University of Limerick

Developing Numeracy Strategies to Improve Interest and Achievement in Mathematics amongst Post-Primary Students.

Eileen Flanagan

M.Sc. 2016

Developing Numeracy Strategies to Improve Interest and Achievement in Mathematics amongst Post-Primary Students.

Submitted by: Eileen Flanagan, B.Sc.

For the Award of Masters of Science Degree

Supervised by: Dr. Niamh O' Meara

University of Limerick

Submitted to the University of Limerick **2016**

Abstract

Interest and achievement in mathematics is currently both a national and international concern. Interest in mathematics is low in comparison to other curricula subjects and achievement in mathematics is also poor when compared with other subjects. In Ireland's post-primary education system many reasons have been criticised in the past for low interest and achievement in mathematics, such as a dated curriculum which emphasised rote learning and procedural tasks and unqualified teachers of mathematics. In the present decade however, mathematics education in Ireland's post-primary schools has been overhauled. The new mathematics syllabus entitled 'Project Maths' encourages students to greater engage with mathematics and encourages more of a collaborative approach to learning. Also a National Strategy has been implemented which hopes to improve numeric abilities of students by setting out goals that need to be achieved by 2020.

Although steps in the right direction have been made in Ireland to improve interest and achievement in mathematics the author found that many students still do not grasp the basic numeracy skills that are incorporated in the Project Maths syllabus. Also, the author found that many students have a poor attitude towards mathematics. As a result the author developed an intervention to improve interest and achievement in mathematics of students in her school. The mathematical abilities which were promoted in this intervention are those mainly at stake in the National Strategy for Literacy and Numeracy. The process began with a review of literature. The author then developed a student handbook and accompanying resources and piloted the intervention materials through peer tutoring. Any necessary changes were made. The intervention took place a second time and from this intervention the author collected both qualitative and quantitative data. The author then analysed the results and discussed the research findings.

The data gathered produced evidence to suggest that the intervention was a success and will be discussed in detail in chapter 6.

Declaration

This thesis is presented in fulfilment of the requirements for the degree of Masters of Science. It is entirely my own work and has not been submitted to any other University or Higher Education Institution, or for any other academic award in this University. Where use has been made of the work of other people it has been fully acknowledged and fully referenced.

Signature: ______________________________

Eileen Flanagan

Date: __________________________________

Dedication

This thesis is dedicated to my Mum and Dad who have encouraged and supported me throughout my studies.

Acknowledgments

I would like to thank most sincerely Dr. Miriam Liston, Prof. John O’ Donoghue and especially my supervisor Dr. Niamh O’ Meara for both offering me the opportunity to conduct this research but for also offering me continuous support throughout. I am genuinely very grateful.

I would also like to thank all my friends and family for their continued support and friendship while writing this thesis as well as everyone in the EPI-STEM National Centre for STEM Education for their advice and encouragement.

I would like to thank the staff and management of my place of work for their support and understanding during the data collecting phase. Finally I would like to thank all the students who took part in this research.

Table of Contents

Chapter 2: Literature Review

Chapter 3: Methodology

Chapter 4: Intervention Design and Implementation

Chapter 5: Research Findings

List of Appendices

List of Figures

List of Tables

Chapter 1
Introduction

1.1 Introduction

On both a national and international level it is commonly known that mathematics is one of the least popular subjects amongst post-primary School students. This is clearly evident by Buxton (1981, p.5) stating that "*among all school subjects, mathematics is the one that triggers the strongest negative emotions, which may become established and even end up in an attitude of refusal towards the subject, or may block thinking processes*". On a national level both interest and achievement in mathematics is poor in relation to many other subjects on the schools syllabus (NCCA, 2012). The Department of Education and Skills (DES) (2011) state that they are not happy with Ireland's ranking in mathematics in comparison to other Organisation for Economic Co-operation and Development (OECD) regions. They maintain that there are many contributing factors to this such as the mathematics syllabus being too abstract and not relevant to real life and the world of work as well as rote teaching and learning occurring in Irish schools.

However, with the introduction of the Project Maths syllabus in 2010 and The National Strategy to Improve Literacy and Numeracy among Children and Young People 2011-2020[1], the DES hope to increase students' interest and achievement in mathematics. Project Maths is designed to be more interactive, investigative and relevant and the Project Maths Development Team (2011, p.1) state that "*students will develop skills in analysing, interpreting and presenting mathematical information; in logical reasoning and argument, and in applying their mathematical knowledge and skills to solve familiar and unfamiliar problems*". There are 2 state examinations in post-primary education in Ireland. The first examination is called the Junior Certificate and students sit this examination after 3 years of study at post-primary school. The second examination, called the Leaving Certificate, takes place after a further 2 years of study. There are 2 study levels in most subjects and 3 study levels in a small number of subjects, one being mathematics. The highest study level is higher level, the next study level is ordinary level.

[1] Hereafter The National Strategy to Improve Literacy and Numeracy among Children and Young People 2011-2020 will be referred to as 'The National Strategy'.

Foundation level is the lowest level of study. Project Maths is a compulsory subject for all students sitting both the Junior and Senior Certificate and can be studied at any of the 3 study levels.

The National Strategy (2011) outlines that schools need to develop both literacy and numeracy policies and that these working documents ought to be put into practice within their schools so as to advance students literacy and numeracy. They advocate that each school makes an effort to enforce the National Strategy by making further steps to ensure that each student leaves school literate and numerate.

This research plans to advance some of the recommendations of the National Strategy by creating a numeracy intervention that aims to improve the interest and achievement of students who struggle with numeracy and mathematics in general. This intervention focuses on the basic numeracy skills that students require to progress their learning of mathematics. There are 5 strands on the Project Maths syllabus and content from four of the five strands is studied in 1st year. Knowledge of the basic numeracy skills in each of these strands is vital for students' progression with their study of Project Maths. This intervention involves students working through a student handbook (Appendix A) containing numeracy material all relevant to the Project Maths syllabus, with an effort being made to embody content that is of interest to teenagers. Information and communications technology (ICT), board games and other hands-on resources are also used during this intervention. The author's plan for the delivery of this intervention is through peer tutoring, which involves a 1st year student working with a transition year (TY) student. Peer tutoring is a form of collaborative work whereby a tutor and tutee work together to improve the tutee's abilities in a specific area. Hislop and Lane (2015) explain that peer tutoring has the potential to improve tutees' learning experience and increases their belief in their abilities. Cohen et al. (2011) explains that while it has benefits for the tutee, the tutor also benefits due to the fact that they have to clearly communicate to their tutee and reflect on what they are doing.

This chapter outlines the background to the study, the aims of the study, the research questions this study aims to answer, significance of the study, the rationale for research, the purpose of the research, theoretical perspectives, research methodologies and the structure of the thesis.

1.2 Background to the Study

Prior to this research the author conducted research within her school, supported by the local education centre, with two of her colleagues. Together they identified the basic numeracy skills in each strand of the Project Maths syllabus such as being able to;

- apply the order of operations
- read time and timetables accurately
- understand the meaning of multiples
- factorise and work with prime numbers
- understand basic set theory
- convert fractions, decimals and percentages
- tally and use a frequency table
- decipher between different types of data
- create effective survey questions
- understand graphical representations of data
- understand the term outcome and be able to find the probability of an event occurring
- distinguish between, vertical horizontal and oblique lines
- distinguish between parallel and perpendicular lines
- measure angles
- understand and identify vertically opposite angles
- find the missing angle in a triangle
- read and plot co-ordinates on a Cartesian graph
- identify visual patterns and sequences, substitute into and simplify expressions and create and solve equations.

