Northern Irish teachers place less emphasis on classroom tests and more emphasis on standardised tests than their Irish counterparts. Once again the strong focus on standardised tests, described by Dervla and other Northern Irish teachers, may be

indicative of an increased accountability agenda in Northern Ireland (Sahlberg, 2007).

Seven of the eleven teachers viewed assessment as being important for gaining data about what students know, which in turn informed teaching. This correlates with the literature, which suggests that assessment allows teachers to match instruction to student needs (Martinez et al., 2009; Stronge et al., 2011). Examples from across the spectrum are Alison's (School B, Ireland) view that:

It's so that I can assess what they know and what they don't know what they need more practice on and what I need to do for my planning and things like that,

and Dervla's (School E, Northern Ireland) words that:

Well I like to do them [written tests] occasionally because I like to make sure that what I have taught is secure and it's really more informative for me ... It is actually informing me where I maybe need to address a few gaps in their learning,

and Majella's (School A, Northern Ireland) point that:

You kind of build up then what they know, and it lets you focus in on what they need extra or what they're struggling with.

In addition, four teachers pointed out the role of assessment in ensuring that mathematics concepts were revised regularly throughout the school year. This is important, as although the literature identifies assessment as an important classroom practice for promoting student achievement (Wenglinsky, 2000; Stronge et al., 2011; Aslam and Kingdon, 2011), the evidence base has not yet linked the classroom practice of revision with assessment. In fact, to my knowledge revision has not yet been identified as an important classroom practice by the teacher effectiveness evidence base. Interestingly, several teachers spoke positively about the use of mental maths assessments from publishers such as Prim-Ed for ensuring mathematics

concepts were revised and not forgotten over the course of the year. For example, Michael (School D, Northern Ireland) noted:

The ones [mental maths tests] that I have, introduce new topics every week and reinforce the ones we've looked at, so I suppose they are quite short tests ... Just 20 reasonably short questions in it. It's a way of ... to me if I cover a topic in September and then I don't come back to it again for however long, it's a good way of just keeping it in their mind.

Similarly, Patricia (School D, Ireland) cited:

... we do the little mental maths tests, and I think they are brilliant because that's constant revision.

When asked for her views on how written tests impact upon student achievement in standardised tests, Phyll (School F, Ireland) also mentioned mental maths tests, due to their effectiveness in facilitating student revision. She stated:

Well, it's constant revision ... I must say the mental maths is great as well for that [revision] because I mean they forget stuff in September. They need constantly to be reminded. I mean measurement and all the different units of measurement all the different topics. They need constant reminding I mean they just can't ... I think it's the whole revision thing ... Just for the basic concepts.

Constant revision was cited by a large proportion of interviewees as being vital for promoting student achievement in mathematics. This provides new knowledge, as revision has not yet been mentioned throughout the mathematics teacher effectiveness literature. It is interesting that many interviewees referred to a specific type of resource that they believed to be effective for ensuring that students revised mathematics concepts continually, namely, daily mental mathematics workbooks from publishers such as Prim-Ed. Another notable factor is the fact that the need for constant revision seems to be particular to the subject of mathematics, due to the large number of concepts that are covered by the curriculum throughout the year, which must then be recalled by students in order to perform well on standardised tests.

Another aspect that was explored during the qualitative interviews was how conducting classroom tests impacts upon student achievement in standardised tests. Interviewees offered up a range of different opinions in relation to this, although the most frequent response was predicated on students being comfortable and familiar with a testing situation. For example, Gareth (School B, Northern Ireland) noted: “... *that formal sitting down to a test alleviates a lot of the fear*” and Michael (School D, Northern Ireland) added:

I suppose it's no harm if they're doing tests all the time and then they are handed a big fancy coloured paper whatever it is I suppose it's not as daunting for them. They are used to the process of tests.

Similarly, Alison (School B, Ireland) cited:

I do think it's good that they're [the students are] used of a test so that they don't find it so daunting – that this big test that they get at the end of the year is the first time that they've seen a test. They'd be thrown by it.

Finola (School A, Ireland) also noted that in completing classroom tests throughout the year, students gain practice in the process of testing, and that they can self-reflect on this process for future testing situations:

... after you've done the test with them [the students] you can talk about what they found difficult or what they'd do again, you know, so it's good practice for them.

During interviews, teachers were also asked for their opinions about the role of informal teacher assessments. Findings showed that seven interviewees linked informal teacher assessments with the immediate, day-to-day or short-term informing of their teaching. These findings align with Stronge et al.'s (2011) conclusion that effective teachers use informal assessment to gauge student understanding and they adjust their instruction accordingly. Informal assessment was also mentioned by a number of teachers in their description of a good lesson, with Patricia explaining:

You're watching them [the students] all the time to judge what pace to go at.

Patricia's description, like six other interviewees' responses, linked informal assessment with immediate, short term informing of lesson pace.

The identification of struggling learners was also in evidence in four interviewees' opinions on the role of informal teacher assessment. For example, Ciara (School E, Ireland) pointed out:

They [informal assessments] tell you where the problems are, they tell you where to aim your next lesson and they tell you if you need to do your lesson again.

Similarly, Majella (School A, Northern Ireland) noted:

That's [Informal assessment is] informally letting you know "Does he understand that, did he grasp that lesson or does he need extra help with that?"

In summary, interviewees identified two distinct roles for written assessments. Classroom pen and paper assessments were seen as a way in which to gather information on student knowledge, and this information was then reported to be used to inform future teaching. Interestingly, written assessments were also viewed by teachers as an important activity through which to promote constant revision of mathematics concepts. Constant revision was linked by eight teachers throughout the interviews to student achievement on standardised tests. In describing how they believed classroom assessments influenced students on achievement tests, most interviewees' responses were predicated on the idea that the testing process would be familiar and therefore less daunting to students. Lastly, interviewees differentiated informal assessment from written assessment by noting that informal assessment is data that is gathered about student knowledge during lessons, which is acted upon in a short space of time – either during the same lesson, or in the days following the lesson. In a similar manner, informal assessment was viewed by many interviewees

as an important tool for identifying struggling learners, so as to allow teachers to subsequently assist these students. There were no notable differences between the views of Irish and Northern Irish teachers regarding the role of assessment in student learning and achievement in mathematics. However, echoing the TIMSS 2011 findings, there was evidence that teachers in Ireland and Northern Ireland placed different levels of emphasis on classroom and standardised tests due to differences in the curriculums and accountability systems of each country.

4.3.4 Mental maths/revision

Eight out of the eleven interviewees included mental mathematics revision in their descriptions of good lesson structure. This is not explored in the TIMSS 2011 dataset or across the teacher effectiveness literature base. However, it was considered important by a majority of interviewees in this study. Mental mathematics was associated with quick-fire questioning, either oral or written, and most interviewees noted that they started their lessons with a mental mathematics exercise. Teachers strongly associated mental mathematics with the revision of mathematics concepts, and in turn with promoting student achievement. The need for constant revision in mathematics was a theme that recurred frequently throughout the interviews conducted in Ireland and Northern Ireland. The extract below is taken from the interview conducted with Geraldine (School C, Northern Ireland), and it clearly explains why revision with respect to mathematics is so important:

Geraldine: *It' practise, practise, practise at maths ... and keep revisiting and revisiting and revisiting.*

Researcher: Yes ...Why do you think that is so?

Geraldine: *Because they forget so quickly. And especially P6, certainly in our system, because everything has to be covered before they go into P7 really – just to be able to answer questions for the test [transfer test] or whatever. So maybe we do fractions, decimals, percentages. By the time we get to Percentages*

which is really related to Decimals and Fractions then we forgot Time which was done before that and we have to go back over it. So what we do in P6 is we have mental maths every single day.

Researcher: Yes

Geraldine: *That I call out to them as well as for homework there's mental maths every night. So you're just trying to revisit everything regularly because they do forget so, so quickly.*

Once again in Geraldine's extract, mental mathematics exercises are associated strongly with revision. This extract also highlights why revision in mathematics is so important. Because so many concepts are covered in the curriculum throughout the course of the year, constant revision is vital so as to ensure children do not forget what they have learned. For this reason, constant revision is considered an important factor for promoting student achievement on standardised tests at the fourth class level.

4.3.5 Use of ICT

Question G9c on the TIMSS 2011 Teacher Questionnaire investigated whether teachers use computers in their classroom instruction. In the case of fourth class students in Ireland, 97.2% were taught by teachers who use computers in their classroom instruction, in comparison to 99.5% of P6 students in Northern Ireland. This result was statistically significant ($\chi^2 = 56.154$, $p = <.001$, $df = 1$).

Question M4d on the TIMSS 2011 Teacher Questionnaire was specifically related to mathematics and it asked teachers to indicate how they used the resource of computer software in their teaching of mathematics. A three point Likert scale was used with values ranging from basis for instruction, to not used. Results are shown below in table 4.8. Northern Irish teachers used the resource of computer software more in their teaching of mathematics than Irish teachers. The result was statistically significant ($\chi^2 = 370.779$, $p = <.001$, $df = 2$).

Table 4.8 How do teachers use computer software for mathematics instruction when they teach mathematics (M4d)

When you teach mathematics to this class, how do you use computer software for mathematics instruction?	Ireland	Northern Ireland
Basis for instruction	10.3%	13.5%
Supplement	69.3%	81.8%
Not used	20.4%	4.7%

Every interviewee in the qualitative phase, both in Ireland and Northern Ireland, had an interactive whiteboard in their classroom, and most teachers reported that their students had access to a computer room or iPads also. However, teachers in Northern Ireland mentioned specific computer software packages (such as Education City) that were purchased and used by their schools, whereas teachers in Ireland did not seem to have access to purchased software resources of this kind. This appears to correlate with the TIMSS findings for question M4d in table 4.8 above, where more Northern Irish teachers report using computer software in their mathematics instruction.

When interview participants were asked to describe a good lesson structure for mathematics, five interviewees mentioned the use of interactive whiteboards at the beginning of the lesson in the form of a hook, or introduction to the topic, and at the end of the lesson in the form of a game to help summarise the key learning objective. For example, Geraldine (School C, Northern Ireland) noted the use of Powerpoints during the introduction of a mathematics lesson:

We use Powerpoints quite a lot for the introduction, just to let them [the students] see the visual of it [the concept].

On the other hand, Dervla (School E, Northern Ireland) described the use of online video clips to inspire and motivate students during the introduction to the mathematics lesson:

I also believe that the children often need an introduction that inspires them ... we would often go online and look up BBC learning clips, something that would give them a little practical video clip ... so we would allow the children to see real life ... they are a great wee motivator.

With respect to the plenary, Phyll (School F, Ireland) discussed the use of an online “interactive game” as a good way to conclude mathematics lessons.

The literature remains inconclusive about the effectiveness of ICT in improving student outcomes. However, in this study teachers generally considered the use of ICT to be helpful for promoting enjoyment and interest in mathematics, with Alison (School B, Ireland) for example, describing “fun activities” that children could engage in to reinforce and revise mathematical concepts. In addition, ICT was mentioned as a tool for allowing visualisation of concepts, with Majella (School A, Northern Ireland) noting: “Visual learning [using iPad apps] is really good.” However, in line with Thorvaldsen et al.’s (2012) finding, Michael (School D, Northern Ireland) emphasised that the use of ICT alone will not guarantee superior teaching and learning, and that in order to be effective, ICT use must be planned carefully:

As long as you’re not throwing out iPads for the sake of saying “Right we’ll do maths with iPads today!” As long as you’ve planned out a proper use and there will be a gain to using them.

4.3.6 Lesson delivery – summarising lessons

Question G15a on the TIMSS 2011 Teacher Questionnaire asked teachers to indicate how often they summarised what students should have learned from lessons. A four point Likert scale was used with options ranging from every/almost every lesson to never. Results are shown below in Table 4.9. A higher proportion of Northern Irish students were taught by teachers who summarised what students should have learned

in lessons every or almost every lesson (72.3% in comparison to 52.4% of Irish teachers). The result was statistically significant ($\chi^2 = 412.001$, $p = <.001$, $df = 3$).

Table 4.9 How often teachers summarise what students should have learned from lessons (G15a)

How often do you summarise what students should have learned from the lesson in your teaching of this class?	Ireland	Northern Ireland
Every or almost every lesson	52.3%	72.3%
About half of the lessons	28.9%	21.2%
Some Lessons	18.5%	5.6%
Never	0.3%	0.9%

Echoing the TIMSS 2011 data, during the qualitative interviews, three out of the five Northern Irish teachers highlighted a summary or plenary at the end of the lesson as being important for student understanding of the concept being taught. For example, Majella (School A, Northern Ireland) noted:

It is equally important to do a plenary to finish it [the lesson] off ... To wrap it up and show that they [the students] understand.

Two out of the six Irish teachers included a plenary in their description of a good lesson. Similarly to the Northern Irish teachers, they saw the plenary as a time to conclude the lesson and get feedback about what the children had learned. These teacher views about the function of lesson summaries are in line with the literature, which argues that when key points of the lesson are summarised, student memorisation of key concepts is facilitated and student achievement is higher (Muijs and Reynolds, 2011; Panayiotou et al., 2014).

4.3.7 Teacher modelling

Questions M3a and M3d on the TIMSS Teacher Questionnaire asked teachers to indicate how often they asked students to listen to them explain how to solve

problems (M3a), and how often they asked students to work problems in the whole class with direct teacher guidance (M3d). These questions refer to periods during the mathematics lesson where the teacher is actively teaching and modelling how to solve mathematics problems. In the case of both questions, more Irish students were taught by teachers who engaged in teacher modelling in every or almost every lesson. Results are shown below in table 4.10 and table 4.11. The results in both cases were statistically significant (M3a: $\chi^2 = 77.075$, $p = <.001$, $df = 3$), (M3d: $\chi^2 = 189.857$, $p = <.001$, $df = 3$). Qualitative evidence provided a possible reason for Irish teachers engaging in teacher modelling more often than their Irish counterparts, with Majella (School A, Northern Ireland) noting that the revised Northern Irish curriculum advocates more learning by problem solving.

Table 4.10 How often teachers ask students to listen to them explain how to solve problems (M3a)

In teaching mathematics to this class, how often do you usually ask students to listen to you explain how to solve problems?	Ireland	Northern Ireland
Every or almost every lesson	65.6%	58.2%
About half of the lessons	21.6%	30.5%
Some Lessons	12.2%	10.9%
Never	0.6%	0.4%

Table 4.11 How often teachers ask students to work problems together in the whole class with their direct instruction

In teaching mathematics to this class, how often do you usually ask students to work problems together in the whole class with your direct guidance?	Ireland	Northern Ireland
Every or almost every lesson	51.8%	39.5%
About half of the lessons	33.6%	34.1%
Some Lessons	14.2%	25.3%
Never	0.4%	1.1%

During the qualitative interviews, half of the interviewees included teacher modelling in their descriptions of good lesson structure. Writing on the board, explaining and demonstrating, and modelling the use of resources were noted as the prominent activities during teacher modelling. Interestingly, Gareth cited that this was the stage of the lesson where a teacher needs to get their students to “*understand the core [of the concept being taught]*” and, as such, teacher modelling can be viewed as an important teacher classroom practice for promoting student learning. This correlates with the literature, which finds that effective teachers explain content clearly and use modelling to support learning (Schacter and Thum, 2004; Stronge et al., 2011).

4.3.8 Using concrete resources

Question M4c on the TIMSS 2011 Teacher Questionnaire asked teachers to categorise how they used concrete materials (e.g. 3D shapes, plastic money, counters etc.) in their teaching of mathematics. Results are depicted below in table 4.12. More Irish students were taught by teachers who used concrete materials as a basis for instruction (42.2% in comparison to 36% of Northern Irish students). The result was statistically significant ($\chi^2 = 71.771$, $p = <.001$, $df = 2$).

Table 4.12 How teachers use concrete objects or materials that help students understand quantities or procedures (M4c)

When you teach mathematics to this class, how do you use concrete objects or materials that help students understand quantities or procedures?	Ireland	Northern Ireland
Basis for instruction	42.2%	36.0%
Supplement	56.6%	64.0%
Not used	1.2%	0.0%

During the qualitative interviews, interviewees gave their opinions on a good lesson structure. Eight out of the eleven interviewees included the use of concrete resources

in their description of a good lesson. Echoing the TIMSS 2011 findings, five out of the six Irish interviewees considered concrete resources to be an important aspect of good lessons, while three out of the five Northern Irish teachers associated the use of concrete resources with good lessons. The association between the use of concrete resources and student outcomes is explored in more detail in section 4.5, Promoting Student Achievement.