They then developed an academic test (Appendix B) which was given to 1st year students in post-primary school at the end of the academic year to identify strengths and deficits in their basic numeracy skills. The results of this test showed that many students failed to grasp the basic numeracy skills in each strand of the Project Maths syllabus. Similar problems were reported on a national and international level. Mac an Bhaird (2009) states that although the large majority of students pass their Leaving Certificate mathematics exam, a large number of students show many weaknesses in basic mathematical understanding and manipulation. Furthermore, he states that these weaknesses become very obvious in third level education. Sheridan (2013) agrees with Mac an Bhaird and explains that as a result of these poor basic mathematical skills many third level institutes offer support services in mathematics such as drop in centres and refresher courses to try and combat the problem. Rylands (2008) states that in Australia, the United Kingdom (UK) and the United States, third level institutes have a similar problem. Their students also lack the appropriate mathematical background to cope with their third level course content. Returning to the academic test taken by the 1st year students, the basic skills, which would have been visited already in primary school by these students', seemed to be difficult for them to grasp. The author could see that in order for these students to progress with their mathematics some intervention must occur.

The Leaving Certificate examination is the final state examination in post-primary education in Ireland. Mathematics can be studied at 1 of 3 levels in this examination, higher level, ordinary level or foundation level. Foundation level is the lowest level of study whereas higher level is the highest level. The National Council for Curriculum and Assessment (NCCA) (2006) outline that the subjects Irish and mathematics are the only subjects studied in post-primary schools in Ireland that offer students the option of sitting a foundation level examination in both the Junior and Leaving Certificate. This is giving students the option of studying mathematics at a very basic level and this option should be questioned considering many third level institutes do not accept the study of foundation level mathematics for many of its courses (NCCA, 2006). The ideal situation in post-primary schools is that as many students as possible study mathematics at the highest level. However, a large number of students in the author's school sit foundation level mathematics for their Leaving Certificate examination. The national figures from the SEC (2015) show that nationally 2.49% of students study foundation level at Junior Certificate level and 7.6% at Leaving Certificate level. These figures compare with 2.8% and 8.4% in the authors school for Junior Certificate and Leaving Certificate respectively. Deciding to study mathematics at foundation level is often due to the fact that students have failed to grasp the basic numeracy skills they need for the Junior Certificate which leaves them with a poor possibility of studying mathematics at a higher level. Smyth and McCoy (2011) explain that when students move from Junior to Senior Cycle they are more likely to drop study level in mathematics than in any other subject. In the long term if the basic numeracy skills are not grasped from early on, the student can't build on these skills through their Junior Cycle and onto the Senior Cycle.

With the introduction of the National Strategy (2011) schools must be seen to progress this strategy within their schools. It states that schools main responsibility is that each student leaves school literate and numerate. As a result of the author and her colleagues identifying deficiencies in many of their students basic numeracy skills as well as the high number of students studying foundation level mathematics in both the Junior and Leaving Certificate in their school, the school management encouraged the author to develop an intervention to improve these student's basic numeracy skills and advance the National Strategy. Management in the author's school hope that a knock on effect of this intervention will be a reduction in students sitting foundation level mathematics in future years.

1.3 Significance of the Study

A significant feature of this study is that it identifies areas of the Project Maths syllabus that students are struggling with and an intervention is developed that attempts to combat these struggles. As Project Maths is a relatively new initiative, this research is innovative. The intervention used is unique to this study as it has been compiled by the author. The test used in this study was created by the author and 2 of her colleagues and it is a unique research instrument to this study. As a result of both the intervention and the pre and post-tests, the findings of this study have the potential to inform other post-primary schools of strategies to employ in order to improve their students' interest and achievement in Project Maths.

Topping (2005, p.631) describes peer tutoring as "*the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions. It involves people from similar social groupings, who are not professional teachers helping each other to learn and learning themselves by so doing*". Peer tutoring is used regularly in developing students' literacy skills however the gap in the research is in the area of peer tutoring and numeracy. Peer tutoring has been proven to be an excellent strategy to improve literacy skills in students (Cassidy, 2008; Topping, 2002; Nugent, 2001) but there is very little work to prove its benefits in the area of numeracy. This area is awaiting research and development and this study contributed to the area of peer tutoring in mathematics.

1.4 Rationale for Research

The author is a qualified mathematics teacher who has also completed a postgraduate diploma in special educational needs (SEN). In both her main stream teaching and her work with small groups of students with numeracy difficulties she has encountered many students who struggle with mathematics and have little interest or success in the subject. Through a previous project with colleagues, the author identified specific areas of Project Maths that students struggle with. The author also worked with a colleague from the SEN Department to facilitate a literacy intervention to 1st year students who had difficulty with literacy. This intervention involved TY students peer tutoring 1st year students. Seeing the success of this intervention and the merits of peer tutoring the author saw the potential in developing a numeracy intervention to allow 1st year students to improve their interest and achievements in mathematics.

1.5 Project Overview

This research involves 1st year students working with TY students to improve their interest and achievement in mathematics. The author uses peer tutoring with TY students as a strategy to deliver this numeracy intervention to 1st year students. Peer tutoring has been proven to be an excellent and cost efficient way of improving student's interest and achievement in a given area. The author found that students retained interest when learning from a peer tutor and found it more enjoyable than learning from their subject teachers (Goodlad, 1995). The tutor also benefits as their communication skills and subject knowledge improve (Goodlad, 1995). Nugent (2008) outlines that same sex pairings of tutor and tutee work best so the author followed this approach. Person and Graesser (1999) outline that training the tutors in advance of the intervention is integral to its success so the author put aside several weeks of the intervention to train the TY tutors. This involved them working through the student handbook with the aid of the author (intervention facilitator) and a tutor handbook (Appendix C) and answer booklet (Appendix D).

1.6 Aims, Hypothesis & Research Questions

In conducting this research the author's main aim is to develop a successful numeracy intervention that improves 1st year students' interest and achievements in mathematics. The author outlines the approach taken in order to achieve the research aim;

- Conduct a literature review to investigate the issues facing numeracy and mathematics both nationally and internationally, develop an understanding of how to raise interest and achievement amongst students and to develop an understanding of the best way to use peer tutoring as a research instrument.
- Decide on the research methodologies and framework to be used in this study.
- Design and implement a numeracy intervention that will be taught through peer tutoring.
- Collect quantitative and qualitative data to enable analysis of the success of the intervention.

As discussed previously, research suggests that peer tutoring improves students' interest in a subject area and improves the learning of both tutors and tutees. The author therefore hypothesises that a numeracy intervention using peer tutoring as the delivery method will improve students' interest and achievement in mathematics. With this in mind, 3 research questions guided this project.

The following 3 research questions evolved as a result of conducting the literature review;

1. Will 1st year students' interest and achievement in mathematics improve after a numeracy intervention has been implemented?

2. Is a numeracy programme and peer tutoring, together, an effective type of intervention to achieve an improvement in students' mathematical abilities?

3. Will there be an improvement in the tutees' interest and achievement in mathematics?

1.7 Theoretical Perspectives

The author plans to raise interest and achievement in numeracy amongst a group of 1st year students in her school. The theoretical framework (see Figure 1.1) below was designed by the author and provided a framework which guided the development of the intervention and all associated materials.