4.3.9 Student tasks

Questions M3b, M3c and M3e on the TIMSS Teacher Questionnaire asked teachers to indicate how often they asked students to engage in different tasks. Tables 4.13, 4.14 and 4.15 below show the responses of teachers in Ireland and Northern Ireland to each question respectively. The results in all cases were statistically significant: (M3b: $\chi^2=74.232$, $p = <.001$, $df = 3$), (M3c: $\chi^2 = 11.407$, $p = .003$, $df = 2$), (M3e: $\chi^2 = 134.587$, $p = <.001$, $df = 3$).

Table 4.13 How often teachers ask students to memorise rules, procedures and facts (M3b)

In teaching mathematics to this class, how often do you usually ask students to memorise rules, procedures, and facts?	Ireland	Northern Ireland
Every or almost every lesson	29.8%	27.8%
About half of the lessons	40.7%	36.7%
Some Lessons	27.8%	35.2%
Never	1.7%	0.3%

Table 4.14 How often teachers ask students to work problems with teacher guidance (M3c)

In teaching mathematics to this class, how often do you usually ask students to work problems with your guidance?	Ireland	Northern Ireland
Every or almost every lesson	52.3%	56.2%
About half of the lessons	33.5%	31.2%
Some Lessons	14.2%	12.6%
Never	0.0%	0.0%

Table 4.15 How often teachers ask students to work problems while teacher is occupied with other tasks

In teaching mathematics to this class, how often do you usually ask students to work problems while you are occupied by other tasks?	Ireland	Northern Ireland
Every or almost every lesson	20.1%	14.7%
About half of the lessons	29.2%	21.1%
Some Lessons	36.9%	46.9%
Never	13.8%	17.3%

During qualitative interviews, nine interviewees described students engaging in tasks as a feature of good lesson structure. Teachers described various ways of organising student tasks, including group work, individual work and working in stations. Many teachers noted that student tasks should involve “*practical hands-on work*” (Michael, School D, Northern Ireland) where possible, as well as more traditional pen and paper “*book work*” (Ciara, School E, Ireland). In addition, differentiation during student tasks was mentioned by three teachers, either through “*access to concrete materials*” (Finola, School A, Ireland), teacher one-on-one or group support, or differentiated learning tasks.

4.3.10 Time teaching mathematics

Question M1 on the TIMSS 2011 Teacher Questionnaire asked teachers to indicate the amount of time that they spent teaching mathematics per week. There was a surprising and statistically significant difference in the time spent teaching mathematics in Ireland and Northern Ireland. On average, teachers in Northern Ireland ($M = 6.321$, $S.D. = 1.989$) spent 50% more time on mathematics instruction compared to Ireland ($M = 4.096$, $S.D. = .924$). This means that on average fourth class students in Northern Ireland spent an extra 72 hours on mathematics lessons in comparison to their Irish counterparts. Or, giving one hour per maths lesson per day, this is the equivalent of students in Northern Ireland receiving over fourteen extra weeks of mathematics tuition. This is likely to explain Northern Ireland's higher scores and ranking on TIMSS 2011.

During the qualitative interviews, the surprising finding regarding the disparity in time spent on mathematics across Ireland and Northern Ireland was probed more deeply. Interviewees in Northern Ireland indicated that they spent extra time on mathematics teaching due to the existence of the transfer test. Dervla (School E, Northern Ireland) clearly describes the expectation that is placed upon teachers to spend additional mathematics time preparing students for this test:

The dilemma is that you are legally bound to teach the curriculum but yet there is an expectation that you will also cater for preparation [for the transfer test] which is very difficult to strike the balance ... but the way our school has done that is that we are teaching the curriculum and we stand over the fact that any additional preparation in English and maths are still very current to the curriculum.

This extract again highlights the different context of fourth class in Northern Ireland in comparison to Ireland. It is very clear that additional time is spent on mathematics in fourth class in Northern Ireland and that this is very focused and driven towards high achievement on the transfer test. Based on this evidence, it is reasonable to

suggest that the extra time spent teaching mathematics in Northern Ireland may have contributed to Northern Irish students' higher achievement scores on TIMSS 2011. Once again, this substantiates concerns in the literature regarding the interpretation of TIMSS rankings, due to differences in content coverage across different countries (Wang, 2001; Robertson, 2005).

4.4 Teacher attitudes and beliefs

Research questions 1c and 2c explored the teacher effectiveness subclass of teacher attitudes and beliefs, and were as follows:

Q.1c With respect to mathematics, what similarities and/or differences exist between fourth class teacher attitudes and beliefs in Ireland and Northern Ireland, as reported in TIMSS 2011?

Q.2c How do teachers in Ireland and Northern Ireland describe the role of teacher attitudes and beliefs in student learning and achievement in mathematics?

Question M2a-e on the TIMSS 2011 Teacher Questionnaire required teachers to indicate how confident they felt in relation to a range of classroom practices. A three point Likert scale was used, with options ranging from very confident to not confident. Table 4.16 below shows the results. Northern Irish teachers were significantly more confident than Irish teachers with respect to every classroom practice apart from answering students' questions about mathematics, for which the difference was not statistically significant. A possible explanation for this may be that TIMSS 2011 teachers in Northern Ireland were more experienced and may therefore have felt more confident about their teaching. In addition, teachers in Northern Ireland benefitted from more mathematics-related professional

development, which may have boosted teacher confidence in teaching the subject. Although it is not explored in the TIMSS data, qualitative interviews showed that P6 teachers in Northern Ireland had more consecutive years of experience teaching P6 in comparison with their Irish counterparts (see table 3.6). If this was an unobserved factor within the TIMSS 2011 data, it may also explain why Northern Irish teachers were more confident than Irish teachers.

Table 4.16 How confident teachers feel in relation to a range of classroom practices (M3e)

Maths Confidence	Ireland			Northern Ireland			Statistical Significance	
	Very Conf.	Some-what Conf.	Not Conf.	Very Conf.	Some-what Conf.	Not Conf.	Chi-Square	P-Value
M2a: Answer Students' Questions about Mathematics	89.6%	10.4%	0.0%	88.6%	11.4%	0.0%	1.784	0.182
M2b: Show Students Variety of Problem Solving Strategies	67.2%	32.2%	0.6%	80.3%	19.7%	0.0%	165.581	<.001
M2c: Provide Challenging Tasks for Capable Students	61.6%	35.0%	3.4%	70.8%	28.5%	0.7%	104.033	<.001
M2d: Adapt Their Teaching to Engage Students' Interest	65.9%	32.4%	1.7%	75.2%	24.1%	0.7%	77.743	<.001
M2e: Help Students Appreciate the Value of Learning Mathematics	64.5%	34.3%	1.2%	70.9%	29.1%	0.0%	77.743	<.001

During qualitative interviews, teachers were asked about the attitudes and beliefs that were important for promoting student learning and achievement. Two teachers in Northern Ireland pointed out that a confident teacher attitude towards mathematics was important for promoting positive student outcomes in mathematics. This echoes the finding by Stipek et al. (2001) that teacher self-confidence is significantly correlated with student self-confidence. Interestingly, both teachers linked teacher

confidence to teacher mathematics knowledge and surmised that if a teacher is lacking in their mathematical knowledge, they will not communicate a confident attitude towards mathematics within the classroom, which will in turn impact negatively upon students. For example, Michael (School D, Northern Ireland) said:

... the teacher who is maybe not as confident, it will show with the kids. Because as you go up the school ... you could be caught out if you don't know your stuff.

Similarly, Geraldine (School C, Northern Ireland) noted:

Some teachers really lack confidence in maths ... and for example the teachers further down the school [teaching younger classes], who are very capable say "I haven't done that [angles] for ages!"

In fact, confidence was linked to mathematics interest, attitudes and motivation by teachers and this is discussed in detail in section 4.5.2 of this chapter, which discusses factors that hinder teachers in promoting student achievement. However, to synthesise interviewee views regarding confidence, it was perceived that confidence is influenced by teacher mathematics knowledge. It was also perceived that if a teacher is lacking in confidence regarding mathematics, they may hold a negative attitude towards the subject or have less interest in it, which in turn could lead to them being less motivated in their teaching of the subject. The synergy between teacher knowledge, confidence and teaching of mathematics described here is consistent with findings by Geist (2015), who links teacher perceptions about their mathematics knowledge to their confidence about their mathematics ability and in turn to their mathematics teaching approach.

One of the most notable findings regarding teacher attitudes and beliefs, was the notion that the attitude communicated by the teacher towards mathematics was picked up and replicated by their students. This is notable, as the literature to date has been unclear about the way in which teacher attitudes or beliefs impact upon their

classroom practices and, in turn, on student outcomes. Interestingly, the data revealed that the classroom practice of communicating a positive, enthusiastic attitude towards mathematics resulted in students adopting a more positive attitude themselves. This is substantiated by several studies which find correlations with teacher and student attitudes (Stipek et al., 2001; Geist, 2015). Furthermore, it is notable that students were reported to perform better in mathematics when their teacher communicated this strong positive attitude towards the subject. For example, Geraldine (School C, Northern Ireland) noted that parents have “*said to me that their child has learnt more because of my enthusiasm for it [mathematics].*” However, it may be the case that teachers who have a strong mathematics background and communicate positive attitudes towards mathematics to their students also engage in other classroom practices that promote student achievement. For example, Una (School C, Ireland) reflected that her enthusiastic attitude towards mathematics motivates her to devote time to mathematics teaching for one hour every day. She explained:

I do maths every day without fail. If there is nothing else done I will do it.

Nevertheless, communicating a positive attitude towards mathematics, unlike many other classroom practices, is linked definitively by multiple interviewees to increased student achievement and it is therefore noteworthy. However, further research in this area is needed to substantiate these anecdotal reports.

Another interesting finding revealed in this study was the strong link between a teacher’s mathematics background and past experiences, and their attitudes and beliefs with respect to teaching mathematics. This is described in detail in the teacher background section of this chapter (section 4.2.3). To summarise, however, the data revealed that teachers who had positive past experiences and backgrounds with mathematics held very positive attitudes towards mathematics and communicated their love and enthusiasm for mathematics within the classroom. On the other hand,

teachers who had negative past experiences with mathematics held strong attitudes that the students in their own class should not be subjected to similar negative experiences. This translated into classroom practices that involved these teachers making extra efforts to make mathematics enjoyable, interesting and understandable.

4.5 Promoting student achievement

Research question 3 sought to qualitatively investigate how student achievement can be promoted and hindered, and was as follows:

Q.3 How do teachers in Ireland and Northern Ireland describe the factors that help and hinder student learning and achievement/teacher effectiveness in mathematics?

The literature shows that student achievement is predominantly affected by factors that are outside of a teacher's control (Palardy and Rumberger, 2008; Skourdoumbis, 2013). In fact, Hattie (2003) posits that over 70% of the variance in student achievement scores is due to non-teacher-related factors such as student socio-economic status, student special needs status, parental encouragement, class size, and resources. Evidence from teachers in this study about the factors that help and hinder them in promoting student achievement echo findings by the literature, in that most of the factors mentioned are outside of a teacher's control. This supports concerns in the literature regarding the use of standardised test achievement data to measure teacher performance (Welsh, 2011; Lee, 2011; Skourdoumbis and Gale, 2013).

4.5.1 Factors that help teachers in promoting student achievement

During qualitative interviews, teachers were asked about the factors that helped them in promoting student achievement on standardised tests. In Ireland fourth class students complete the Sigma T or Drumcondra Maths Test, whereas in Northern

Ireland P6 students complete the PiM (Progress in Maths) test. It was interesting that there was little consensus among interviewees regarding the factors that positively influence student achievement on standardised tests. Almost thirty different factors were identified by teachers in Ireland and Northern Ireland, with little overlap. This echoes ambiguity within the literature about the teacher- and school-related factors that affect student scores on standardised tests. For example, a meta-review by Goe and Stickler (2008) identified over 100 teacher-related factors that influence student achievement. Nevertheless, some factors that promote student achievement were mentioned by several interviewees, and these factors are discussed below.

Analysis of standardised test data and taking action based upon findings was described by teachers in Ireland and Northern Ireland as playing a role in promoting student achievement on standardised tests. Analysis can be conducted at a student, class or whole school level. For example, when asked about what she would do if she wanted to raise student scores on standardised tests, Finola (School A, Ireland) described conducting a whole school analysis of standardised tests, from which action could be taken within the classroom:

I suppose see what areas are the areas of difficulty school wide and maybe focus on them ... so say if Time is a an issue in the school, every class do 5 or 10 minutes of oral mental maths on time every day, because lots of practice is very useful when it comes to things like that.

Finola's extract highlights the importance of identifying a specific problem area and focusing upon it by giving it extra teaching time. Una (School C, Ireland) also described using analysis of standardised test data to identify a problem area during her master's study, which she then focused upon by devoting more time to this area. Overall, however, Irish interviewees did not report any embedded school-wide approaches for analysing mathematics standardised test data.

On the other hand, interviewees in Northern Ireland reported very specific systems within their schools for analysis of standardised test data in comparison with interviewees in Ireland. Notably, teachers reported that the practice of analysing standardised test data and subsequently acting upon findings improved student achievement scores. This provides evidence of a practice that has been found to raise student achievement. Northern Irish interviewees described similar systems within schools for analysing and acting upon standardised test data. Initially, this data was used *“to identify those children who are underachieving”* (Gareth, School B, Northern Ireland). Action was then taken whereby specific targets, which arose from analysis of the data, were drawn up for underachieving students. A classroom assistant was timetabled to work on these targets with the children and, in Dervla’s (School E, Northern Ireland) experience, this improved scores *“because you’re then not doing a broad umbrella of teaching ... you can look at a very specific area where they [the students] need some individual support, or small group support.”* In addition to targeting individual students that are underachieving, teachers in Northern Ireland described identifying weaknesses at the whole school level, and taking action upon this. Dervla (School E, Northern Ireland) reflected that action taken *“as a direct consequence of a PiM score”* could involve purchasing a new resource. She described the school-wide purchase of the Prim-Ed Mental Maths book and explained how the use of this book now *“begins their [every student’s] morning with 10 minutes mental maths.”* On the other hand, Gareth (School B, Northern Ireland) described getting whole school support from an expert from the education board in order to tackle a school-wide weakness that was identified with relation to problem solving processes. Analysis of the standardised test data after taking action to improve problem solving showed positive results:

When we analysed the results the following year, it was a massive difference, all because they [the students] were getting their maths in a completely different way.

It is interesting that analysing and acting upon standardised test data is one of the only teacher practices that interviewees linked definitively to improved standardised test scores. The need to identify and focus on individual student problem areas as well as school-wide weaknesses in mathematics in order to promote achievement is an important finding. That said, there is unease in the literature about the implications of a sustained focus on standardised tests, with concerns about schools becoming test factories (Imig and Imig, 2006). Indeed, a recent study by Palardy and Peng (2015) substantiates these concerns, by postulating that in order to statistically remove summer effects from value added assessments of teacher performance, students will likely be required to undertake biannual achievement assessments. Overall, although the practice of analysing and acting upon standardised test data is reported to promote student achievement in mathematics, the context within which this practice is undertaken may be important. That is to say, student meaningful learning, rather than external accountability or teacher performance measurement, should be the motivation for employing this practice.

Use of hands-on concrete resources was considered important for promoting student achievement by most teachers. This aligns with Wenglinsky's (2000) finding that hands-on learning significantly promotes student achievement. Interviewees explained that being able to visualise and work with a concrete resource was more effective for promoting student understanding of concepts. What is interesting is that teachers in Ireland mention concrete resources as being an important factor for promoting achievement, but in the next section (4.5.2), it becomes clear that many interviewees from Ireland are frustrated with a lack of mathematics resources for teaching within their schools. On the other hand, Northern Irish interviewees appear

to have better access to mathematics resources and mention resources less frequently in relation to promoting student achievement. However, Northern Irish teachers frequently reported the use of concrete resources in their descriptions of good lesson structure, suggesting that they, like Irish teachers, consider concrete resources important for teaching and learning.

As mentioned in the assessment section of this chapter (section 4.3.3), analysis of the data revealed a consensus among interviewees regarding the need for constant revision of mathematics concepts in order to promote achievement on standardised tests. Eight interviewees considered asking mental maths questions, either written or oral, to be an optimum classroom practice for ensuring constant revision of concepts. In addition, Alison (School B, Ireland) described online mathematics games as being helpful for revising mathematics concepts in a fun and enjoyable way.

Following from this, there was consensus among teachers that mathematics lessons should be fun and enjoyable in order to promote student achievement in standardised tests. For example, Majella (School A, Northern Ireland) noted:

You have to make your lessons interesting, I suppose, as child friendly as possible. Make sure they are not long winded or boring, and I do think that the interactive learning [using iPads and ICT] does help with that.