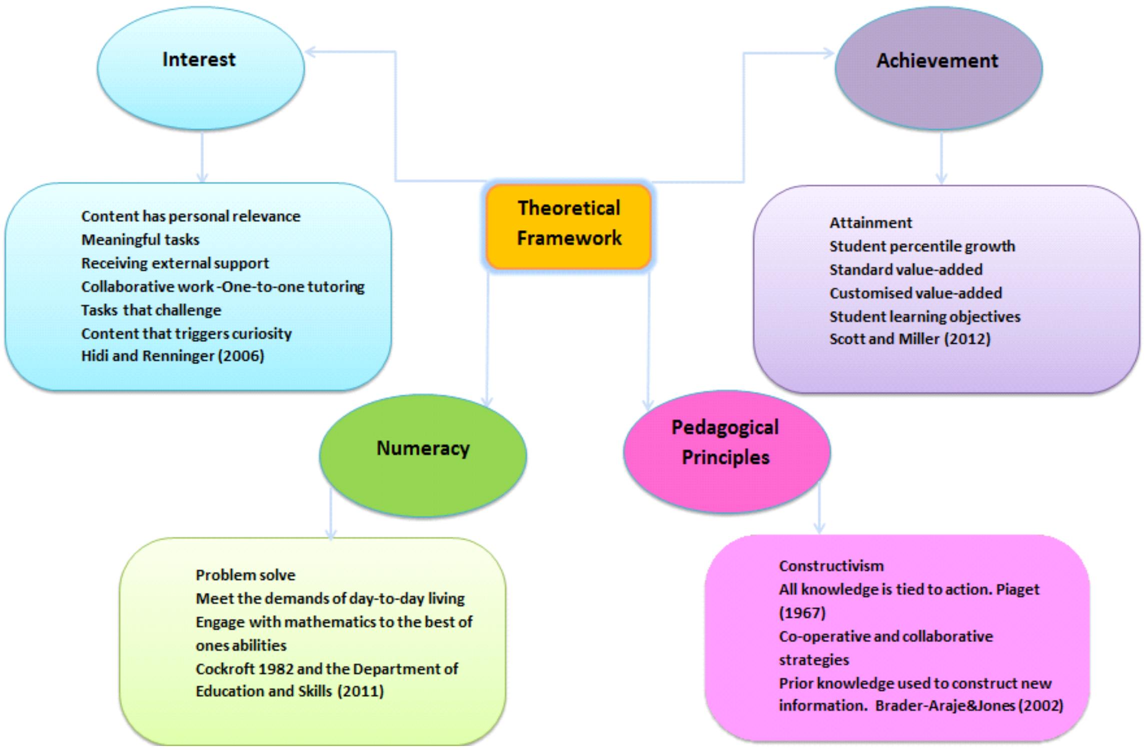


Figure 1.1: Theoretical Framework

This framework outlines the main concepts that are relevant to this study, i.e. numeracy, interest, achievement and constructivism. The author developed her own definition of numeracy based on Cockroft's (1982) and the DES (2011). This definition of numeracy involves students being able to problem solve, meet the demands of day-to-day living and engage with mathematics to the best of ones abilities. In order to achieve this, students must develop an interest in numeracy and mathematics. To increase students' interest in a subject area Hidi and Renninger (2006) state that the content must have personal relevance and be meaningful to the students. The author aims to make all the content in the student handbook both relevant and meaningful to teenagers in the hope of triggering and maintaining their interest. This content follows the constructivist approach outlined by Piaget (1967) and Brader–Araje and Jones (2002) by using prior knowledge to construct new information as well as using co-operative strategies to increase student engagement. The tasks must also challenge the students and trigger their curiosity and these features will occur through the different tasks in the student handbook. To measure achievement Scott and Miller (2012) outline an increase in attainment must be assessed, value added must be apparent and learning objectives must be achieved. This will be done through the use of a pre and post academic test and an attitudinal survey[2] (Appendix E).

The theoretical framework will be discussed in greater detail in Section 3.4.2

1.8 Research Methodology

The research instruments used in this study are a pre and post academic test, an attitudinal survey and focus groups. The academic test involves questions on concepts and skills and contexts and applications. There are questions on each of the 4 strands that the students will have worked on during the intervention. The survey comprises of questions on students interests and achievements in mathematics. The pre and post-test used for this study are identical. There are 2 focus groups, one comprised of 1st year students from the test group and the other made up of the TY group of students. The data gathered from this study is both quantitative and qualitative. Quantitative research generates numerical data whereas qualitative research generates data that gives an understanding of its samples opinions, beliefs and motivations. There are merits to both quantitative and qualitative research. Theam-Choy (2014) states that the main benefits of conducting quantitative research is that it can be administered and appraised quickly and comparisons and contrasts between data can be made easily while qualitative research involves open ended questioning and the data collected gives a deeper scope into the samples attitudes and opinions. As both types of research have positive attributes the author decided to adopt a mixed method approach in this research. Driscoll et al. (2007) state that methodology triangulation strengthens research and offsets any weakness that one type of research may have. This study is undertaken in the form of action research. Nolen and Vander-Putten (2007) outline that action research is ideal for use in an educational setting where it lends to teachers reviewing

[2] Hereafter the academic test will be referred to as the test and the attitudinal survey will be referred to as the survey.

their own teaching and their students learning. This allows teachers to gain a deeper knowledge of their area of research and attempt to make improvements where necessary.

Phase 1 of this project will involve desk research. Desk research will form the basis of the literature review. Through doing this the author will gain a deeper understanding of how best to conduct her project as she will have developed a deeper understanding of the pertinent issues and how to tackle them most effectively. From this she can thoroughly plan her intervention. Phase 2 involves developing the intervention. Phase 3 is when the intervention is piloted. Phase 4 involves editing the intervention and collecting qualitative and quantitative data. Firstly the TY, peer tutor students and control group students will be identified. TY students will sit the test and then fill in a survey on their attitude towards numeracy. The TY students will undergo training from the author/intervention facilitator, whereby the contents of the intervention will be thoroughly worked through. Phase 5 is when the 1st year students take the test and survey. After this, peer tutoring will take place. During Phase 6 all students are re tested and a focus group discussion will be facilitated. Phase 7 is when results will be analysed using SPSS.

1.9 Limitations of this Study

There were a number of limitations identified in this study. To begin, the study took place in 1 school, the school in which the author works in. As a result, the sample taken for this study is from a small population. Furthermore, the school timetable allowed the tutor/tutee pair to meet just once a week and so the intervention was relatively short. The mainstream class teaching the students received throughout the first term of 1st year may also contribute to an increase in each students' proficiency in the post intervention test. Both the control and test group are being taught mathematics outside of the intervention which may have some impact on data gathered. However, this is the same for both the control group and the test group so any discrepancies recorded can be attributed to the intervention. However, the control group will not have studied some of the test content since the previous year which will have to be considered when analysing the test findings. Students from the test group all come from different base classes so as a result many of them have different mathematics teachers. The control group are all from the one base class and they have the same mathematics teacher, however this teacher is a different teacher to all the other base classes. The impact different teachers can make to students' interest and achievement can vary so the different mathematics teachers involved in teaching both the test group and the control group is a limitation to this study. Finally, the sample size for this study could be no larger than 30 due to timetable constraints and classroom size. The larger the sample size, the more likely it is that the results would reflect the entire population.