Alison (School B, Ireland) and Ciara (School E, Ireland) also mentioned online computer games as a powerful tool for making mathematics learning fun and interesting, with Alison noting: “... *they [the students] don’t realise they’re learning.*” Interestingly, Ciara found that using the interactive online resource of Khan Academy “*definitely helped our maths results in the school this year.*” Khan Academy is a free online personalised learning resource which allows students to learn mathematics at their own pace. Personalised learning appears to be an important factor for mathematics achievement and was linked to achievement scores

by Dervla (School E, Northern Ireland) earlier in this section, with respect to targeting specific mathematics concept weaknesses in underachieving children.

Lastly, many interviewees considered parental support to be a factor that promoted student achievement on standardised tests. Michael (School D, Northern Ireland) noted:

You can tell the kids that are getting help at home ... they don't struggle quite as much.

Similarly, (Patricia, School D, Ireland) reflected:

... the parental support ... whatever they're [the students are] getting at home ... that's so important.

Overall, although interviewees identified a large range of factors that promote student achievement, there was consensus regarding the importance of analysing standardised test data and acting upon findings to target specific mathematics weaknesses at the student, classroom and whole school level. Interview participants indicated that this process positively impacts upon student achievement.

4.5.2 Factors that hinder teachers in promoting student achievement

Interviewees were also asked during the semi-structured interviews about the factors that they felt hindered teachers in promoting student achievement on standardised tests. Three out of the six Irish interviewees considered a lack of resources to be a factor that hinders teachers in promoting student achievement within their school. For example, Phyll (School F, Ireland) described a recent experience:

The lack of concrete hands on material, I mean I was doing 3D shapes last week and to get a box of shapes ... we didn't get them – it was impossible – for shapes you are trying to teach!

Alison (School B, Ireland) and Finola (School A, Ireland) also expressed frustration with the lack of concrete resources available to them for teaching mathematics, with

Finola also noting difficulties for classroom organisation when dealing with limited access to concrete materials:

When you've a larger class ... you mightn't have enough concrete materials for all the children, so then you have to try and work it that they're working in groups or things like that, which makes it more difficult.

It was very much in evidence from the data that a lack of resources was not a problem for most Northern Irish teachers. An extract from the interview with Geraldine (School C, Northern Ireland) exemplifies this:

Researcher: So that would require resources?

Geraldine: *Yes and this school is very well resourced.*

Researcher: Do you think that helps?

Geraldine: *Oh I think it's necessary. It's essential actually. And every year Mr Blogs you know, our principal is really, really good and he and our Parents' Association this year provided £2000 for example to get workbooks for one thing.*

Although Northern Irish interviewees described their schools as being well resourced for mathematics teaching, Michael (School D, Northern Ireland) did mention that there was a lack of resources available to help teachers facilitate students with dyscalculia. However, he was referring to dyscalculia resources available on the market as opposed to within his school, and overall Michael described his school as one that is well resourced for mathematics teaching.

Two teachers in Northern Ireland viewed class size as a factor that hinders teachers in promoting student achievement, although no Irish teachers mentioned this as a limiting factor. For example, Majella (School A, Northern Ireland) cited:

Well of course large class size, numbers, that's the biggest thing. We have over 30 in every class coming up through the school now ... big class sizes definitely play a big part now in the children's learning.

This was echoed by Dervla (School E, Northern Ireland), who pointed out that:

I do think that large class size is quite a difficult hindrance ... We do have to take up to 35 [pupils] ... One of our classes has 31 pupils in it. So it's just a government led problem in that there is not enough funding for education. I do believe if we had smaller class sizes we would have more time to devote with children on a more individual basis.

Negative attitudes towards mathematics were cited by teachers in both Ireland and Northern Ireland as factors that hinder teachers in promoting student achievement. These negative attitudes could come from parents, with Ciara (School E, Ireland) describing:

I suppose lack of encouragement at home [can hinder teachers in promoting student achievement] sometimes. "The maths was too hard last night, so we couldn't do it."

In addition, Geraldine (School C, Northern Ireland) noted that a lack of interest from students or teachers could hinder student achievement. Interestingly, and once again echoing findings by Geist (2015), she reflected that if a teacher is not confident with a subject, then they may have less interest in it and she pointed out that:

... nobody is going to say they don't want to teach [mathematics] but it's just giving them [teachers] confidence. I think it's a confidence thing – to make sure everyone is confident in what they are teaching and how they are teaching it.

This suggests that boosting confidence with a subject can help to alleviate negative attitudes towards that subject. Following from this, interestingly, Una (School C, Ireland) and Majella (School A, Northern Ireland) highlighted a lack of student confidence as a hindering factor for teachers in promoting student achievement, and both described how they try to boost low confidence. For example, Una reflected:

If a child isn't getting the right answers, they can become quite reserved and I've had that with a few of my children and they kind of think that they

are not good at maths ... so I have a big emphasis on attempt marks ... that they have achieved some success.

Majella described a similar scenario. What is interesting in Majella's extract is the description of the impact of low mathematics confidence on a student's interest and engagement with the subject:

I suppose children's interest may be [a factor that hinders teachers in promoting achievement] ... if they feel that they're not good at maths, it would be trying to keep the children confident and I know that they all can't do everything but even if a child does lack confidence in maths you would be trying to reassure them all year to bring them up you know or to do the best they can and you know praise them when they need it, when they deserve it and (laughs) even when they don't deserve it, because if they feel they're a failure at maths they're just going to let go – like they will not take interest.

It was very much in evidence throughout the interviews that a sense of failure among students due to getting wrong answers was an issue that many interviewees dealt with by encouraging students, praising them and supporting them. Furthermore, this sense of failure was particular to mathematics and was not an issue with other subjects. The data has revealed an interesting link between mathematics confidence and interest in mathematics. This link is mentioned at both the teacher and student level. The data indicated that teachers were acutely aware that the mathematics confidence of students could be eroded easily due to the sense of failure that is associated with getting wrong answers. Therefore, many interviewees described encouraging and praising their students frequently in order to ensure that they remained confident and interested in the subject. This aligns with the literature, which suggests that students perform better when their teachers consider their academic, social and psychological needs (Puklek Levpušček and Zupančič, 2009; Cadima et al., 2010; Stronge et al., 2011).

There was a consensus among interviewees in Ireland and Northern Ireland that time influenced teachers in promoting student achievement on standardised tests. In order

for children to achieve to the best of their ability on standardised tests, they need to have covered the curriculum before sitting the test. However, Patricia (School D, Ireland) pointed out that the time in which to teach the curriculum has diminished in Ireland due to new government guidelines:

We give out the standardised tests in the middle of May, so that's a bit of a problem, because you're cutting yourself short there in those few weeks at the end of the year and you're trying to cram in everything ... to make sure that it's covered, so that is a problem and the fact that school reports now have to be out in the middle of June, you know, so you can't really push the standardised tests on into June so, em, you need to have the course covered.

Geraldine (School C, Northern Ireland) identified a similar issue for teachers of younger classes in Northern Ireland:

And the trouble with PiM is – especially in the lower school – the P5 and so on, they haven't covered everything by the time we do our PiM [standardised mathematics] tests. So it's not a true reflection to be honest with you. We have found in many cases that it's not a true reflection of a child's ability – those tests. Because when you look at the scores and then compare them with their day to day work and what they're able to achieve, it doesn't collate.

In summary, interviewees identified a number of factors that they believed hindered them in promoting student achievement on standardised tests. Some factors, such as class size in Northern Ireland and a lack of resources in Ireland, were particular to a country, suggesting particular issues within the education systems of each country. A notable hindering factor was the link between a lack of confidence and a lack of interest in mathematics. Because confidence was perceived to be eroded easily in maths due to students getting wrong answers, teachers described the need to encourage and praise students more often in mathematics than in other subjects, in order to keep them confident, motivated and interested. Finally, a lack of time in which to cover the curriculum before the undertaking of standardised tests was also mentioned by interviewees as a factor that they felt hindered them in promoting student achievement on standardised tests.

4.6 Teacher effectiveness

Research question 4 qualitatively investigated participant understandings of the term ‘teacher effectiveness’, and was as follows:

Q.4 How do teachers in Ireland and Northern Ireland understand the term ‘teacher effectiveness’?

The literature equates teacher effectiveness with student achievement on standardised tests. During qualitative interviews, teachers in Ireland and Northern Ireland were asked to describe the meaning of the term teacher effectiveness in their own words. Interestingly, in contrast to the current measurement of teacher effectiveness in the literature (Nye et al., 2004; Palardy and Rumberger, 2008; Stronge et al., 2011), none of the interviewees equated teacher effectiveness with student scores on standardised tests. A majority of interviewees linked a myriad of classroom practices and interactions with the term, highlighting the complex and multidimensional nature of the teacher and learning process (Hikmet et al., 2008). Examples from Irish and Northern Irish interviewees include Una’s (School C, Ireland) description:

I think an effective teacher ... number one is classroom management, if the children are on task and ready to go, if they are quiet and listening, when they need to be and ... on task, doing their work, whether it be group work or independent ... children can't learn if they don't have that. The effective teacher will ask questions regularly ... Assessment is a big thing. Then just having a bit of enthusiasm, having children engaged, having a bit of a fun lesson, there are so many maths games ... just making it a bit of fun as well,

and Majella’s (School A, Northern Ireland) account:

Teacher effectiveness is a good variety of teaching and learning strategies, varying your lessons, feedback from pupils. Peer assessment-I think it's very important as well. I think if the child did something and another child put up her hand and says "Well I think you should have done it this way." Or ... self-evaluation as well: they could say "Look I did well. I think I did well and that I understand that." A variety of resources and not keeping the lessons too long winded ... keep them short, to the point and interesting.

Half of the Irish interviewees associated teacher effectiveness simply with student learning, with Finola (School A, Ireland), for example, citing:

I suppose it [teacher effectiveness] means are you getting across what you want to teach to the students? Are they learning what you're trying to teach them?

All interviewees spoke strongly against the use of standardised test scores as a measure for teacher effectiveness. A key issue that interviewees cited in opposition to their use was predicated on the fact that standardised tests have not been made for the purpose of measuring teacher effectiveness. This aligns with questions raised in the literature about whether standardised tests accurately reflect teacher or school performance (Lemke et al., 2006; D'agostino et al., 2007b). Geraldine (School C, Northern Ireland), for example, noted that standardised tests provide “*a guideline [for student learning] and nothing more than that.*” In addition, interviewees argued that standardised tests provide a snapshot of one day in a student's life, and that unfortunately students can panic or have an off day. For example, Phyll (School F, Ireland) reflected:

Some children unfortunately panic of course at the whole thought of a test. I had experience over the years, the ones [students] you really expect to perform make the silliest mistakes. Different children respond to testing in different ways.

Similarly, Majella (School A, Northern Ireland) pointed out that:

A child might not succeed on that day [of standardised testing]. It might be the exam situation throws them off completely or they can feel that they can't do it, or it might be a bit of nerves, might be sick ... It's only one score at the end of the day. I don't think it's a true reflection of the child.

Therefore, Dervla (School E, Northern Ireland) highlighted the importance of “*teacher judgement*” and their personal knowledge of their students' circumstances in understanding standardised test scores. Similarly, Michael (School D, Northern Ireland) pointed out:

It's [teacher effectiveness is] not just one thing ... You just can't pin it to one thing. It has to be holistic.

The interviewees in this study, who have considerable experience with conducting standardised tests, argue against not only their use as a singular measure of teacher effectiveness, but in some cases against standardised tests in capturing student learning progress effectively. This echoes concerns that have been raised recently across the literature regarding the use of standardised tests as a measure of teacher effectiveness (D'agostino et al., 2007b; Lee, 2011; Welsh, 2011; Skourdoumbis and Gale, 2013; Skourdoumbis, 2013).

4.7 Conclusion

This chapter presented the data analysis for each of the research questions and has drawn upon quantitative data from the TIMSS 2011 dataset, as well as qualitative data from interviews with eleven fourth class teachers across Ireland and Northern Ireland. Analysis of both the quantitative TIMSS data and the qualitative interview data showed that teachers in Ireland and Northern Ireland generally used similar teacher classroom practices and held similar attitudes and beliefs regarding mathematics teaching and learning. The most notable differences between teachers of fourth class students in Ireland and Northern Ireland related to the subclass of teacher qualifications, with teachers in Northern Ireland being more experienced and having engaged in more mathematics professional development. In interpreting the TIMSS 2011 data, one might have assumed that teacher qualifications therefore influenced the higher scores of Northern Irish students. However, the literature suggests that teacher qualifications are not as important as teacher classroom practices in influencing student achievement (Hanushek, 2002; Palardy and Rumberger, 2008). Therefore, this finding was probed in the qualitative phase of the study. Data analysis revealed the transfer test as being an important unobservable variable which greatly

influenced the selection of teachers with specific qualifications as well as the context of teaching and learning in fourth class in Northern Ireland.

The next chapter synthesises the findings presented here, drawing upon the relevant literature, as well as the conceptual framework, to develop a thematic analysis of the research data.

Chapter 5. Discussion of findings

The research reported in this thesis set out to explore how teachers influence student learning and achievement in mathematics, in the context of the fourth class primary school level in Ireland and Northern Ireland. Five significant findings emerged from the insights of teachers in this mixed methods, comparative study. It is important to point out that the main findings of this research project emerged from the qualitative data. These findings are based on the perceptions of eleven teachers and while they provide interesting information, it is acknowledged that the findings are not generalisable to larger contexts. The main findings are:

- The importance of qualitative teacher voice within the quantitative-dominated teacher effectiveness paradigm was highlighted. Teacher insights:
 - ❖ helped to explain large-scale TIMSS 2011 findings
 - ❖ contributed new knowledge to the teacher effectiveness paradigm by revealing new classroom practices that are believed to promote student learning and achievement in mathematics
 - ❖ highlighted the complex interconnectedness of the teacher-related factors which influence student learning and achievement
- The perceived positive influence of consecutive years of experience at the same grade level on teacher pedagogical knowledge and, in turn, student learning and achievement in mathematics was revealed
- The reported positive influence of constant revision on student learning and achievement in mathematics was highlighted, and classroom practices that help to promote constant revision (questioning, assessment, using mental mathematics textbooks) were also revealed

- The perceived positive influence of a whole school strategic plan for promoting achievement on standardised tests was highlighted
- The perceived positive influence of communicating a positive attitude to mathematics was revealed

In this chapter each theme is discussed separately, and this discussion is complemented by the inclusion of diagrams depicting the main findings from the data analysis. The emergent themes relate to the evaluation of the use of a mixed methods approach within the teacher effectiveness paradigm, as well as common perceptions of fourth class teachers regarding how to promote student learning and achievement in mathematics. The study adopted a comparative approach, in recognition of the two differing education systems that exist in Ireland and Northern Ireland. These two countries scored very differently on the TIMSS 2011 study in fourth class mathematics, and thus became the primary units of analysis for this research. However, the analysis of data showed that at the classroom level, teachers in Ireland and Northern Ireland reported very similar classroom practices. It was in fact the difference in the context of fourth class in both countries that became evident as having more power and dominance in influencing student learning and achievement in mathematics across the two countries.

This research design has been underpinned throughout by an ontology that views reality as being multiple, variable and ambiguous (O' Leary, 2004). An interpretivist approach generated deeper understanding of the perspectives of social actors in their current contexts with respect to the phenomenon of teacher effectiveness. Iterative engagement with theory, the literature base, and data collection and analysis have led to the main findings discussed in this chapter.

5.1 Qualitative teacher voice within the teacher effectiveness paradigm

Campbell et al. (2004) reported a lack of qualitative investigations of teacher effectiveness, with further calls to move away from quantitatively evaluating teachers using the single measure of student achievement gain scores on standardised tests (Imig and Imig, 2006; Skourdoumbis and Gale, 2013). The need for governments to promote educational research with diverse methodological perspectives has also been highlighted by Berliner (2002), who argues that using scientific methodology alone is not sufficient to understand educational phenomena of huge complexity. The findings from this research study affirmed the need for qualitative insights within the teacher effectiveness paradigm, and three important advantages of including qualitative teacher voice in such studies were revealed. Firstly, the use of qualitative data allowed for a deeper investigation of the contexts within which teachers worked, and this provided a better understanding of quantitative findings. Secondly, qualitative data revealed insights about the functions and complex interconnectedness of teacher effectiveness variables in a manner that would have been very difficult to replicate using quantitative methodology alone. Lastly, the theory generation characteristic of qualitative methodology facilitated the identification of new teacher-related variables which were seen to influence student learning and achievement in mathematics by interview participants. These are: holding consecutive years of experience at the same grade level, facilitating constant revision of mathematics concepts, implementing a strategic plan for analysing and acting upon standardised test score data, and communicating a positive attitude towards mathematics. These variables were perceived to be important for promoting student achievement in mathematics, thus adding to the current teacher effectiveness base.

5.1.1 Using context to understand quantitative findings

The teaching and learning process is hugely complex (Hikmet et al., 2008) and is impacted greatly by the “power of contexts” (Berliner, 2002, p18). Evidence from this study highlighted the importance of culture and context in understanding quantitative findings from the TIMSS 2011 international assessment with respect to Ireland and Northern Ireland. Almost all of the major differences in teacher-related factors between teachers in Ireland and Northern Ireland as reported in TIMSS 2011 were explained through gaining a better understanding of the fourth class context in both countries, using qualitative data (see Table 6.1 in the next chapter for a comprehensive summary). For example, upon analysis of the fourth class TIMSS 2011 quantitative data for Ireland and Northern Ireland, one might have initially drawn the conclusion that students in Northern Ireland outperformed students in Ireland in mathematics due to having significantly more experienced teachers, as this was the most notable difference in teacher-related factors between the two countries, with 71% of Northern Irish students taught by a teacher with eleven or more years of experience in comparison to 35% of Irish students. However, when this study qualitatively explored *why* teachers of fourth class in Northern Ireland were more experienced than their Irish counterparts, a clearer picture of the context of fourth class in both countries emerged, which provided an alternative, more multifaceted understanding of the differential student achievement scores in the two countries.

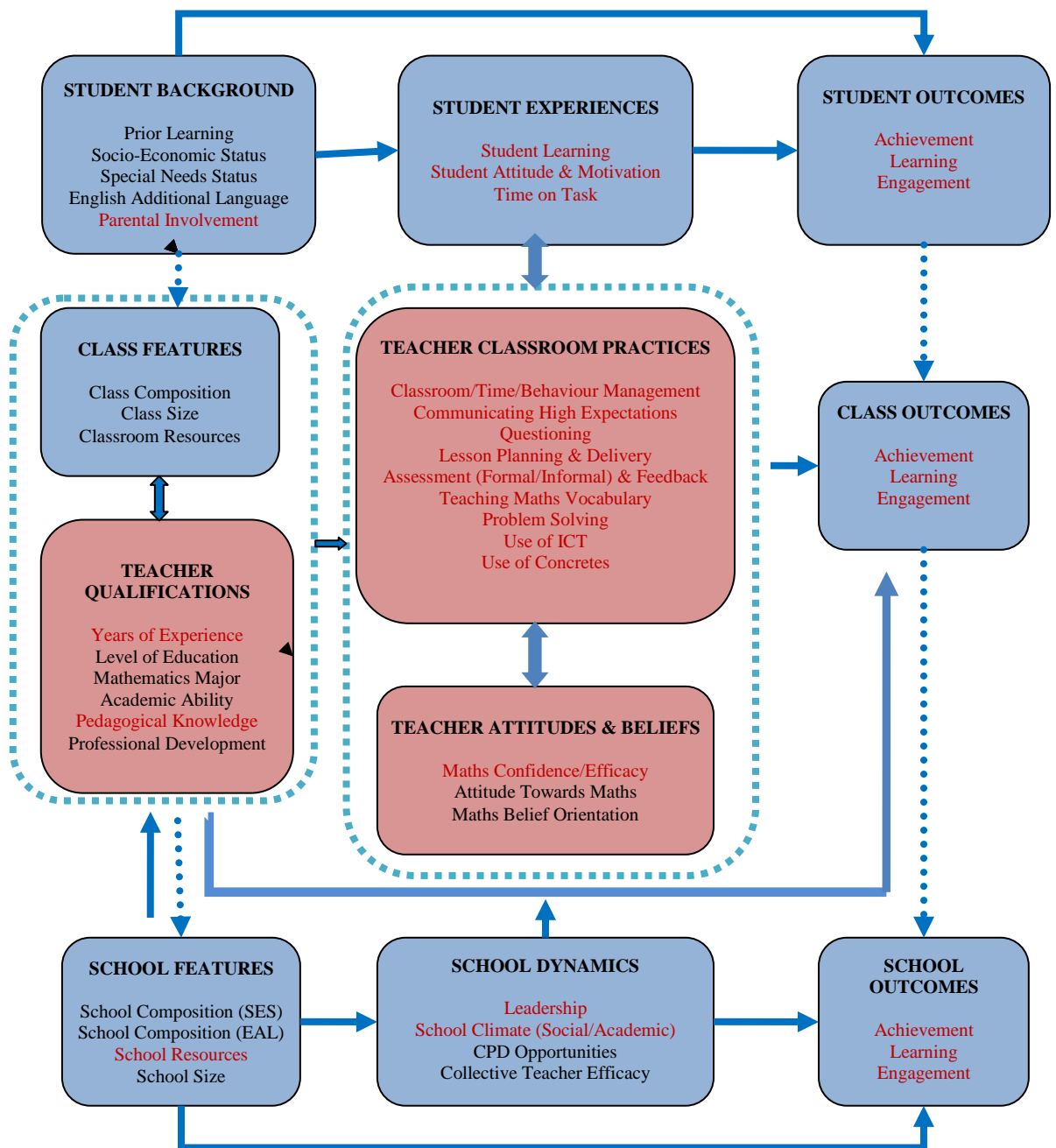
The qualitative data suggested that more experienced teachers may be chosen to teach fourth class (P6) in Northern Ireland due to the existence of unregulated external transfer tests, which secondary schools currently require students to take during their final year in primary school, P7. The transfer test is a high stakes test in which students are motivated to achieve highly. This is because transfer test scores influence whether or not a student will be accepted into the secondary school of their

choice. The existence of this test was perceived to impact upon the teachers chosen to teach P6 in this study, because teachers needed to have the expertise to teach the entire P6 mathematics curriculum, while also being expected to prepare P6 students for this transfer test. For example, Dervla (School E, Northern Ireland) described that teaching P6 in Northern Ireland is “*quite a specialism*”, as teachers are “*legally bound to teach the curriculum but yet there is an expectation that you will also cater for preparation [for the transfer test].*” The existence of the transfer test is also likely to explain the surprising finding within the TIMSS data that students spent a mean of 6.3 hours per week learning mathematics in Northern Ireland in comparison to 4.1 hours in Ireland. Evidence from the qualitative data also revealed that in addition to spending extra time learning mathematics in school, many fourth class students in Northern Ireland attended extra tuition in mathematics outside of school and that their parents were highly motivated in ensuring that they achieved well in the transfer test. Furthermore, Gareth (School B, Northern Ireland) noted that students experienced stress due to the academic pressure of the transfer test. While all of these factors relate directly to the existence of the transfer test in Northern Ireland, it is highly likely that they impacted upon Northern Ireland’s higher score in TIMSS 2011.

On the other hand, analysis of the data showed no evidence that fourth class students in Ireland experienced academic pressure to perform well on high stakes exams in mathematics, that they routinely spent extra-curricular time studying mathematics, or that more experienced teachers were selected by school leadership to teach them. Therefore, it is likely that these differences between the mathematics learning experiences of Irish and Northern Irish students may explain the fact that Northern Irish students outperformed Irish students in TIMSS 2011. This supports Wang’s

(2001, p20) argument that TIMSS findings should be “scrutinized carefully” due in part to the fact that exposure to mathematics content may differ across nations, as is the case regarding Ireland and Northern Ireland. By including qualitative data in this study, the transfer test was suggested to be an unobservable variable with respect to the quantitative TIMSS 2011 data, which impacted variables at the student, classroom and school levels of the conceptual framework (see Figure 2.1). An edited version of this framework is shown below in Figure 5.1. Variables which data analysis suggests were influenced by Northern Ireland’s high stakes transfer test context are highlighted in red.

Figure 5.1 Variables influenced by the Northern Ireland transfer test



5.1.2 The complex interconnectedness of teacher-related factors

In this study, qualitative teacher voice highlighted and provided an understanding of the interconnectedness of the array of teacher-related factors which influence student learning and achievement in mathematics. This revealed the deep complexity of the teaching and learning process and, echoing Skourdoumbis and Gale (2013), raised a question over whether the teaching and learning process can be easily translated into mathematical formulae. Data analysis of qualitative teacher insights revealed perceptions of a high level of interconnectedness between teacher-related factors across and within all three subclasses of teacher effectiveness. This supports Kyriakides et al.'s (2009, p20) finding that “teacher level factors are interrelated and should not be treated as isolated.”

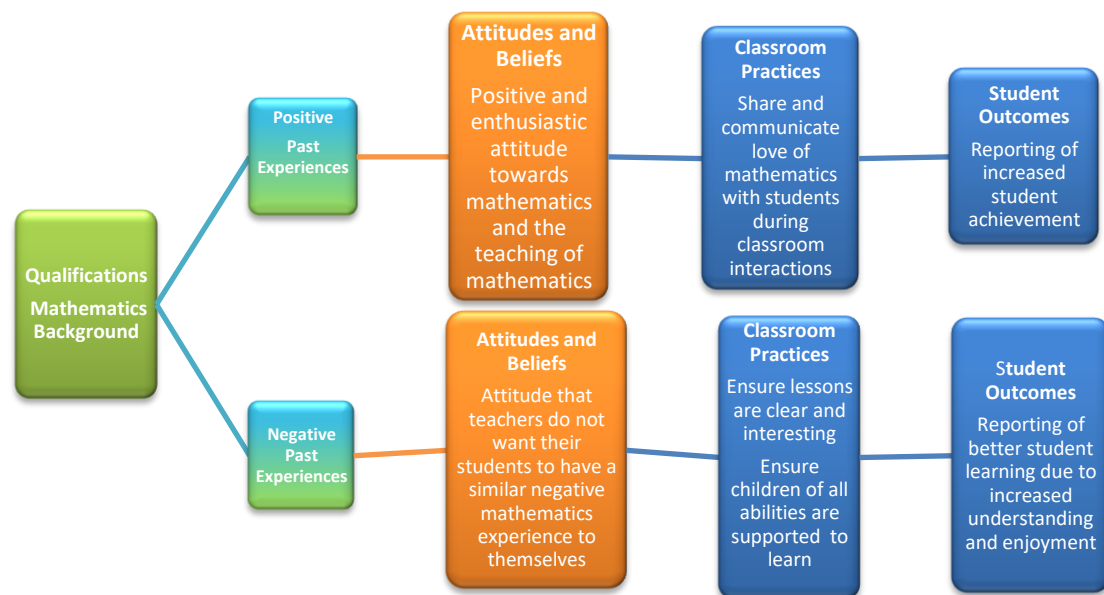
The interconnectedness of teacher level factors was evident in the analysis of all teacher-related factors that were covered within the scope of this study. Indeed, in all of the subsections of this chapter specific links and connections are clear between different teacher variables. However, one example is discussed here in order to provide a clear picture of how various teacher-related factors are connected. Analysis of the data revealed that a teacher's own personal mathematics background, in particular their past experiences with mathematics, was connected closely to their attitude towards teaching mathematics, and this was linked to their classroom practices, which in turn influenced student learning and achievement (Figure 5.2). For example, Alison (School B, Ireland) below describes a negative mathematics background, which results in an attitude that she does not want her own students to have a similar negative experience, which in turn influences her classroom practices:

Maths was probably one of my least favourite subjects in school, but I find now ... I nearly try harder to explain, because I found it difficult.

This echoes findings from a study by Geist (2015) which suggest that a teacher's past experiences with mathematics influence their attitude towards mathematics and their confidence with teaching the subject, which in turn impacts upon their classroom practices. It is interesting that negative past experiences with mathematics were not associated by interviewees with negative attitudes towards teaching the subject. Although this was true for the participants in this study it must be acknowledged that this may not always be the case. Nevertheless, a case study by Askew et al. (1997, p94) reported similar findings, where teachers who had negative experiences as mathematics learners tried to make mathematics "enjoyable and accessible for all children".

Overall, while the literature suggests that teacher qualifications are not the most important teacher effectiveness subclass impacting student achievement (Goe and Stickler, 2008), and rather classroom practices have a more proximal influence (Stigler and Hiebert, 1999), qualitative findings in this study showed that teachers connected their qualifications to very specific classroom practices as well as attitudes and beliefs. This finding regarding the interconnectedness of teacher-related factors affirms Palardy and Rumberger's (2008) position that all three sublevels of teacher effectiveness (teacher qualifications, teacher classroom practices and teacher attitudes and beliefs) should continue to be considered in teacher effectiveness studies, in order to gain a comprehensive picture of the phenomenon.

Figure 5.2 The interconnectedness of teacher effectiveness subclasses



The interconnectedness of teacher variables, which was revealed from data analysis in this study, highlights that teacher-related variables do not operate in isolation; rather, the teaching and learning process functions in a manner that is complex, dynamic and multidimensional (Hikmet et al., 2008). This multifaceted nature of the teaching and learning process poses difficulties for statistical models used in quantitative studies, which try to disentangle teacher-related factors from other factors which influence student achievement (Rowe, 2003; Skourdoumbis and Gale, 2013). Hierarchical Linear Modelling, which is one of the most commonly used statistical models for exploring teacher effectiveness, has been criticised for ambiguous empirical and theoretical foundations (Gorard, 2007). Furthermore, correlations between teacher-related factors may cause statistical problems in education production functions due to omitted variable bias or endogeneity bias (Bonesrønning, 2004). Therefore, in order to gain a deep and nuanced understanding of the teaching and learning process, the findings from this study suggest that researchers must be open to the idea that teacher variables are interconnected in

complex ways – ways which may not become evident unless the data is explored qualitatively.

5.1.3 Identification of new teacher-related factors impacting student achievement

The inclusion of qualitative data in this study allowed for the identification of a new sublevel of the teacher qualification teacher experience, namely, consecutive years of experience at the same grade level (discussed in section 5.2). What emerged from the data was that using a mixed or qualitative methodology may reveal important new insights within the heavily researched area of teacher qualifications. Similarly, new teacher classroom practices, which were believed to promote student achievement in mathematics at the fourth class level, were also revealed. These practices include facilitating constant revision, having a strategic plan for analysing and acting upon standardised test score data, and communicating a positive attitude towards mathematics. These classroom practices are explored in detail in section 5.3. It is very promising that the inclusion of qualitative teacher voice in this teacher effectiveness study provided new evidence, which add to the current knowledge base. This affirms Dimarco's (2009) position that teacher insights are central to understanding how student learning and achievement in mathematics can be promoted.

5.2 Consecutive years of experience at the same grade level

Many studies have found that teacher experience has a positive effect on student achievement in mathematics (Rowan et al., 2002; Clotfelter et al., 2007; Kane et al., 2008); however, other research suggests that the effects of teacher experience tend to stabilise after a few years (Rockoff, 2004; Hanushek et al., 2005; Boyd et al., 2007). Evidence from this study revealed that a sublevel of teacher experience may play a

more important role in impacting student achievement than general teacher experience, and that this sublevel has distinct influences on teacher classroom practices. This newly identified sublevel of teacher experience has been entitled in this study as consecutive years of experience in teaching at the same grade level. Data analysis showed that consecutive years of experience in teaching at the same grade level had a unique and important impact upon a teacher's classroom practices and attitudes and beliefs, which in turn was reported to influence student outcomes. This impact may have an effect over and above that of the teacher experience variable, in that a teacher could have ten years of experience teaching a senior class; however, if they began teaching a junior class in their eleventh year of teaching, a steep learning curve would be involved, where the benefits and knowledge gained through having experience at the senior level may not be entirely transferable to teaching at the junior level. Consecutive years of experience at the same grade level have not been considered by the teacher effectiveness literature regarding their impact on classroom interactions or student outcomes; however, findings from this study suggest that this may be a promising area for future research.

An unexpected finding of this study was that the three advantages of holding consecutive years of experience at the same grade level, which were reported by participants in this study, are three forms of pedagogical knowledge for teaching posited by Ball et al. (2008). This evidence indicates that experience at the same grade level positively influences a teacher's pedagogical knowledge for teaching mathematics to that particular grade level. Pedagogical content knowledge was first defined by Schulman (1986, p9) as knowledge of "the most useful ways of formulating and representing the subject to make it comprehensible to others." The findings from this study are exciting, as they add another dimension to the literature on pedagogical content knowledge, in providing an insight into how this knowledge

originates and is used by teachers. This is notable, as Kersting et al. (2012) highlight the importance of understanding the kinds of knowledge that teachers draw upon and how they utilise them in their classroom teaching.

Table 5.1 summarises the sublevels of teacher effectiveness that holding consecutive years of experience at the same grade level was reported by interviewees to impact upon. Following this, the mechanisms through which holding consecutive years of experience impacts upon the three forms of pedagogical content knowledge identified by Ball et al. (2008) are described in detail.