1.10 Structure of the Thesis

This thesis consists of t chapters. A brief outline of each chapter is given below.

- Chapter 1 – Introduction: This chapter gives an overview of the study, stating how the idea for this research was generated, its significance, aims and purpose.

- Chapter 2 – Literature Review: Chapter 2 discusses all the literature pertinent to this research. Numeracy is defined and issues in relation to mathematics both nationally and internationally are discussed. Interest and achievement are analysed, in particular in relation to mathematics. Project Maths is examined and merits and demerits of peer tutoring are outlined. A discussion surrounding the educational theory of constructivism concludes this chapter.

- Chapter 3 – Methodology: This chapter outlines the design of this study and the theoretical framework of the study. Action research is explained and the importance of validity, reliability and triangulation of data is established. The research instruments are discussed.

- Chapter 4 – Intervention Design and Implementation: An outline is given on how the intervention was designed and how it was implemented. An in-depth analysis of the content and format of the student handbook is provided. Finally, any problems encountered with implementation of the intervention are discussed.

- Chapter 5 – Research Findings: The findings from the data analysis are presented and are analysed using Shapiro’s (1981) model for intervention evaluation.

- Chapter 6 – Discussion of Research Findings: Detailed discussions of findings, guided by the research questions, are discussed in relation to national and international literature.

- Chapter 7 - Conclusions, Contributions, Recommendations and Further Research: Final conclusions are drawn from the research. Its contribution is discussed and limitations to the study are examined. Recommendations are then made for future research.

1.11 Conclusion

The aim of this chapter is to outline why this study is taking place, how it is taking place and what the author hopes to achieve. Chapter 2 consists of a literature review which will inform the design and implementation of this research.

Chapter 2
Literature Review

2.1 Introduction

The purpose of this chapter is to examine and discuss the area of numeracy particularly in relation to interest and achievement amongst post-primary students. It will firstly explore the various definitions of numeracy in the literature and clarify the author's stance on numeracy in relation to this research. Issues facing mathematics education both nationally and internationally will be discussed. The impact of the recent introduction of the Project Maths syllabus in Ireland is highlighted and discussed. 'Interest' will be explored and the relevance of different types of interest in relation to mathematics education will be analysed. The author is also concerned with achievement levels of students in mathematics education so this issue will also be investigated. Due to its known benefits, peer tutoring is an important methodological aspect of this research so it is discussed and evaluated. Educational theories will also be researched, in particular constructivism. Finally, the summary conclusion will collate the literature review and will direct the research, particularly the methodologies employed in order to address the research questions.

2.2 Definition of Numeracy

There are many definitions of the term 'numeracy' in education. This implies that this term can be subjective. O' Donoghue (2002, p.48) identifies aspects of numeracy as "*Basic computational arithmetic, essential mathematics, social mathematics, survival skills for everyday life, quantitative literacy, mathematical literacy and an aspect of mathematical power*". The Programme for International Student Assessment (PISA) (2012, p.2) uses the term "*mathematical literacy*" and defines it as

> "*An individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists*

individuals to recognise the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens."

Numeracy is defined by PISA (2009, p.14) as

> "*An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen*".

Probably the most famous definition of numeracy is given in the work of Cockroft (1982, p.11). He states:

> "*We would wish 'numerate' to imply the possession of two attributes. The first of these is an 'at-homeness' with numbers and an ability to make use of mathematical skills which enable an individual to cope with the practical mathematical demands of his everyday life. The second is ability to have some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease*".

While O' Donoghue (2002) points out that Ireland has no one definition for numeracy the recent report by the DES offers their own definition of numeracy. In 2011, the National Strategy was developed in order to address issues facing mathematics education in Ireland. The National Strategy defines numeracy as "*the ability to use mathematics to solve problems and meet the demands of day-to-day living*" (DES, 2011, p.8).

Although all these definitions are accurate in their own right, the author ascertains that aspects of these national and international definitions of numeracy should be emphasised for the purpose of this study. Hence for this research study, the author focuses on attributes of numeracy such as the ability to use mathematics to solve problems, meet the demands of day-to-day living and engage with mathematics to the best of ones abilities. This emphasis is a combination of that used by the DES (2011) and the Cockroft Report (1982) and is one that the author of this study deems best suited to the study in question. Ensuring every student is numerate is a challenge however, with many issues facing mathematics education both in Ireland and Internationally.

2.3 Issues Facing Mathematics Education Nationally

Smith (2004) explains that mathematical ability is necessary in order for people to be equipped with the skills necessary to conduct both their private and work life and outlines that a basic level of mathematics skills are required for all types of employment. He explains that it is the foundation of many areas such as science, engineering, modern business and industry. From the introduction of the National Strategy (2011) it is apparent that the Irish Government are aware that many students are under performing in the area of mathematics and in particular in the area of numeracy. Even though the Government acknowledges the importance of numeracy skills, many students leave Ireland's education system with poor levels of understanding in this area (DES, 2011). This is of great concern in particular because it has been proven that there is a direct link between student performance in cognitive tests and Gross Domestic Product Growth of a country. According to McDonagh & Quinlan (2012, p.3), "*small improvements in mathematical skills of a nation's labour force can have very large impacts on future economic well-being*". Other countries in the OECD realise the importance of having a workforce with good mathematical skills and understand that a proficiency in mathematics can have a huge impact on an employee's earnings (Murnane et al., 1995). In comparison to other OECD countries, less tuition time is given to mathematics in Irish schools which McDonagh & Quinlan (2012) argue could be one of the reasons to blame for students leaving post-primary education without the fundamental numeracy skills. If the Irish Government wants an improvement in students' mathematical abilities the tuition time given to this subject needs to be considered, including innovative ways of increasing tuition time. There are many areas that warrant discussion in mathematics education nationally such as PISA performance, The National Strategy, mathematics teacher qualifications, Project Maths, time afforded to mathematics in schools, uptake of higher level mathematics and subject choice and gender issues. All of these issues facing mathematics education nationally will be discussed, beginning with Ireland's performance in PISA.

2.3.1 PISA Performance

PISA is an assessment conducted with 15 year olds in 65 countries every 3 years. It assesses students' competencies in the key subject areas of reading, science and mathematical literacy. Every 3 years its main focus is one of the 3 areas, with a minor focus on the other 2. Mathematical Literacy was the main focus in 2003 and 2012. The assessment has 6 levels. Cosgrove et al. (2004) states that in PISA 2003, while not significantly so, Ireland's performance in mathematics was just above the OECD average. The OECD average in 2003 was 499.6 with Ireland score being 505.4. However, Cosgrove et al. (2013) found that in PISA 2009, Irish students' performance in mathematics was significantly lower in comparison to the OECD average. PISA 2012 showed an improvement whereby Irish students' performance in mathematics has risen to above average. The mean score for Ireland was 501.5, compared with an OECD average of 494. From Figure 2.1 below, it is clear to see that although Irelands score is above average and better than its 2009 score, it is very similar to its 2003 and 2006 scores so therefore it can be said that no significant improvement has been made since 2003. Cosgrove et al. (2013) found that although it is positive that Ireland's performance has not decreased between 2003 and 2012 there has been a decline in many of the other OECD countries scores between 2009 and 2012 so this could have contributed to Ireland's improved ranking from 2009.