Table 5.1 Levels of impact of consecutive years of experience at the same grade level

	Teacher Qualifications	Teacher Classroom Practices	Teacher Attitudes and Beliefs	Student Outcomes
Impact of consecutive years of experience at the same grade level	Pedagogical knowledge of content and students	Teacher can anticipate mathematical concepts that students will find difficult and address difficult concepts by devoting more time to, and facilitating regular revision of, these concepts	Increased confidence regarding knowledge of the best teaching strategies and resources to promote student learning and achievement in mathematics	Student learning and achievement on standardised tests
	Pedagogical knowledge of content and teaching	Teacher is capable of clearer lesson delivery due to self-evaluation of previous lessons		
	Pedagogical knowledge of content and curriculum	Teacher has practical knowledge of the best resources to complement teaching and student learning due to deep working knowledge of curriculum		

Knowledge of content and students is defined by Ball et al. (2008, p401) as a “knowledge that combines knowing about students and knowing about mathematics” where, for example, teachers are able to anticipate what students may find confusing. Analysis of the data in this study showed that consecutive years of teaching

experience at the same grade level led to teachers reporting that they had a deep working knowledge of how their students responded to the mathematics curriculum for that particular grade level. This provided teachers with an awareness of mathematical concepts that students found difficult. Evidence showed that this information was then used by teachers in their planning and teaching the following year, in that they reported devoting extra time to teaching and revising more difficult concepts throughout the school year. For example, Alison (School B, Ireland) explained this effectively by noting:

I've had 4th a few times ... I know what they find difficult ... so what I would do is I'd place more emphasis on the things they're finding more difficult ... spend more time.

If for each grade there are mathematical concepts within the curriculum that students commonly find difficult to understand, then CPD that is focused on these problem areas, and that is specific to each grade level, may be important for teachers who are new to a grade level – regardless of their years of experience teaching. In fact, Cohen and Hill (2000, p312) found that professional development that is grounded in gaining a deeper knowledge of student curriculum is more likely to impact teacher classroom practices than professional development that is more general or “peripheral to subject matter (‘using mathematics manipulatives’).”

Knowledge of content and teaching is defined by Ball et al. (2008, p401) as combining “knowing about teaching and knowing about mathematics”, where teachers evaluate the most advantageous way to represent and teach mathematical ideas. Further evidence of the positive effect of consecutive years of experience at the same grade level was revealed, with teachers reporting this variable’s impact upon their teaching and lesson delivery. Participants reported that self-evaluation of teaching mathematical concepts to a particular grade level often led to the perception of improved lesson delivery of these concepts in future teaching, especially with

respect to ensuring that mathematical concepts were delivered clearly to students.

For example, Geraldine (School C, Northern Ireland) explained that:

... every year ... you learn from your own mistakes, and how to make things as simple as possible for them [the students], especially in numeracy ... because you want to get the concepts really clear in their head.

This is notable, as several studies have linked clear lesson delivery to improved student achievement (Van de Grift, 2007; Stronge et al., 2011). It was also interpreted from the data that due to having experience in delivering concepts clearly, teachers who had consecutive years of experience in teaching at the same grade level were more confident in their teaching of mathematics concepts to that grade level. This is an important factor, as teacher self-confidence as mathematics teachers is positively correlated with their students' self-confidence as mathematics learners (Stipek et al., 2001).

Knowledge of content and curriculum is not defined by Ball et al. (2008); however, Schulman (1986, p10) defines curricular knowledge as knowledge of “the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances.” Evidence from this study revealed that consecutive years of experience at the same grade level provided teachers with the opportunity to gain a deep working knowledge of the curriculum. As part of this, teachers reported that they were able to build up suitable resources for their teaching of that grade level, and these resources were linked to the needs of students and lesson delivery. For example, Majella (School A, Northern Ireland) noted that in gaining teaching experience at the same level:

... you build up the resources and you're familiar with the curriculum, you're familiar with what needs to be taught.

In summary, when teaching, teachers draw on a different kind of mathematics knowledge to that learned in university or second level mathematics courses (Ball et al., 2008). What the findings from this study show is that consecutive years of experience at the same grade level allows teachers to build upon three forms of pedagogical knowledge through self-evaluation and reflection upon mathematics teaching and learning. This sublevel of teacher experience affords teachers the opportunity to accumulate, evaluate and analyse data about teaching and learning for a specific grade level, which leads to teachers being more confident in their ability to deliver mathematical concepts clearly to students as well as being more confident in their ability to ensure student achievement, through effectively addressing mathematics concepts which students find difficult.

5.3 Practices that promote student achievement

Increasing mathematics achievement of students necessitates identifying effective teacher classroom practices. However, very few studies to date have focused upon what teachers need to do to within the classroom to increase student achievement in mathematics (Morgan et al., 2015). This research highlighted the importance of gaining teacher perspectives regarding how teachers can promote student achievement, and three new classroom practices, which have not been explored to date within the teacher effectiveness literature, were identified.

5.3.1 Constant revision

Many research participants in this study argued that that the teacher classroom practice of facilitating constant revision of mathematical concepts is a vital factor for promoting student achievement in mathematics. Furthermore, the need for regular revision seems to be particular to promoting achievement in the subject of

mathematics at the fourth class level, as teachers noted the large number of mathematical facts and concepts that need to be recalled by students in order to perform well on standardised tests.

In this study, teachers endorsed a number of resources and classroom practices as mechanisms for facilitating regular revision in mathematics, echoing once again the finding in section 5.1.2 that teacher practices and traits do not operate in isolation. The practices of assessment, questioning and using a mental oral starter were associated with revision of mathematics concepts, which in turn were linked to positive student outcomes including learning, understanding and achievement on standardised tests; see Figure 5.3.

Figure 5.3 Inputs and outputs of constant revision



Teachers considered the classroom practice of assessment as an important tool for ensuring that mathematical facts and concepts were revised regularly and not forgotten by students, with Michael (School D, Northern Ireland) noting:

... if I cover a topic in September and then I don't come back to it again for however long, it's [assessment is] a good way of just keeping it in their [the students'] mind.

Similarly, in describing how assessments influence student achievement on standardised tests, Phyll (School F, Ireland) linked assessment with constant revision:

... It's [assessment is] constant revision ... they [the students] need constantly to be reminded ... it's the whole revision thing ... for the basic concepts.

While assessment has been identified by the literature as an effective practice for promoting student achievement (Wenglinsky, 2000; Aslam and Kingdon, 2011), evidence from this study suggests that further investigation of assessment, which explores the importance of its associated revision component, may be merited. Conducting frequent assessments is a feature of teaching in the top performing countries in TIMSS 2007 at the eighth grade level (Dodeen et al., 2012). However, perhaps it is not the practice of assessment itself that promotes student achievement, but rather the function it serves for student learning, namely, the facilitation of regular revision of mathematics concepts. This is a research area which may be of interest to future researchers within the teacher effectiveness paradigm.

In addition, the classroom practice of questioning – often as part of the mental oral starter at the beginning of lessons – was noted by participants in this study as being helpful for promoting effective revision of mathematics concepts. For example, Finola (School A, Ireland) noted that “5 or ten minutes of oral mental maths” questioning was useful for ensuring that difficult concepts, such as time, were practised and revised regularly. The literature highlights questioning as an integral classroom practice of effective teachers, and the frequency of academic questions asked by teachers is predictive of student achievement gains (Brophy, 1988; Muijs and Reynolds, 2011). What this study showed was the variety of functions that

questioning can serve. In this case, the use of quick fire product style questions at the beginning of mathematics lessons was perceived to promote student revision of mathematics topics, concepts and facts, while also allowing teachers to informally assess student knowledge and learning.

Surprisingly, there was a very strong connection made by teachers between effective mathematics revision and the use of mental mathematics textbooks. For example, a textbook that was referred to by Finola (School A) in Ireland and Geraldine (School C) in Northern Ireland was *New Wave Mental Maths* published by the Irish company, Prim-Ed. This student workbook provides opportunities for daily practice of mathematical computation, as well as for revision of mathematics concepts and facts. Geraldine (School C, Northern Ireland) noted that mathematics requires “*practice, practice, practice ... revisiting, revisiting, revisiting ... because they [the students] forget so quickly ... so ... we have mental maths every single day.*” By their design, all questions in mental mathematics textbooks are intended to be basic enough to be carried out mentally, and daily exercises are designed to be completed in ten to fifteen minutes. The exercises facilitate students in developing fluency and quick recall of mathematical concepts.

What is notable about the revision opportunities provided by mental mathematics books that are currently on the market is that they revisit facts and concepts repetitively. This process seems to be important for student learning and recall of facts, which in turn positively influences achievement on standardised tests. Teachers in this study considered constant practice of mathematics concepts as being essential for student achievement. This approach for learning mathematics concepts is in many ways reflective of repetitive learning, which is linked closely to rote learning and memorisation, styles of learning that are emphasised in high performing Asian

countries in TIMSS, such as China. However, there is a tension between the practices of repetitive learning and deep learning within mathematics education, with western educators emphasising the latter and Chinese educators advocating the former (Lai and Murray, 2012). That said, Handa (2012) offers an explanation for the perceived value of constant revision by teachers in this study, which goes beyond the rote version of repetition, in positing that engaging repeatedly with an idea can gradually lead to understanding and *intimacy* with the idea. By repeatedly encountering simple questions relating to mathematical concepts and facts in their daily mental maths exercises, students progress in their understanding of these concepts and move towards memorising these facts in a manner that is much different to the “meaninglessness associated with rote” (Handa, 2012, p268). This may be a reason for teachers perceiving mental mathematics exercises as being important for promoting student revision and, in turn, student achievement in mathematics. However, more research in this area would add to these findings.

5.3.2 A strategic whole school approach to analysing and acting upon standardised test data

While analysis of the qualitative interviews showed that teachers in Ireland and Northern Ireland held very similar views on effective classroom practices for promoting student achievement in mathematics, a notable difference was highlighted between the two countries regarding how they analysed and acted upon standardised test score data. In Northern Ireland, there was a very definite plan in place within schools for utilising standardised test score data to improve student achievement, and teachers described strategic whole school plans and approaches for addressing student underachievement on standardised tests; see table 5.2. Northern Irish teachers reported that in their schools underperforming students and their particular weaknesses were identified using standardised test data and, following this, a

personalised learning strategy was implemented to address the highlighted weaknesses in their mathematics understanding. (A detailed description of this is explored in Chapter 4 in Sections 4.3.1 and 4.5.1.) In addition, at the whole school level, analysis of aggregate standardised test score data was used to identify areas of mathematics weakness across the whole school. These areas were addressed by formulating and implementing an action plan tailored to suit specific needs of the general school population. Intrinsic to school strategies for addressing underachievement on standardised tests in Northern Ireland was a collaborative and team approach, with class teachers supported by classroom assistants, the numeracy coordinator, the numeracy team, the Principal and the school management team to set and meet goals regarding improving mathematics achievement.

Table 5.2 Process for analysing and acting upon standardised test data in Northern Irish schools

People Involved	Student/Classroom Level Actions	School Level Actions
1. Analyse Standardised Test Data		
<p>Computer program analyses standardised test data by maths topic for easy identification of problem areas</p> <p>Numeracy coordinator and numeracy team</p> <p>Principal</p> <p>Class teachers</p>	<p>Compare students' mathematics standardised test scores to their scores on standardised intelligence test</p> <p>Identify students who are underperforming in relation to their intellectual ability (separate to learning support children)</p> <p>Analyse standardised test of students who are underperforming to identify concepts or procedures that are not secure</p>	<p>Look for trends across school standardised test data to identify weak mathematics concepts or procedures</p>
2. Take Action		
<p>Class teachers who are supported by numeracy coordinator, numeracy team, principal and specially trained classroom assistants</p>	<p>Specifically trained classroom assistants take identified children for extra practice of weak mathematics topics</p> <p>Class teacher tracks and monitors progress of underachieving students</p> <p>Numeracy coordinator oversees this process and reports to principal</p>	<p>A whole school action is decided upon. This may involve the purchase of a new resource, or staff engagement in targeted and specific professional development</p> <p>Class teacher focuses on weak, problem areas in coordination with agreed school action plan</p> <p>Numeracy coordinator oversees action plan implementation and reports to principal</p>
3. Evaluate the success of actions taken by analysing data from latest standardised tests		
<p>Computer program for analysing mathematics standardised test data</p> <p>Numeracy coordinator and numeracy team</p> <p>Principal</p> <p>Class teachers</p>	<p>Evaluation of actions taken based upon analysis of new standardised test data</p> <p>Return to step 1 of the cyclical process</p>	<p>Evaluation of actions taken based upon analysis of new standardised test data</p> <p>Return to step 1 of the cyclical process</p>

Although the approach outlined by Northern Irish teachers in this study was reported to positively influence student achievement and, as such, may be of interest to both

Ireland and other countries which seek to promote student mathematics achievement on standardised tests, it is important to take cognisance of the wider context within which the approach operates. Interpretation of the data in this study showed that a likely reason for schools in Northern Ireland placing a major emphasis on standardised tests and taking the outlined approach (see table 5.2) to analysing and acting upon standardised test performance data is that in Northern Ireland a key feature of Department of Education inspections is the analysis of longitudinal school performance data based upon standardised test results. For example, Dervla (School E, Northern Ireland) noted that as part of school inspections, standardised test performance data is *“looked at very closely and if there is any discrepancy in the progress that your school is making ... they [the inspectorate] will ask questions.”* Inspectors analyse internal school performance data and, in order for schools to perform well on published Department of Education inspections, most students must be performing in line with or above their ability. This contextual feature of the Northern Irish education system provides strong motivation for the approaches outlined by teachers in Northern Ireland in this study. However, the literature cautions against policies and practices that involve punitive accountability systems, as such systems have been found to erode teacher professionalism and autonomy (Dimarco, 2009; Tucker, 2011). Therefore, while a strategic whole school plan for analysing and acting upon standardised test data was seen by teachers in this study to promote student achievement on standardised tests, caution is advised about the context within which this approach should operate. If the approach is set in a context of forced or punitive accountability, it may have a negative long-term effect on teacher autonomy. However, if this approach is set within a context that ultimately promotes teacher trust and professional autonomy, then the probability is that students, teachers and schools alike will benefit.

5.3.3 Communicating a positive attitude to mathematics

A notable finding in this study was the belief that the attitude a teacher communicates towards mathematics has an influence on student learning and achievement. A number of participants reported that communicating a love for mathematics had a positive impact, not only on student interest in the subject, but on standardised test achievement also. For example, Geraldine (School C, Northern Ireland) described telling her students that she “*loves maths*” and in turn having parents inform her that “*their child has learnt more*” because of her enthusiasm for the subject. Similarly, Una (School C, Ireland) noted that a teacher’s communicated attitude and “*enthusiasm about maths will certainly affect the children.*” Interestingly, the particular participants who reported this had strong mathematics backgrounds, having majored in mathematics at university. Evidence that communicating a positive attitude towards mathematics was felt to alter student attitudes towards the subject is a remarkable finding of this study. It is highly significant, as mathematics anxiety is a well-documented hindering factor in student engagement and achievement in mathematics (Harari et al., 2013), and teachers in this study were very aware of the anxiety that some children associated with mathematics. Student negative attitudes towards mathematics were found to be a factor that hindered teachers in promoting student achievement in mathematics. According to participants in this study, negative attitudes were a particular problem with mathematics as a subject due to the sense of failure students experience from getting wrong answers. Therefore, many teachers reported the need to regularly encourage their students and boost their confidence in mathematics through the pedagogical relationship. For example, Majella (School A, Northern Ireland) described trying to boost the confidence of children who “*feel that they’re not good at maths ... because if they feel they’re a failure at maths they’re just going to let go*

... *they will not take interest.*” These practices align well with Puklek Levpušček and Zupančič’s (2009) finding that student motivation and achievement is higher when students perceive that their teachers take into account the psychological needs of competence and relatedness.

In summary, interview participants reported that students pick up on and replicate the attitude that their teacher communicates towards mathematics. This echoes a finding by Stipek et al. (2001) that teacher and student self-confidence relating to mathematics teaching and learning respectively are positively correlated. However, as the sample in the qualitative phase of this study was small, further research in the area of how teacher attitudes influence student learning and achievement would support these interesting findings.

5.4 Conclusion

This chapter discussed the main findings that emerged from analysis and interpretation of the data. The importance of qualitative data within the predominantly quantitative teacher effectiveness paradigm was revealed. Qualitative teacher insights provided contextual explanations for TIMSS 2011 findings, highlighted the complex interconnectedness of teacher-related factors, and uncovered new knowledge regarding teacher classroom practices that teachers saw as promoting student learning and achievement in mathematics.