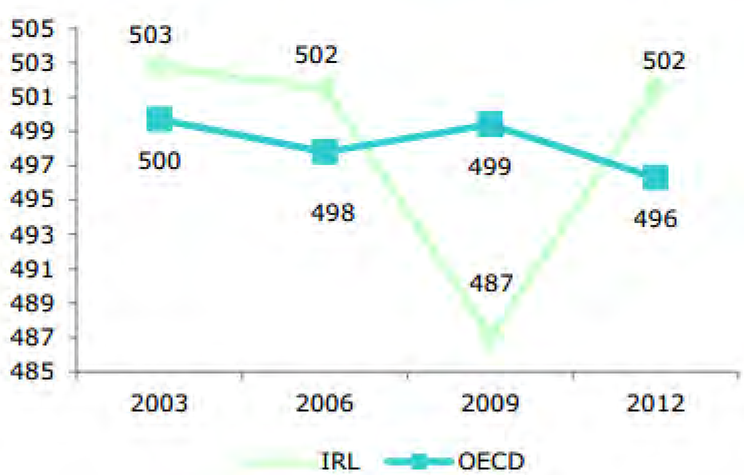


Figure 2.1: Irelands Mean Score in Comparison to other OECD Countries in PISA Mathematics 2003 - 2012. Source: Educational Research Centre

From PISA results it is clear that no major improvements have been made in Ireland's overall performance in mathematics since 2003. From the DES's (2013) in-depth analysis of PISA 2012, it was found that Irish students performed best in the area 'uncertainty and data', they performed less well in this area in comparison to 2003. Irish students performed poorly in the area 'space and shape', which is also observed as the main area which many other countries perform poorly in. Although no significant improvements in Ireland's overall performance has been recorded, DES (2013) credit the impact of the National Strategy and Project Maths with sustaining Ireland's performance. They also acknowledge that the Irish students who will partake in PISA 2015 will have studied Project Maths since 1st year so some of the impact of this initiative will be evident in the PISA 2015 results. They also acknowledge their ongoing commitment to both initiatives. They promise careful monitoring of the implementation of Project Maths, with a major focus on space and shape reasoning. They also promise to carefully monitor cross curricular emphasis of mathematics as outlined in the National Strategy. This amongst other details of the National Strategy will now be discussed.

2.3.2 The National Strategy

Over the past few years, the Irish Government has developed many strategies to tackle the fact that students are under performing. The National Strategy (2011) requires all students to leave school numerate and highlights the fact that "*literacy and numeracy are among the most important life skills that our schools teach. No child should leave school without having mastered these skills to the best of their abilities*".

The main issues outlined by the National Strategy (2011) are improving the curriculum and learning experiences, improving assessment and evaluation to support better learning in numeracy, helping students with additional learning needs to achieve their potential and improve the abilities of Principals and Deputy Principals to lead improvements in literacy and numeracy. Within these parameters the aims are to promote more positive attitudes towards mathematics, ensure that schools set goals and strategies that aim to improve students numeric and mathematical abilities and monitor progress to achieve improvements, assess the performance of students at the end of second year, improve PISA results and increase the percentage of students taking higher level mathematics in both the Junior and Senior Cycle. The strategy outlines each objective, details of what needs to be achieved, identifies who is responsible for realising each objective and states the approximate date that plans need to be put in place in order to achieve these objectives. The fact that the strategy is so detailed and is specific, measurable, achievable, realistic and timely offers hope for improvements in Irish students' mathematical performance in the future. These targets, if realised, could lead to a significant improvement nationally in both interest and achievement in mathematics by 2020. These targets are ambitious yet achievable. The DES (2011) details that schools need to be creative with time and resources and develop interventions that can achieve the National Strategies targets.

The main areas of reform in the National Strategy relate to improving teacher qualifications and changing the school curriculum.

2.3.3 Teachers of Mathematics

There are currently many issues surrounding mathematics teachers' qualifications in Ireland. One of the first issues recognised is the discrepancy of entry requirements onto primary education teacher training courses. Irish, English and mathematics are all core subjects in the primary school curriculum however the entry requirement for mathematics is lower than the other two core subjects. The minimum entry requirements, as set out by the DES, state that in Irish a minimum of a C3 in higher level is required. In English a minimum of a D3 in higher level or C3 in ordinary level is necessary, however in mathematics a D3 in higher or ordinary level is adequate. McDonagh and Quinlan (2012) state that such requirements imply that literacy is more important than numeracy. The statistics show that of those who enrol on a primary teacher training course, 95% have honours in English and 35% have honours in mathematics. This difference could have an effect on how mathematics and numeracy is taught in the primary school as well as the mathematical interest developed in students in Irish primary schools. McDonagh and Quinlan (2012) explain that mathematicians often perform their most original work at a young age. As all primary teachers have to place a strong emphasis on mathematics in the primary curriculum, it is important that each teacher has a positive relationship with mathematics themselves in order to develop the same in their students. McDonagh and Quinlan (2012) further highlight the fact that students standard of education is dependent on the quality of the teachers.

Prior to the introduction of the Numeracy Strategy, Engineers Ireland (2010) conducted an investigation into mathematics and science education at second level. Their research at that time found that approximately 25% of mathematics teachers in Ireland have a degree in mathematics with more having studied mathematics to degree level yet their degree is not a mathematics degree. Ní Ríordáin and Hannigan (2009) conducted their own study which involved 324 post-primary mathematics teachers. 48% of the teachers that they surveyed were not qualified to teach mathematics. Of those teachers who were not qualified to teach mathematics, 35% (55 teachers) had a B.Sc. primary degree without a substantial amount of mathematics studied, 34% (53 teachers) had a B. Commerce/Business primary degree, again without a substantial amount of mathematics studied and 27% (42 teachers) had a teacher education degree which did not involve any mathematics. From the 168 teachers who were deemed qualified to teach mathematics, 73% had a BA/B.Sc. with a primary degree in mathematics, 14% had a mathematics teacher education degree and 11% had a B.Sc. primary degree with a large mathematics component throughout. The older teachers of mathematics tended to be more qualified with 65% of those over 35 being qualified in comparison to 40% of those under 35. Teachers qualifications in the subject area in which they teach is linked to students achievements in that subject area with Metzler and Woessmann (2010) stating that in research they conducted with the University of Munich on the impact of teacher subject knowledge on student achievement, they found a significant link between teachers subject knowledge and their students achievements in that subject. This outlines the importance of teachers of mathematics to be qualified to teach mathematics in order for students to achieve their potential in the subject area. In March 2006, the Teaching Council was set up in Ireland. The Teaching Council (2011) aims to regulate and monitor the teaching profession and teachers, as well as advocate the continuing professional development of teachers. They outline that in order to become registered to teach a subject, that subject must be studied up to the third year or above of a degree programme and all relevant examinations must be passed or a post graduate diploma in mathematics must be studied. A teacher training qualification is also required. From the research discussed earlier by Engineers Ireland (2010) and Ní Ríordáin and Hannigan (2009) it is very apparent that a large number of unqualified teachers teach mathematics. This is mentioned in the National Strategy as an area that needs to be addressed.

Engineers Ireland (2010) explains that in recent years NUI Galway introduced a 4 year Bachelor of Arts in Mathematics and Education which specialises in both mathematics and applied mathematics. They further state that the University of Limerick opened a National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) in June 2009. NUI Maynooth, now offer a Master of Science in mathematics and education for those who have not studied mathematics to degree level. However it was also seen as necessary to up skill teachers who already teach mathematics and are not qualified to do so. NCE-MSTL (2014) state that they won a tender by the DES in 2011 to create and deliver a post-graduate diploma in mathematics for teaching, free to post-primary teachers of mathematics who are not recognised by the teaching council to teach mathematics. This course is 2 years in duration and has approximately 300 participants. They further explain that the course took its first enrolment in September 2012, with a second group enrolling in 2013, a third in 2014 and a fourth in 2015. 288 graduated in the first cohort and 230 are expected to graduate in 2016. McDonagh and Quinlan (2012) state that the aim of this course is to improve the quality of teaching in Irish post-primary schools. Although recent figures released by the Teaching Council (2015) outline that there are less qualified mathematics teachers in schools than there are English teachers, 5,443 and 8,015 respectively, this is an improvement on previous years and is set to increase with the graduation of students from the aforementioned courses. Another current issue gaining media attention is a discussion around incentives to encourage mathematics graduates into teaching. Professor Ted Hurley, Department of Mathematics, NUIG, maintains that offering a training bursary to encourage the best maths graduates into teaching should be introduced and states that this is common practice in other countries, for example, the UK. (http://www.irishtimes.com/news/education/call-to-pay-maths-graduates-bonus-to-go-into-teaching-1.2062310). He points out that incentives are offered in other areas to encourage mathematics graduates so it should also be done in education. These are all positive steps towards ensuring that teachers of mathematics in Ireland are fully qualified to teach the subject which in turn should have a positive effect on students' achievements in mathematics.

As well as improving mathematics teacher's qualifications which in turn should raise student's achievements in the subject, another main area of reform to mathematics education in Ireland is the introduction of Project Maths.

2.3.4 Project Maths

One of the most significant changes in mathematics education in Ireland in recent years is the introduction of Project Maths. After years of consultation and analysis which included comparing mathematics education in top performing countries, the DES introduced Project Maths, a revised post-primary mathematics syllabus. Project Maths came about after many years of discussion about the problems with the teaching and learning of mathematics in Ireland. These problems were made clear by reports by Lyons et al. (2003), Conway and Sloane (2005) as well as Chief Examiner's reports in mathematics and PISA assessments. All these sources combined revealed a lack of basic understanding of mathematical concepts amongst Irish students. This prompted action from the NCCA which evolved into what is now known as Project Maths (Cosgrove et al., 2012). This syllabus was developed prior to the publication of the National Strategy for Literacy and Numeracy but the aims and objectives are similar in both. This recent change in the Irish post-primary school mathematics syllabus was developed with the hope of positively affecting interest and achievement in students. Jeffes et al. (2012) states that the aim of Project Maths is to develop students interest in mathematics and promote students to think creatively about the way mathematics can be used.

Project Maths Summary

The introduction of Project Maths involved the transformation of the post-primary mathematics curriculum in Ireland. Not only has the course content changed, but the way that students are taught and assessed has also been reformed. McDonagh and Quinlan (2012) state the new curriculum focuses largely on developing student understanding of mathematical concepts and using contexts and applications that relate to real life in the hope of developing student's problem solving abilities. Cosgrove et al. (2012, p.7) identifies one of the key ideas around Project Maths to be "*a greater emphasis on an investigative approach, meaning that students become active participants in developing their mathematical knowledge and skills*". This means that not only will the changes be in the mathematics syllabus but there will also be significant changes in the approaches to teaching and learning. With the introduction of the Project Maths syllabus, the DES hope to increase students' interest and achievement in mathematics as the new course is designed to be more interactive, investigative and relevant. The Project Maths development team (2010, p.2) state that "…*students will develop skills in analysing, interpreting and presenting mathematical information; in logical reasoning and argument, and in applying their mathematical knowledge and skills to solve familiar and unfamiliar problems*". Merriman et al. (2014) explain that Project Maths was first piloted in 2008 in 24 schools and it is now implemented in all post-primary schools in Ireland.

There are 5 strands in the Project Maths syllabus: statistics and probability; geometry and trigonometry; number; algebra and functions. Cosgrove et al. (2012) states that one of the differences between the old syllabus and Project Maths is that some areas of the old course have been removed, e.g. vectors and matrices, some areas have been de-emphasised, e.g. calculus and linear algebra, and a greater emphasis has been made towards statistics and probability. A benefit of Project Maths is the bridging framework which has developed between the maths syllabus in 5^{th} and 6^{th} class of primary school and 1^{st} year of secondary school. This framework "maps" content in the primary curriculum to the Junior Cycle curriculum thus making the transition to post-primary mathematics easier for students. A Common Introductory Mathematics Course for 1^{st} year students has also been introduced for all 1^{st} year students. As a result, all 1^{st} years are taught the same course content regardless of the level at which they intend to study mathematics at (Cosgrove et al., 2012).

Boaler (1998) conducted a case study on alternative mathematical teaching approaches and compared the knowledge acquired by students who were taught in the traditional way in comparison to those who were taught using open-ended activities. Those who were taught in the traditional way developed procedural knowledge which they could not apply to different situations. This contrasts with those who were taught using open-ended activities as these students developed a deeper understanding and could apply their knowledge acquired in different contexts. Students' opinions on both teaching strategies also contrasted greatly. Boaler (1998, p.52) states that the traditionally taught students' comments largely described their "*lack of understanding and their dislike for text books*" while those taught using open ended activities comments were mainly concerned with "*the interest in lessons and their enjoyment of open-ended work*". These findings bode well for Project Maths as its ideals are to move away from rote learning and develop conceptual understanding in students.

Impact of Project Maths to Date

The author compared the number and percentage of Junior and Leaving Certificate students who studied each level of mathematics in 2010 to the number and percentage who studied each level in 2015. She also compared the Junior and Leaving Certificate pass and fail rate in 2010 to that in 2015. The data obtained from the State Examinations Commission (SEC, 2015) is displayed in Table 2.1 and Table 2.2 below.

Junior Certificate Mathematics				
	2010	**% Fail**	**2015**	**% Fail**
Higher Level	24,840 (44.93%)	4.2	32,535 (55.26%)	4.2
Ordinary Level	25,853 (46.76%)	7.2	22,854 (38.82%)	5.9
Foundation Level	4,597 (8.31%)	3	3,485 (5.92%)	3.2
Total	55,290		58,874	

Table 2.1: A Comparison of 2010 and 2015 Junior Certificate Mathematics Level Uptake and Failure Percentage.

In comparing the uptake of mathematics in the Junior Certificate from 2010 and 2015 (see Table 2.1) an increase of just over 10% in the number of students studying higher level is evident. As discussed in Section 2.3.2., the National Strategy's aim is to have 60% of Junior Cycle students studying higher level mathematics by 2020. If the trends in uptake from 2010 to 2015 continue, then the National Strategy's aims are achievable. The failure rate is the same in 2010 as it is in 2015. From Table 2.1, there is a noticeable decrease in the number of students studying ordinary and foundation level in Junior Cycle. Also of importance is the fact that the failure rate in ordinary level has decreased and in foundation level the failure rate is almost the same, with an increase of 0.2%.

Leaving Certificate Mathematics				
	2010	**% Failure**	**2015**	**% Failure**
Higher Level	8,390 (16.05%)	3.6	14,691 (27.42%)	5.2
Ordinary Level	37,903 (72.49%)	9.7	33,266 (62.10%)	5.3
Foundation Level	5,997 (11.47%)	4.8	5,613 (10.48%)	5.9
Total	52,290		53,570	

Table 2.2: A Comparison of 2010 and 2015 Leaving Certificate Mathematics Level Uptake and Failure Percentage.