Although this research focused upon the teacher effectiveness subclass of teacher classroom practices, interesting findings also emerged relating to the subclasses of teacher qualifications and teacher attitudes and beliefs. The main findings relating to the three subclasses of teacher effectiveness are based on the reported views of teachers and include:

- teacher experience at the same grade level is thought to positively influence teacher pedagogical knowledge, teacher confidence and student learning and achievement
- constant revision in mathematics is believed to positively influence student learning and achievement on standardised tests
- A strategic plan and resources for addressing underachievement within schools is felt to promote improvement in achievement on standardised tests
- The attitude that a teacher communicates towards mathematics is seen to be replicated by their students and is considered to influence student learning and achievement

These findings suggest practical ways which may be helpful for teachers who wish to positively influence student learning and in turn achievement on standardised tests in mathematics. In addition, the findings provide strong arguments for including qualitative methodology in studies across the teacher effectiveness paradigm. The next chapter concludes this thesis by summarising the key findings of the research presented in Chapter 4 and synthesising the interpreted findings of Chapter 5. Finally, recommendations for future research are put forward and limitations of the current study are discussed.

Chapter 6. Conclusions

6.1 Introduction

This comparative, mixed methods research study explored how teachers influence student learning and achievement in mathematics at the fourth class level in Ireland and Northern Ireland. The study focused on gaining teacher perspectives regarding the teacher classroom practices that are important for improving student learning and achievement in mathematics in fourth class. A focus on the teacher effectiveness subclass of classroom practices addressed a noted research gap in this area. However, the teacher effectiveness subclasses of teacher qualifications and teacher attitudes and beliefs were also included. A quantitative investigation in the first phase of the study using data from TIMSS 2011 highlighted areas of interest to explore in the second qualitative phase of the research project. Significant methodological and practical classroom findings emerged from the research. These findings may be useful for schools and teachers who wish to improve student achievement in mathematics, and for researchers within the teacher effectiveness paradigm. The main findings are based on the perceptions of eleven teachers and include:

- Qualitative teacher voice is an important addition to the quantitative dominated teacher effectiveness paradigm. Teacher insights:
 - ❖ helped to explain large-scale TIMSS 2011 findings
 - ❖ contributed new knowledge to the teacher effectiveness paradigm by revealing new classroom practices that were believed to promote student learning and achievement in mathematics
 - ❖ highlighted the complex interconnectedness of the teacher-related factors which influence student learning and achievement

- Consecutive years of experience at the same grade level was reported to have an influence on teacher pedagogical knowledge and, in turn, student learning and achievement in mathematics
- The teacher classroom practice of facilitating constant revision was considered to promote student learning and achievement in mathematics
- Implementing a whole school strategic plan for tackling underachievement on standardised tests was seen to improve student achievement in mathematics
- Teacher communication of a positive attitude towards mathematics was believed to have an effect on student attitudes, learning and achievement in mathematics

6.2 Summary of key findings with respect to the research questions

The research questions for this study emerged from the literature review, and the conceptual framework provided a structure for reporting findings. As each of the research questions has been addressed in Chapter 4, this chapter does not aim to re-present these findings, but rather it revisits each question in order to highlight the key findings. The research evidence is based on data from the TIMSS 2011 study pertaining to fourth class mathematics teaching in Ireland and Northern Ireland, as well as interviews with eleven fourth class teacher participants: six in Ireland and five in Northern Ireland.

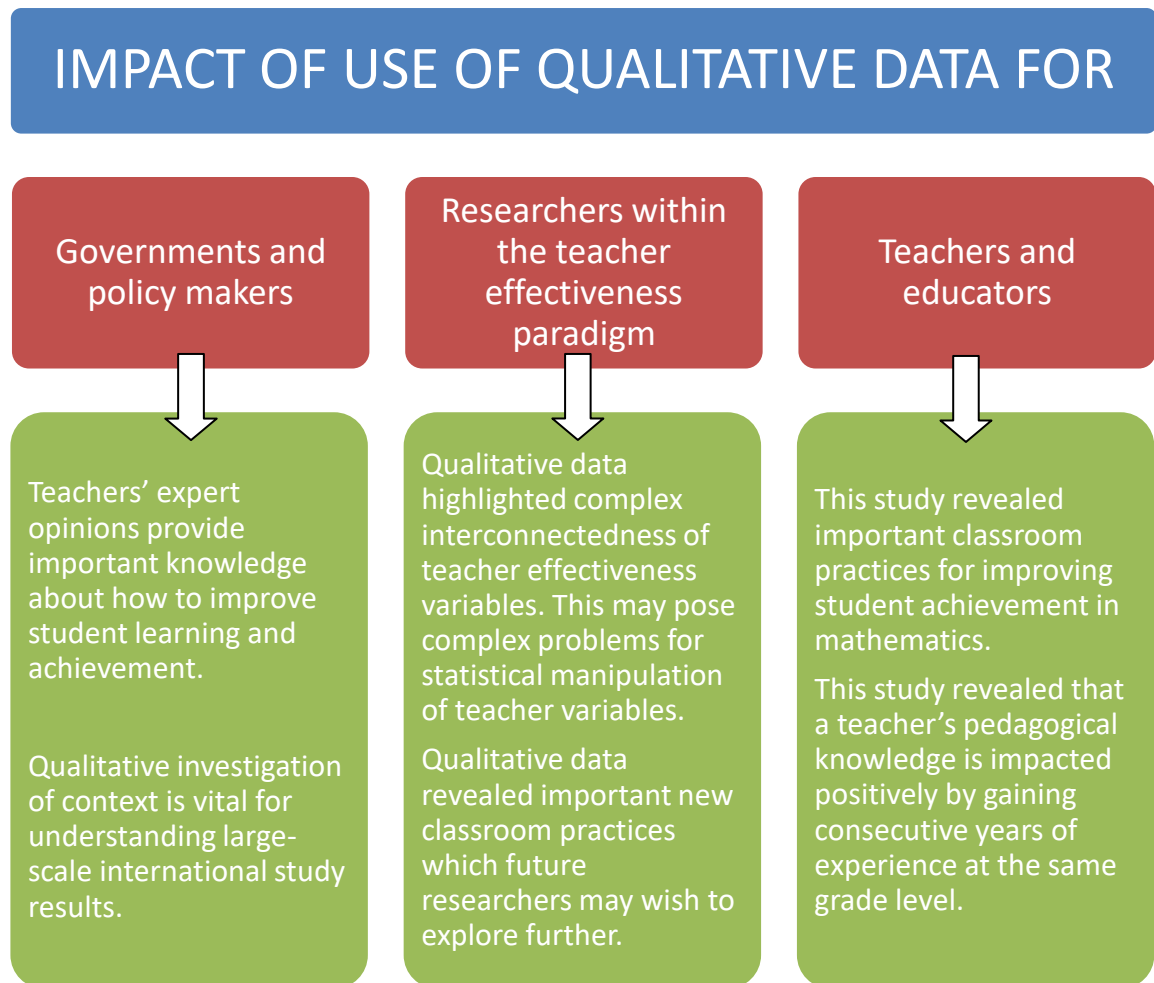
6.3 Qualitative data in the teacher effectiveness paradigm

The teacher effectiveness paradigm to date has been dominated by positivist quantitative studies that tend to evaluate teachers rather than gain a meaningful understanding of the teaching and learning process. In contrast, this study placed qualitative data at the heart of its methodology and the results are exciting. Three significant methodological findings emerged. These are:

- Qualitative data was a powerful tool for providing a deeper understanding of large-scale quantitative findings; see tables 6.1, 6.2 and 6.3
- Qualitative data highlighted the complex interconnectedness of teacher-related factors across and within the subclasses of teacher effectiveness
- Qualitative data added new classroom practices to the teacher effectiveness knowledge base

The benefit of including qualitative data within the methodology of teacher effectiveness studies is the most important finding of this study. Qualitative data enriched all aspects of the research project and it permeated all of the significant findings of the study. The use of qualitative data in this study resulted in findings that may be of significant interest to governments, policy makers, educational researchers and teachers, thus impacting those at the macro and micro levels of education. Figure 6.1 summarises how the qualitative findings of this study may impact various educational stakeholders.

Figure 6.1 Possible impacts of research findings on educational stakeholders

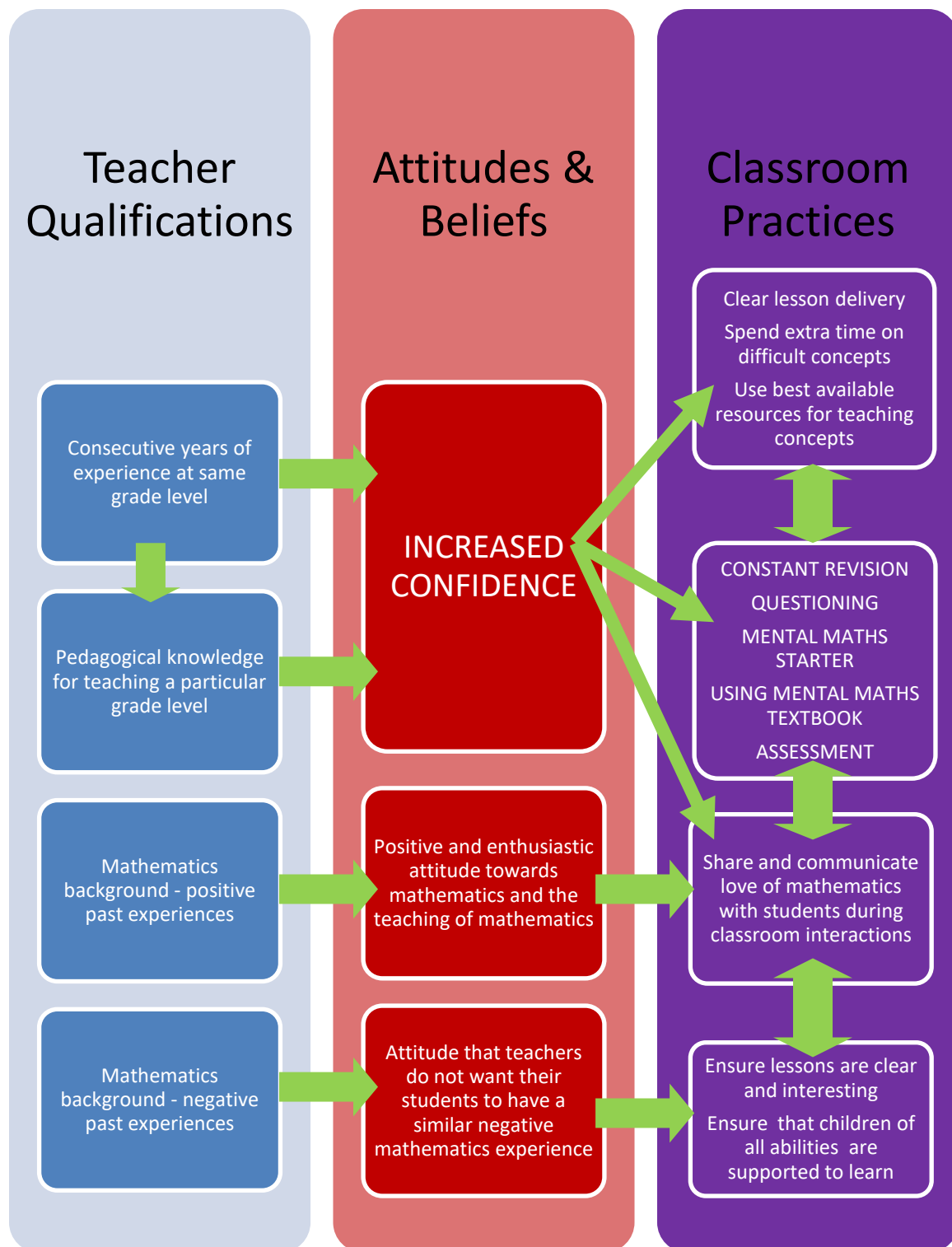


At the macro level, governments and policy makers may take note of the valuable contributions qualitative teacher voices make to research within the teacher effectiveness paradigm, especially when it comes to understanding the results of large-scale international study results. For example, a qualitative exploration of context was vital for understanding the quantitative disparities between teacher qualification variables for Ireland and Northern Ireland in TIMSS 2011, echoing Berliner's (2002, p18) postulation that educational phenomena are greatly influenced by the "power of contexts". This finding may have implications for policy makers and governments who tend to act upon large-scale findings without first acquiring

knowledge about the multifaceted educational contexts within which these findings are set.

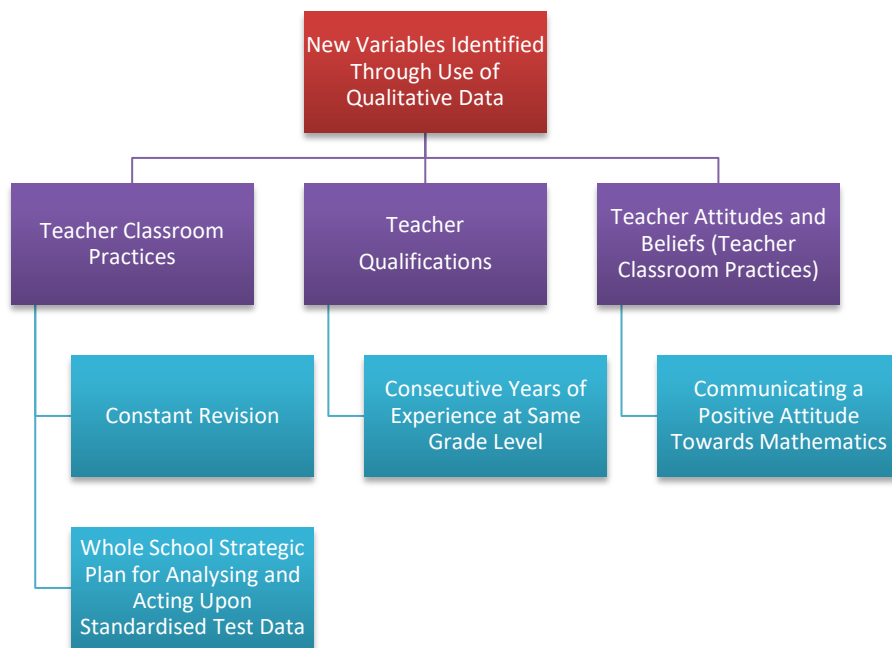
The methodological findings of this research study may also impact educational researchers working within the teacher effectiveness paradigm. The inclusion of qualitative data in this study led to the identification of classroom practices that participants perceived to be essential for promoting student achievement on standardised tests. This added original knowledge to the literature base, which to date has linked classroom practices to student achievement, but has not explored why certain classroom practices are important, or how they impact on student learning and achievement. In addition, the complex interconnectedness of teacher-related variables was highlighted, with some teacher variables found to be strongly related to other variables within and across the subclasses of teacher effectiveness. Figure 6.2 depicts the links between teacher-related variables that were reported by teacher participants in this study. The interconnectedness of teacher-related variables displayed in Figure 6.2 would pose complex problems for statistical models that are currently in use within the teacher effectiveness paradigm as these models seek to link isolated teacher-related variables with student achievement.

Figure 6.2 The complex interconnectedness of teacher effectiveness variables



At the micro level, the findings of this study may have a positive impact on teachers, by recognising that they have an expert understanding of what may work for improving student learning in mathematics. Although teachers have a knowledge of student learning and achievement that is richer and less one dimensional than standardised test results (Martinez et al., 2009; Foreman and Gubbins, 2015), their opinions and perceptions are not dominant across the teacher effectiveness literature base. Therefore, the finding that giving teachers a voice and investigating teacher effectiveness through a qualitative lens can produce novel and original findings is important. The use of teacher expert opinion was considered vital for illuminating new teacher classroom practices, which teachers within this study reported to help them to promote student learning and achievement in mathematics. These variables are shown below in Figure 6.3 and are discussed in greater detail in the relevant sections throughout this chapter. Furthermore, teacher voice highlighted the importance of a new teacher qualification variable, namely, consecutive years of experience at the same grade level, and revealed very strong links between this variable and increased teacher pedagogical knowledge.

Figure 6.3 New variables identified through use of qualitative data



6.4 Teacher qualifications

Research questions 1b and 2b investigated the teacher effectiveness subclass of teacher qualifications and were as follows:

Q.1b With respect to mathematics, what similarities and/or differences exist between fourth class teacher qualifications in Ireland and Northern Ireland, as reported in TIMSS 2011?

Q.2b How do teachers in Ireland and Northern Ireland describe the role of teacher qualifications in promoting student learning and achievement in mathematics?

Quantitative findings pertaining to research question 1b are summarised in Table 6.1 below. For questions which involved a Likert scale, the percentages displayed in the tables are those from the category within which the highest percentage of teachers answered. For yes or no questions, the percentages displayed in the table are yes responses. Differences in responses between teachers in the two countries that amount to 10% or more are highlighted in red. Qualitative data was used to enhance

understanding where TIMSS responses between teachers in the two countries were notably different. This is detailed in the far right column of the table. Tables 6.2 and 6.3 follow the same format as this.