In comparing the uptake of mathematics in 2010 and 2015 in Leaving Certificate, an increase in the number of students studying higher level is also evident. The increase of just over 11% means that the uptake of higher level mathematics in Leaving Certificate is less than 3% away from the National Strategy's target. With that, there is a noticeable decrease (10%) in the percentage studying ordinary level and a small decrease in the percentage studying foundation level. The failure rate at ordinary level has decreased although it has increased at higher level and foundation level by 1.6% and 1.1% respectively.

Merriman et al. (2014) conducted research for the Educational Research Centre comparing the PISA performance of students in the initial Project Maths (IPM) schools that piloted the curriculum and those in the non-Project Maths (NPM) schools as well as comparing attitudes towards mathematics. Students studying the Project Maths curriculum were rated as being more familiar with the concepts, content, and processes of PISA items at all syllabus levels than students studying the pre-Project Maths curriculum. Students in the IPM schools were far more comfortable with PISA's style of questioning which, like Project Maths, often contains a large amount of written text. Students in the IPM schools reported using group work and computers more than students in NPM schools and students in IPM schools also commented on the use of real life situations in their mathematics school work. Cosgrove et al. (2012) compared the old Junior Cycle syllabi with the PISA mathematics framework and they found a difference in the content between the two. The main concepts and contexts used in PISA mathematics were not familiar to the Junior Cycle students who studied the old mathematics course. This difference was also noted to be evident between the PISA assessment and the Junior Certificate examination. Having discussed the impact that Project Maths is having on students study level and performance another area to consider is teachers' perceptions of Project Maths.

Teachers Perceptions of Project Maths

One challenge facing Project Maths as recognised by Merriman et al. (2014) is that teachers do seem reluctant to embrace this change in curriculum. A survey conducted by Engineers Ireland (2012) on teacher's opinions of Project Maths yielded many outcomes. When asked if teachers think that Project Maths will improve student's achievement in mathematics, 57.5% said no. Reasons given were that the course is not easier, content contains too many words and also that there were not enough resources to implement the curriculum. Another concern raised was that the course itself is now longer and that teachers will have to rush through it in order to complete it. If Project Maths is to achieve the improvements in post-primary students' interest and achievement in mathematics that it aspires to, teachers of mathematics need to adapt their teaching so as to embrace the Project Maths curriculum. Cosgrove et al. (2012) conducted research into the teaching and learning of Project Maths and surveyed teachers' views on Project Maths at Junior Cycle. Much of the data collected however proved inconclusive which suggests that it may be too early to gain a real insight into its success or lack thereof. The first Interim Report on Project Maths Research investigated the impact of Project Maths on student achievement, learning and motivation by Jeffes et al. (2012) and it again found that not enough time had passed to be able to find any significant increase in mathematical ability to date. However Jeffes et al. (2013) found that a lot of progress has been made in the implementation of Project Maths. They state that in their research they identified excellent practice of teaching and learning in the Project Maths classroom and positive reports of students attitudes towards and achievement in mathematics.

In PISA 2015 we should begin to see the impact of Project Maths on Ireland's ranking and this should give an indication as to the success or failure of this initiative. Another factor to consider in mathematics education in Ireland is the time afforded to the subject, which will now be discussed.

2.3.5 Time Allocated to Mathematics

The National Strategy (2011) details that the amount of time allocated to Mathematics at both primary and post-primary level be increased. From January 2012, DES (2011) increased the amount of time allocated to mathematics in primary schools by 70 minutes. This now sees 3 hours and 25 minutes per week afforded to mathematics among infants (4 to 6 year olds) and 4 hours and 10 minutes per week to older students in primary school (6 to 12 year olds). Engineers Ireland (2010) suggested that a minimum of one class per day be allocated to mathematics teaching in second level. This seems to be the minimum allocation in all schools' however the amount of time allocated varies from school to school (Prendergast and O'Meara, 2015).

Post-primary schools are required to allocate 330 hours to mathematics over the academic year (http://www.JuniorCycle.ie/Info/FAQs/What-time-should-be-allocated-to-English,-Gaeilge). The current Project Maths syllabi states that 240 hours ought to be allocated to the Junior Certificate mathematics course. The Leaving Certificate Project Maths syllabus indicates that 180 hours be allocated to the course. Schools are allowed to allocate the extra hours in ways that will promote numeracy amongst its students. Having these extra hours to afford to numeracy in schools, many schools allocate some of this time to increasing tuition time in mathematics which is encouraging for students studying these subjects, particularly at higher level. The author will now discuss the uptake of higher level mathematics in post-primary schools in Ireland.

2.3.6 Uptake of Higher Level Mathematics.

The author examined the uptake of higher level mathematics in comparison to the 2 other compulsory subjects on the curriculum, Irish and English to see if there is a greater interest in studying these subjects at a higher level. If a difference in the level studied in each of these subjects is identified then it is important to examine reasons for this difference. Figure 2.3 overleaf shows the percentage of students who sat higher, ordinary and foundation level mathematics in the Junior Certificate from 2012 to 2015. The lowest percentage of students sat the higher level paper in mathematics compared to the other two subjects in each of the 3 years analysed with a difference of almost 20% between mathematics and English each year. With the lowest percentage uptake, the higher level paper also has the highest percentage failure each year. Furthermore, the foundation level mathematics paper is sat by a greater percentage of students than the Irish and English foundation level papers. A positive to take from these statistics is that the number of students who are taking the higher level mathematics paper has increased considerably since 2012 and the number taking the ordinary and foundation level papers has decreased. Although the failure rate at higher level has increased, this increase is less than the percentage increase in uptake. The National Strategy (2011) states that one of its aims is to have 60% of Junior Certificate students taking the higher level paper by 2020, which, if trends continue, seems to be an achievable goal.

Junior Certificate	Irish (% Fail)	English (% Fail)	Mathematics (% Fail)
2012 Higher	51.38 (2.3)	71.63 (1.5)	48.07 (2.8)
2013 Higher	52.62 (2.4)	73.13 (2.1)	51.62 (3.3)
2014 Higher	54.29 (2.3)	74.75 (2.2)	53.74 (4.5)
2015 Higher	59.97 (1.2)	75.12 (1.9)	55.26 (4.2)
2012 Ordinary	45.32 (2.9)	25.84 (1.8)	44.68 (6.7)
2013 Ordinary	44.71 (3.8)	24.69 (1.4)	41.78 (5.2)
2014 Ordinary	43.27 (4.1)	23.30 (1.7)	40.33 (4.6)
2015 Ordinary	41.69 (3.9)	23.09 (2.0)	38.82 (5.9)
2012 Foundation	3.30 (3.4)	2.53 (5.5)	7.25 (3.0)
2013 Foundation	2.67 (4.0)	2.18 (3.8)	6.60 (2.7)
2014 Foundation	2.49 (4.2)	1.95 (4.5)	5.92 (3.1)
2015 Foundation	2.34 (4)	1.79 (6.4)	5.92 (3.1)

Table 2.3: Summary of Percentage of Students Sitting Junior Certificate Core Subjects in Each Level from 2012 – 2015 and Percentage Failure Rate. Source: (www.examinations.ie)

A similar pattern is visible in the Leaving Certificate (final state examination in post-primary school). Table 2.4 overleaf, shows the percentage of students who sat each level paper in the Leaving Certificate from 2012 to 2015.