Table 6.1 Summary of TIMSS 2011 comparisons of teacher qualifications variables

Teacher Effectiveness Subclass	TIMSS 2011 Question	Ireland	Northern Ireland	Possible Explanations of TIMSS findings from Qualitative Data
Teacher Qualifications	11 or more years of experience (G1)	35%	71%	<ul style="list-style-type: none"> • Different contexts of P6 in Northern Ireland and 4th class in Ireland • Existence of Transfer Test in Northern Ireland
	Advanced Degree (G4)	17%	25%	
	Maths Major (G5b)	4%	8%	
	Participated in Mathematics Professional Development in Past Two Years (M11a–e) (Average)	32%	60%	<ul style="list-style-type: none"> • A lot of professional development made easily available to teachers in Northern Ireland around the time of TIMSS 2011

The quantitative data showed that in TIMSS 2011, fourth grade Northern Irish teachers were significantly more experienced than Irish teachers. However, Wang (2001) suggests that TIMSS results should not merely be taken at face value, and evidence from this study supports the need for caution. Qualitative findings revealed very different contexts of fourth class in Ireland and Northern Ireland, which most likely explain the notable differences in teacher qualifications between teachers in both countries. In particular, the existence of a high stakes external transfer exam for secondary school selection in Northern Ireland was revealed to impact on teacher qualifications variables, as well as many other teacher variables within the Northern Irish TIMSS data.

Research question 2b investigated teacher perceptions regarding how teacher qualifications influence student learning and achievement in mathematics. A highly

significant finding in the area of teacher qualifications was the identification of a sublevel of teacher experience, namely, consecutive years of experience at the same grade level. This sublevel was perceived to greatly influence a teacher's pedagogical knowledge for teaching the particular grade level, and was reported to impact upon all three forms of pedagogical knowledge for teaching posited by Ball et al. (2008). Evidence showed that these three forms of pedagogical knowledge were linked to specific classroom practices, as well as more confident attitudes and beliefs regarding mathematics, and teacher participant reports of increased student learning and achievement; see figure 6.4. The identification of a new sublevel of teacher experience is exciting, as although previous studies have found that teacher experience is important for promoting student achievement, the effects of this variable tend to stabilise after a few years (Hanushek et al., 2005; Boyd et al., 2007).

Figure 6.4 Impact of consecutive years of experience at the same grade level



Dimarco (2009) found teacher pedagogical knowledge to be a crucial component for student engagement and teacher effectiveness. Therefore, the strong link that was revealed in this study between consecutive years of experience at the same grade level and pedagogical knowledge may be important for school leaders to consider when selecting teachers to teach various grade levels. In addition, governments who wish to promote and improve the effectiveness of teachers in a cost effective way may also find this finding of interest. Results from this study suggest that both professional and deep pedagogical knowledge development take place when a teacher is afforded the opportunity to teach at the same grade level for a number of

years. This professional development is free and takes place within the classroom during mathematics lessons, and subsequently in the form of a cognitive reflection and evaluation process.

Evidence from this study showed that gaining consecutive years of experience at the same grade level allows teachers to informally evaluate and assess mathematics teaching and learning within their classrooms, and in this way to gain invaluable knowledge about what makes a difference for student learning and achievement for that particular grade level. This promotes teacher autonomy, allowing them to find out what classroom practices work best for them in promoting student mathematics achievement.

6.5 Teacher classroom practices

This study addressed a gap that exists within the literature regarding the interplay between teacher classroom practices and student learning (Polly et al., 2013). Research questions 1a and 2a explored the teacher effectiveness subclass of teacher classroom practices quantitatively and qualitatively and were as follows:

Q.1a With respect to mathematics, what similarities and/or differences exist between fourth class teacher classroom practices in Ireland and Northern Ireland, as reported in TIMSS 2011?

Q.2a How do teachers in Ireland and Northern Ireland describe the role of a range of teacher classroom practices in student learning and achievement in mathematics?

Table 6.2 below summarises the key quantitative findings pertaining to research question 1a. Data within the table follows the same format outlined for Table 6.1. This is with the exception of question M1 on the TIMSS 2011 teacher questionnaire,

where the mean time given to teaching mathematics per week is displayed in hours.

In most cases where there were significant differences in responses in Ireland and Northern Ireland, the qualitative data provided a deeper understanding and possible explanations for the findings; see the right hand column.

Table 6.2 Summary of TIMSS 2011 comparisons of teacher classroom practices variables

Teacher Effectiveness Subclass	TIMSS 2011 Question	Ireland	Northern Ireland	Possible Explanations of TIMSS findings from Qualitative Data
Teacher Classroom Practices	Perception of teacher expectations for student achievement within school very high (G6d)	35%	52%	<ul style="list-style-type: none"> • Strategic plans operate in many schools in Northern Ireland to improve student achievement and performance on standardised tests • School and student achievement data is externally monitored by the Northern Irish Inspectorate • These factors may explain why more Northern Irish teachers perceived teacher expectations within their schools to be very high
	Encourages students to improve performance in every/almost every lesson (G16d)	88%	90%	
	Asks students to explain answers every/almost every lesson (M3f)	61%	61%	
	Asks students to take a written test or quiz in about half of lessons (M3h)	20%	15%	
	Places a major emphasis on evaluation of ongoing work (M10a)	93%	94%	

Table 6.2 continued

Teacher Effectiveness Subclass	TIMSS 2011 Question	Ireland	Northern Ireland	Possible Explanations of TIMSS findings from Qualitative Data
Teacher Classroom Practices	Places a major emphasis on classroom tests (M10b)	52%	42%	<ul style="list-style-type: none"> Accountability agenda more prevalent in Northern Ireland. This may explain why fewer Northern Irish teachers place a major emphasis on tests that they themselves have designed autonomously
	Places a major emphasis on national achievement tests (M10c)	32%	37%	
	Uses computers in classroom instruction (G9c)	97%	100%	
	Uses computer software as a supplement for mathematics instruction (M4d)	69%	82%	<ul style="list-style-type: none"> All Northern Irish teachers have access to purchased software packages such as Education City Most Irish teachers only have access to free digital resources such as online games or Khan Academy
	Summarises what students should have learned from lessons in every/almost every lesson (G15a)	52%	72%	<ul style="list-style-type: none"> Qualitative data did not provide an explanation for this difference. However, summarising lessons is an important part of the numeracy hour structure, which was a key feature of the national numeracy strategy in Northern Ireland (2008)
	Asks students to listen to teacher explain how to solve mathematics problems every/almost every lesson (M3a)	66%	58%	
	Asks students to work on problems together in whole class with teacher's direct guidance in every/almost every lesson (M3d)	52%	40%	<ul style="list-style-type: none"> Differences in curriculum demands between the countries of Ireland and Northern Ireland. Northern Ireland – more group work and problem based learning
	Uses concrete materials that help students understand quantities or procedures as a supplement (M4c)	57%	64%	
	Average hours spent teaching mathematics per week M1	4.1 hours	6.3 hours	<ul style="list-style-type: none"> Extra time spent on mathematics in Northern Ireland due to transfer test

As was also seen in the teacher qualifications findings section, qualitative insights about the educational context in Ireland and Northern Ireland provided probable explanations for disparities between teacher classroom practices variables between the two countries. For example, quantitative data from TIMSS 2011 highlighted that over the course of the school year, fourth class teachers in Northern Ireland spent an extra 72 hours teaching mathematics in comparison to their Irish counterparts and it is reasonable to attribute this factor to the higher mathematics score recorded for Northern Irish students on TIMSS 2011. However, qualitative data suggested that this score was most likely due to teachers in Northern Ireland spending extra time preparing their students for the transfer test, once again highlighting the importance of context in understanding educational phenomena.

Research question 2a qualitatively investigated teacher perceptions regarding how and why a range of teacher classroom practices are important for promoting student achievement in mathematics. A significant outcome of this research was the identification of two new classroom practices which add original knowledge to the current literature base. The two practices revealed were:

- Promoting constant revision of mathematical concepts; see figure 5.3
- Implementing a school-wide strategic plan for addressing underachievement on standardised tests.

In addition, an interesting finding regarding communicating a positive attitude towards mathematics was made. However this will be discussed in the teacher attitudes and beliefs section.

The identification of practical classroom practices that are believed to promote student attainment on standardised tests may be useful in helping teachers and

schools to improve student achievement in mathematics. Due to the current pervasive global accountability agenda, many school leaders and governments are very interested in how they can improve their students' achievement on standardised tests. While this is placing a very narrow focus on literacy and numeracy, and transforming educational systems worldwide (Exley and Ball, 2014), it is not within the scope or power of this study to change this. Instead, this research project recognises the current reality in which teachers and schools find themselves, and provides them with practical ways to promote student achievement in mathematics, as this is what is being asked of them more and more by parents, principals, school management and governments alike.

That said, this study in a small way challenges the current pervasive accountability agenda by giving teachers a voice within the teacher effectiveness paradigm and by showing that in moving from evaluating teachers to listening to their expert opinions, practical and useful strategies for promoting student learning and achievement can be illuminated. For example, the inclusion of qualitative teacher insights meant that how and why questions regarding important classroom practices could be answered. With respect to the classroom practice of constant revision, interviewees explained that mathematics, unlike literacy, requires students to recall a large number of facts and concepts in order to perform well on standardised tests. Therefore, constant revision was considered to be essential for promoting mathematics achievement. In contrast to quantitative data, the qualitative methodology also enabled participants to illuminate how constant revision could be promoted at a practical level within the classroom. In this way, links were made between revision and four other classroom practices, namely, assessment, questioning, the mental mathematics starter and using a mental mathematics textbook.

What this shows is that teachers have very useful data regarding effective mathematics teaching and learning. It also highlights qualitative teacher voice as an invaluable tool for providing knowledge about how student mathematics achievement can be improved (Dimarco, 2009). In this way, the study answers the call for teacher effectiveness research to move from evaluating teachers to addressing the deep complexity of the teaching and learning process (Skourdoumbis and Gale, 2013), and understanding how teachers can help to promote student learning and achievement (Imig and Imig, 2006).

6.6 Teacher attitudes and beliefs

Research questions 1c and 2c explored the teacher effectiveness subclass of teacher attitudes and beliefs, and were as follows:

Q.1c With respect to mathematics, what similarities and/or differences exist between fourth class teacher attitudes and beliefs in Ireland and Northern Ireland, as reported in TIMSS 2011?

Q.2c How do teachers in Ireland and Northern Ireland describe the role of teacher attitudes and beliefs on student learning and achievement in mathematics?

Table 6.3 below summarises the key quantitative findings pertaining to research question 1c. Data within the table follows the same format outlined for Table 6.1. In general, teachers in Northern Ireland reported feeling more confident regarding a range of teaching tasks in TIMSS 2011. This is likely to be linked to the fact that teachers in Northern Ireland were more experienced and had undertaken more professional development in mathematics, in comparison to Irish teachers.

Table 6.3 Summary of TIMSS 2011 comparisons of teacher attitudes and beliefs variables

Teacher Effectiveness Subclass	TIMSS 2011 Question	Ireland	Northern Ireland	Possible Explanations of TIMSS findings from Qualitative Data
Teacher Attitudes and Beliefs	Teacher feels very confident in answering students' questions about mathematics M2a	90%	89%	
	Teacher feels very confident in showing students a variety of problem solving strategies M2b	67%	80%	<ul style="list-style-type: none"> Teachers in Ireland are less experienced and participated in less mathematics PD Revised curriculum in Northern Ireland (2007) – strongly promotes problem solving
	Teacher feels very confident in providing challenging tasks for capable students M2c	62%	71%	
	Teacher feels very confident in adapting their teaching to engage students' interest M2d	66%	75%	
	Teacher feels very confident in helping students to appreciate the value of learning mathematics M2e	65%	71%	

The literature to date has been unclear about the way in which teachers' attitudes or beliefs impact on their classroom practices and in turn on student outcomes. However, one of the most notable findings with respect to the subclass of teacher attitudes and beliefs in this study was the perception of interview participants that their students replicated the attitude that they as teachers communicated towards mathematics. Significantly, teachers who communicated a strong, positive and enthusiastic attitude toward mathematics reported increased student engagement, enjoyment and achievement in mathematics. This is a new finding, and it shows that the attitude communicated towards mathematics by teachers may play a noteworthy role in student achievement on standardised tests. Although Charalambous et al. (2009) similarly revealed that negative attitudes demonstrated by teachers towards mathematics can negatively impact upon student attitude and achievement, no studies

within the literature review investigated the impact of demonstrating a positive attitude, and therefore the current finding adds original knowledge to the literature base.

6.7 Teacher understandings of the term ‘teacher effectiveness’

Q.4 How do teachers in Ireland and Northern Ireland understand the term ‘teacher effectiveness’?

In relation to teacher understandings of teacher effectiveness, evidence from this study showed that while some teachers associated the term with a myriad of teacher classroom practices such as frequent questioning, good classroom management, assessment, and use of a wide range of teaching and learning strategies, many teachers associated the term simply with student learning. However, participants were strongly against the use of standardised tests as a stand-alone measure for student learning, and, in turn, teacher effectiveness. In line with findings by Dimarco (2009), teachers in this study argued that if a single test is used as a measure of student learning and teacher effectiveness, it would be quite easy to teach to the test and in turn be recognised as a ‘good teacher’. Other research participants argued that standardised tests provided only “*a guideline [of student learning]*” (Geraldine, School C, Northern Ireland) and that teacher judgement was essential, due to the fact that students “*respond to testing in different ways*” (Phyll, School F, Ireland). This is supported by Foreman and Gubbins’ (2015, p5) findings that teacher judgements of gifted students were a better indicator for future performance on an advanced mathematics curriculum than test scores, with authors summarising that “teachers see what ability scores cannot”. The evidence from this study therefore supports the argument that the results of standardised tests should not be solely equated with student learning or teacher effectiveness (Skourdoumbis, 2013).

6.8 Factors that help and hinder teachers in promoting student learning and achievement in mathematics

Q.3 How do teachers in Ireland and Northern Ireland describe the factors that help and hinder student learning and achievement/teacher effectiveness in mathematics?

Participants reported several factors which they believed helped teachers in promoting student achievement on standardised tests:

- Analysing standardised test data and taking action based upon findings
- Availability and use of hands-on concrete resources to support mathematics learning
- Constant revision of mathematics concepts throughout the year
- Making mathematics lessons interesting and enjoyable
- Parental support

On the other hand, participants considered that the following factors hinder teachers in promoting student achievement on standardised tests:

- Lack of resources
- Large class size
- Negative attitudes towards mathematics from parents, students or teachers themselves
- Low confidence in students due to a sense of failure from getting wrong answers in mathematics
- Lack of time

These factors, which teachers highlighted as helping and hindering them in promoting student achievement in mathematics, emphasise the myriad of variables

influencing student outcomes on standardised tests. This once again calls into question the current accountability agenda, which increasingly draws a straight line between student scores on standardised tests and a teacher's effectiveness (Skourdoumbis and Gale, 2013). Those at the ground level of education, including teachers, students, parents and principals, understand that children's learning is complex, multifaceted and not easily measured (Hikmet et al., 2008). It is their voice that now must be heard across the teacher effectiveness paradigm in order for education to turn its focus away from measurement and accountability and return that focus back to genuine teaching and learning.

6.9 Recommendations

In light of an emerging prescriptive accountability trend in Ireland, Northern Ireland and globally, which currently focuses on evaluating teachers through the use of narrow parameters of student achievement on standardised tests in mathematics and literacy, a number of recommendations are made resulting from this research:

- Due to the notable qualitative findings made in this study, researchers within the teacher effectiveness paradigm should consider including qualitative methodology, which draws on and values teacher expert opinions in their studies. What this study showed is that teachers have invaluable data about the teaching and learning process (Foreman and Gubbins, 2015), which can highlight classroom practices that may improve and promote student learning and achievement in mathematics. Currently, this important data is being overlooked due to an emphasis on performance evaluation and accountability.
- Quantitative researchers within the teacher effectiveness paradigm should consider this study's finding relating to the complex interconnectedness of teacher-related variables and the implications that this may have for the

design and interpretation of complex statistical models. Furthermore, because variables within and across teacher effectiveness subclasses are inextricably linked, teacher effectiveness studies should include all three subclasses in their research (Palardy and Rumberger, 2008).

- As this research revealed four new teacher variables which were perceived by teacher participants to influence student learning and achievement in mathematics, the author recommends that future teacher effectiveness research explores these variables in other contexts or on a larger scale, so as to substantiate the current small-scale findings.
- Governments and policy makers should resist the temptation to make decisions based upon the results of large-scale international quantitative comparative studies (Wang, 2001). This study showed that a qualitative exploration of context was vital for understanding and explaining discrepancies in test scores between students in different countries.
- Principals and school leaders should consider the importance of gaining consecutive years of experience at the same grade level for teachers' pedagogical knowledge and incorporate this into teacher class rotation policies as well as professional development plans.
- Teachers who wish to improve their students' achievement in mathematics should engage in the practices of promoting constant revision, collaborating with staff team in implementing a strategic plan for assessing and addressing student underachievement in mathematics, and communicating a strong positive attitude towards mathematics to their students.

6.10 Limitations

A limitation of this study is that the main findings of the research project are based on data from a relatively small sample of eleven teachers, regarding their perceptions

about effective classroom practices. As a result, the findings need to be treated with caution and claims about external validity are not being made. However, the interview participants in this study were selected from a wide range of schools including small remote rural schools and large urban schools with high levels of SES, EAL and affluence. The teachers themselves had varying levels of experience and four interviewees held mathematics majors whereas one interviewee held a master's degree. And yet, despite these variations between the schools and the teachers' wide range of contexts, this study found there to be agreement on many themes, such as the perceived importance of constant revision for promoting student learning and achievement in mathematics. It is possible therefore, that these findings could cautiously be seen as being indicative of findings that might be found in other contexts, and the suggestion here is that this would be an ideal area for further large-scale research.

The quantitative phase of the study relies solely on the responses of fourth class teachers to the TIMSS 2011 teacher questionnaire. It is cautioned in the literature that teacher self-reporting of classroom practices may not correlate with their actual classroom practices. However, as the questionnaire was anonymous, there can be reasonable confidence in teacher responses. Furthermore, teacher responses in the qualitative phase of the current study corroborated those from the TIMSS 2011 questionnaire, despite qualitative data collection taking place four years after the TIMSS 2011 study.

It is important to note that the teacher effectiveness paradigm represents only one view in the field of mathematics education research. A multitude of studies (see for example; Nicolaou and Pitta-Pantazi (2016), Van Den Heuvel-Panhuizen (2003), Van Dooren et al. (2010) and Morgan and Alshwaikh (2012)) explore mathematics

teaching and learning without the constraint of linking teaching to student achievement data, however, as this research project aimed to investigate how teachers can promote student achievement in mathematics, it was conducted within the paradigm of teacher effectiveness research. Nevertheless, the assumptions and definitions used within this paradigm posed significant difficulties for the researcher. Most importantly, the working definition of teacher effectiveness used in this study, which links teacher effectiveness to student achievement on standardised tests in mathematics is problematic. My experience as a teacher and actuarial and financial mathematics graduate led me to question the appropriateness of using standardised tests as the sole measure of teacher effectiveness, due to the fact that test scores are impacted by a multitude of factors that are beyond a teacher's control and in many cases do not accurately reflect student learning. Similarly, the statistical models used to link teacher factors to student achievement were a cause for concern due to the complexity of the teaching and learning process and the inherent difficulties that ensue when endeavouring to represent this complex process numerically. An awareness of the links between the teacher effectiveness paradigm and accountability agendas worldwide also has led to concern over whether children are becoming measurement tools for governments to test the effectiveness of teachers, schools and education systems, with little thought been given to the educational advantages of the increased testing that children are being exposed to. Despite issues with the assumptions made by the teacher effectiveness paradigm, it was nevertheless considered important to conduct this research project within its parameters so as to give teachers a voice therein and in doing so to cast a new light on the complexities of teaching and learning.

6.11 Final conclusion – the importance of teacher voice

The current global accountability agenda, which has driven much of the teacher effectiveness research to date, places a premium on statistical evidence, while largely ignoring the judgements of those in best position to provide information on teaching and learning, namely, teachers themselves. Positivist studies to date have focused on evaluating teachers in a way that erodes their professionalism (Dimarco, 2009). While these studies confirm that an effective teacher plays an important role in promoting student learning and achievement in mathematics, what needs to occur during classroom interactions to optimally promote student achievement in mathematics has remained elusive within the literature, despite decades of quantitative research into teacher effectiveness.

By qualitatively investigating what teachers consider to be the main factors for promoting student learning and achievement in mathematics, this research has enabled new themes and areas for future research to emerge. This study has revealed three teacher classroom practices which were perceived by teacher participants to positively influence student achievement in mathematics at the fourth class level. These include: promoting constant revision of mathematical concepts, engaging a collaborative staff strategic plan for assessing and addressing student underachievement on standardised tests, and communicating a strong positive attitude towards mathematics to students. In addition, the teacher qualification of holding consecutive years of experience at the same grade level was believed to positively influence teacher pedagogical knowledge as well as student learning and achievement in mathematics.

Furthermore, the qualitative design of the second phase of this study revealed the importance of including teacher expert opinions in studies investigating the teaching

and learning process, and also highlighted three methodological areas for reflection within the teacher effectiveness paradigm. Firstly, context was highlighted as being vital for understanding large-scale quantitative findings. Secondly, teacher variables were found to be complexly and inextricably linked across and within teacher effectiveness subclasses, which may pose statistical problems for the design and use of statistical models in quantitative teacher effectiveness studies. Lastly, the qualitative design of the second phase of this study facilitated the identification of new teacher classroom practice variables that were seen by teacher participants to promote student learning and achievement in mathematics. More importantly, the data revealed how and why these variables are important for student achievement, thus providing educators with a rationale for implementing them in their own schools and classrooms.

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Appendices

Appendix 1: Ethical approval form

EA2



Ethical Approval Form:

This form must be completed for each piece of research activity conducted by academics, graduate students and undergraduates. The completed form must be approved by the CERD Research Ethics Committee.

Please complete all sections. If a section is not applicable, write N/A.

1 Name of researcher	Maria Mc Mahon
	Department/School CERD
2 Position in the University	Ed D student
3 Role in relation to this research	Primary investigator
4 Brief statement of your main research question	<p>What similarities and/or differences exist between mathematics teacher instructional behaviours in Ireland and Northern Ireland as reported in TIMSS 2011?</p> <p>What are effective mathematics teachers in Ireland and Northern Ireland's perceptions of the importance of a range of teacher instructional practices?</p> <p>What are effective mathematics teachers' perceptions of the link between their instructional behaviours and student attainment in Ireland and Northern Ireland?</p>
5 Brief description of the project	<p>This study is set within the context of governments worldwide seeking to improve teacher effectiveness as measured by student attainment. While considerable research has been conducted into the effects of teacher background credentials on student attainment, relatively few studies have</p>

	<p>investigated the link between teacher instructional practices and student attainment. Of the studies that investigate this link fewer still have examined it qualitatively. Therefore this study seeks to address this gap in the literature by exploring the perceived link between teacher behaviours and student attainment in two adjacent countries (Ireland and Northern Ireland) through a mixed methods approach. Ireland and Northern Ireland have been chosen to be investigated as, although these countries have similar population demographics, cultures and education systems, their performance in mathematics in the 2011 wave of TIMSS was very different, with Northern Ireland ranking at number 7 (top performing country in Europe) and Ireland ranking at 17.</p> <p>The aims and objectives of this study are:</p> <ul style="list-style-type: none"> • To compare the teacher behaviours as reported in TIMSS 2011 in Northern Ireland and Ireland • To investigate teacher perceptions of effectiveness in Ireland and Northern Ireland • To explore teacher perceptions of the importance of a range of instructional practices and the link between teacher instructional practices and student attainment in Ireland and Northern Ireland 							
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Approximate start date:	Anticipated end date:							
May 2014	December 2014							
6 Name and contact details of the Principal Investigator (if not you) or supervisor (if a student)	<table border="0"> <tr> <td colspan="2">n/a</td> </tr> <tr> <td>Email address:</td> <td>Telephone:</td> </tr> <tr> <td>n/a</td> <td>n/a</td> </tr> </table>		n/a		Email address:	Telephone:	n/a	n/a
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n/a	n/a							
7 Names of other researchers or student investigators involved	n/a							

<p>8 Location(s) at which this project is to be carried out</p>	<p>The TIMSS 2011 data will be analysed from the researcher's desk/laptop.</p> <p>I propose to call to six schools in Ireland and six schools in Northern Ireland and to interview teachers in school settings. I aim to choose schools similar to those categorised in the TIMSS 2011 survey using a purposive sampling strategy.</p>
<p>9 Statement of the ethical issues involved and how they are to be addressed, including discussion of the potential risks of harm to both project participants and researchers</p> <p>This should include:</p> <ul style="list-style-type: none"> • an assessment of the vulnerability of the participants and researchers • the manner and extent to which the research might not honour principles of respect, beneficence and justice • concerns relating to the relationships of power between the researcher(s) and those participating in or affected by the research 	<p>This study will be conducted within the guidelines of the University of Lincoln ethical principles and those of the British Educational Research Association (BERA).</p> <p>This is an ethically sound study that satisfies the principles of beneficence, justice and respect for persons and, as such, ensures the welfare of the individuals and groups that are impacted by the research. Overall, the study explores worthwhile knowledge regarding teacher instructional behaviours, which is lacking within the teacher effectiveness literature.</p> <p>With respect to the use of secondary TIMSS 2011 data, ethical issues will be addressed by:</p> <ul style="list-style-type: none"> • engaging in a process of reflexivity so as to ensure potential harm is anticipated and guarded against at all times throughout the research study • referencing and acknowledging TIMSS as the owners of the dataset • analysing the data in accordance with the guidelines set out in "TIMSS 2011 User Guide for the International Database" (Foy et al., 2013) <p>Regarding the conducting of interviews with six teachers in both Ireland and Northern Ireland, I will mitigate ethical issues by:</p> <ul style="list-style-type: none"> • obtaining access to one 'effective' mathematics teacher in each school through telephone contact with the gatekeeper of the school (the principal). The principal will then be asked to identify an effective teacher of mathematics (as measured by student attainment on standardised tests) who will be

	<p>available to take part in the study. An ethical issue lies around choosing a teacher who is most effective as this may suggest that other teachers within the school are less effective. This issue is mitigated by asking the principal to choose an effective teacher of mathematics rather than the most effective teacher, because the former suggests there are many effective teachers within the school and the principal will choose just one who is available for the interview</p> <ul style="list-style-type: none"> • informing interviewees and gatekeepers of the aims and objectives of the research study by way of a written project brief • obtaining informed consent from interviewees by way of a consent form, confirming that they have read the project brief, are willing to participate in the study, are willing for their interview to be recorded, understand that they have the right to withdraw at any time up until the completion of data analysis (approximately 4 months' time) and understand how the data will be stored and used • informing the interviewees about how the data collected will be stored – using a password secured hard drive that will be locked away securely by the researcher at all times and destroyed after the publication of the research • Guaranteeing that the ethical issues around interviewing colleagues are considered by choosing a colleague with whom I have a professional rather than close personal relationship to interview for my pilot study • guaranteeing the interviewees' and schools' anonymity by use of a coding system to ensure no school or teacher is identifiable • consulting with my supervisor regarding any ethical issues pertaining to the study
10 Does this research involve children and/or	Yes <input type="checkbox"/> No ✓ <input checked="" type="checkbox"/>

young people?	
	<p>If yes, please explain (a) how you have obtained or will obtain the appropriate permissions to work with these people (E.g., DBS check in the UK), and (b) your principles for their ethical engagement.</p> <p>n/a</p>

Ethical approval from other bodies

11 Does this research require approval from an external body?	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
	If yes, please state which body: n/a	
12 Has ethical approval already been obtained from that body? Please note that such approvals must be obtained before the project begins.	Yes <input type="checkbox"/>	(Please append documentary evidence to this form.)
	No <input type="checkbox"/>	(If no, please explain why below.)
	n/a	

APPLICANT SIGNATURE

I hereby request that the CERD Research Ethics Committee review this application for the research as described above, and reply with a decision about its approval on ethical grounds.

I certify that I have read the University's Ethical Principles for Conducting Research with Humans and Other Animals (which can be found online here: <http://visit.lincoln.ac.uk/C11/C8/ResearchEthicsPolicy/Document%20Library/Research%20Ethics%20Policy.pdf>).

Maria Mc Mahon

29/05/14

Applicant Signature

Date

Maria Mc Mahon

Appendix 2: Interview schedule

Prompts For Researcher:

- Thank you for agreeing to take part in this interview
- Aim is to get your views on teaching and student achievement in Sigma T and other standardised maths tests
- Assurance of confidentiality and anonymity
- Consent form completion
- Permission to record
- Approximate duration – no longer than 1 hour
- This interview is semi-structured and informal – basically a conversation – where I want you to have the opportunity to tell me your views on what makes an effective teacher of mathematics. However, I do have some key issues that I hope we can discuss so I will check my prompts from time to time to make sure that we cover all areas.
- For the purpose of digital recording please state date, time, place and interview with ...

Personal Information

- Can you tell me about yourself?
- Have you been teaching 4th class for long
- What other classes have you taught?
- Your role within the school
- Can you tell me about your school – size, status, SSE subject?
- Mathematics background, interest level in mathematics

Standardised Tests

- What in your opinion is the role of standardised tests?
- Would they play a role in your daily teaching?
- How can teachers improve student achievement in mathematics tests like the Sigma-T?
- What factors help teachers in promoting student achievement? (parental involvement, SES, EAL, class composition, resources, leadership)
- What factors hinder teachers in promoting student achievement?
- (Student background – SES, EAL, Special needs, Parental) (Classroom – class composition, class size) (School leadership, resources, composition)

Teacher Background

- What effect do you think a teacher's years of experience have on their teaching of mathematics?
- How important is a teacher's background knowledge of mathematics in their teaching of mathematics?
- Teacher attitudes and beliefs
- What sorts of teacher attitudes or beliefs do you think are important for promoting mathematics achievement?
- Why?

General Teacher Behaviours During a Mathematics Lesson

- What structure do you think maths lessons should have?
- What role do you see for ____ in maths lessons? (Doing examples/helping children/asking questions/classroom managements/behaviour management/time management)

- In your opinion what is the most important thing teachers can do to promote student achievement in mathematics?
- What effect do you think planning has on student learning?

Teacher Questioning

- What do you see as the benefits to asking questions during mathematics lessons?
- What part do you feel product style questions have to play in daily mathematics lessons?
- What role do you think process style questions have to play in daily mathematic lessons?
- How do you approach higher order questions in your teaching?
- Of these three types of questions which do you think is most beneficial for student learning?
- How do you think wrong answers to questions should be approached?
- What role do you feel teacher questioning during lessons has to play in student achievement later on?

Conduction of Point-In-Time Assessments

- How often do you think teachers should conduct tests or quizzes in mathematics?
- What benefits do you see in conducting mathematics tests?
- What role do you think informal assessments should play in the teaching of mathematics?
- What role do you think mathematics tests play in promoting student achievement?

Holding High Expectations

- What effect do you think holding high expectations for student learning has on student attainment in tests?

Defining and Understanding

- What does the term teacher effectiveness mean to you?
- How would you say, can you tell that a teacher is good or effective at teaching mathematics?
- What factors do you think would help to shape a teacher's effectiveness?
(Resources, CPD, leadership)

Appendix 3: Participant information form

Thank you for agreeing to participate in my research study. This sheet will give you information about this research project and your rights in relation to the data you provide.

The Purpose of The Research

I am conducting this research as part of a doctoral study, which I am completing with the University of Lincoln. This study aims to gain teacher perspectives on ‘teacher effectiveness’ with respect to mathematics. It seeks to explore how teacher instructional behaviours are thought to influence student attainment. It also will explore what factors motivate teachers to choose certain instructional behaviours in the teaching of mathematics. A focus will be on the teacher behaviours of questioning and conducting point-in-time assessments. It is important to note that this research has not been commissioned by any agency or organisation. Data will be collected through interviews. It is hoped that the research may be of use to those involved in education who are interested in promoting student achievement.

Informed Consent

This research will be conducted according to the ethical guidelines set out by the British Educational Research Association. The researcher will ask permission for the interview to be recorded. Interview participants may withdraw from the research process at any time. Participants may ask at any time for clarification of anything that they would like to be explained further. Interview participants are free to refrain from answering any question during the interview process.

Confidentiality and Anonymity

Confidentiality is of the highest priority. Interview tapes and transcripts will only be used for the purposes of the research and the researcher alone will have access to them during the research study. Information will be stored in locked cabinets and at the time of disposal digital files will be erased and documents shredded. Transcripts will be encoded so that no participant is identified or identifiable. Schools or individuals will be made anonymous and will not be mentioned in any publications that arise from the research.

Feedback

If participants wish, they will be sent a summary of the findings of the research project.

Consent

If you require any further information prior to consenting to take part in this project please contact me on 087 2671362 or by email at maria.mcmahonsna@gmail.com

I understand the purpose of this research project and my rights in relation to participating in it. I understand that I can withdraw from the research at any time.

I do ☐ do not ☐ consent to the interview being recorded

Please provide email address if you would like a summary of the findings of this project to be sent to

you: _____

Signed _____

Date _____