Leaving Certificate	Irish	English	Mathematics
2012 Higher	37.09 (0.7)	65.25 (1.8)	22.07 (2.3)
2013 Higher	38.18 (0.4)	65.48 (1.6)	25.59 (3.3)
2014 Higher	40.06 (0.6)	67.19 (1.3)	27.35 (4.5)
2015 Higher	41.80 (0.5)	67.89 (1.2)	27.42 (5.2)
2012 Ordinary	53.24 (4.3)	34.75 (3.7)	67.24 (9.4)
2013 Ordinary	52.85 (4.4)	34.52 (3.6)	63.25 (9.3)
2014 Ordinary	51.54 (3.6)	32.81 (3.5)	61.91 (8.7)
2015 Ordinary	50.60 (4.0)	32.12 (3.8)	62.10 (5.9)
2012 Foundation	9.67 (4.8)	No Paper	10.70 (7.4)
2013 Foundation	8.97 (5.8)	No Paper	11.14 (5.2)
2014 Foundation	8.40 (4.1)	No Paper	10.74 (5.6)
2015 Foundation	7.61 (5.8)	No Paper	10.48 (5.3)

Table 2.4: Summary of Percentage Students Sitting Leaving Certificate Core Subjects in Each Level from 2012 – 2014 and Percentage Failure Rate. Source: (www.examinations.ie)

The lowest percentage of students sat the higher level paper in mathematics, compared to the other 2 subjects in each of the 3 years analysed with a difference of close to 40% between mathematics and English each year. With the lowest percentage uptake, the higher level paper also has the highest percentage failure rate each year. It is also evident that the foundation level mathematics paper is sat by a greater percentage of students than the Irish foundation level paper while a foundation level paper is not available in English. Again, a positive to take from these statistics is that the number of students who are taking the higher level mathematics paper is increasing each year and the number taking the ordinary and foundation level papers in this subject has decreased from 2012 to 2015. The National Strategy (2011) outlines that its plan is to have 30% of students taking higher level mathematics in the Leaving Certificate by 2020. 4.7% of students taking the ordinary level mathematics paper in 2012 got an A-grade, 5.4% in 2013 and 6.8% in 2014 which sees this percentage steadily increasing. However this figure plateaued to 5.5% in 2015. McDonagh and Quinlan (2012) found that in 2012, the highest numbers of A's were awarded to Leaving Certificate ordinary level mathematics students. This may suggest that many people who sat the ordinary level paper would have been capable of sitting the higher level paper if encouraged. McDonagh and Quinlan (2012) suggest getting one in three of those who study ordinary level to successfully study higher level would greatly improve mathematical achievement in Ireland. The DES (2010) maintains that improving students' experience of mathematics at Junior Cycle is essential to increasing the number of students who study higher level in Senior Cycle. Developing strategies to improve interest and achievement of Junior Cycle students in mathematics could impact the mathematics level they study in Senior Cycle.

From analysing Ireland's PISA results, the DES (2013) state that in the hope of increasing the students' engagement with mathematics, initiatives will be considered in order to increase the level of engagement in extra-curricular activities that are related to mathematics. An incentive that may impact on mathematics study level in Senior Cycle is a bonus point scheme awarded to students who successfully pass the Leaving Certificate higher level paper. The Central Applications Office (CAO) (2012) explains that for Leaving Certificate 2012, 25 points will be added to each student's points score if they pass the higher level paper. However, from the State Examinations Commissions (SEC) statistics of the 2015 state examinations, a record high of 5.2% of students failed the higher level mathematics paper in Leaving Certificate. Media coverage surrounding the Leaving Certificate mathematics results 2015 discuss close monitoring of the bonus point scheme (http://www.irishexaminer.com/ireland/leaving-cert-results-no-major-changes-to-grades-but-maths-failure-rate-rises-347640.html). There also seems to be strong moves towards offering students who fail the paper points, where the norm has been that no points are awarded for a fail grade. On September 3rd 2015 national broadsheet newspapers stated that Universities and other Higher Level Institutes were very close to signing off on an agreement whereby students who get a grade of between 30% to 39% be given 37 CAO points (http://www.irishtimes.com/news/education/cao-points-changes-aim-to-reduce-pressure-on-students-1.2339120). This has since been agreed. This is a further incentive for students to study and sit the higher level paper in the Leaving Certificate examination.

Further analysis of the statistics presented in Tables 2.3 and 2.4 brings another issue to the fore, namely the link between gender and mathematical uptake.

2.3.7 Subject Choice & Gender Issues

In PISA 2012, Cosgrove et al. (2013) found a difference in performance between Irish male and female students. The male scores were substantially higher than that of Irish females and from Figure 2.2 below, it is clear to see that this has been the common trend since Ireland's participation in the PISA assessment began.

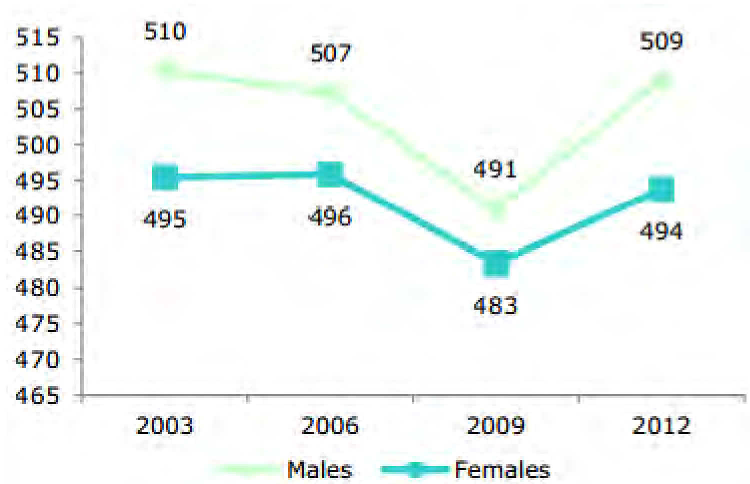


Figure 2.2: Comparison of Male & Female Irish Students PISA Results
Source: Educational Research Centre

Furthermore, from analysis of the Leaving Certificate 2015 results, a variance in gender is also evident. Of the 14,691 students who sat the mathematics higher level paper, 7,695 are male and 6,996 are female. 5% of these male students failed the paper and 5.5% of females failed. Furthermore, 13.4% of the male cohort received an A grade, whereas only 7.5% of females reached this level. The evidence that less female students are taking the higher level paper and those who do take it are not performing as well as their male peers is an area warranting further research. This finding makes the author more aware of differences in performance between male and female students and is something that the author may need to be mindful of when planning the intervention for this research.

With regard subject choice, McDonagh and Quinlan (2012) compares Irish students' preference of higher level subjects in post-primary education's final state exam in comparison to Scottish Higher and the UK in 2011. Mathematics is the most popular subject amongst male students in the UK and is the second most popular in Scotland. However in Ireland, mathematics is the eighth most popular subject at higher level amongst male students. Mathematics ranks at number 9 for Irish females while it ranks at number 2 and 5 for Scottish higher and the UK respectively. These statistics show that interest levels in mathematics amongst Irish students is very low in comparison to its neighbouring countries. McDonagh and Quinlan (2012) discuss how Ireland's competitiveness in mathematics would greatly improve if higher level mathematics became a top 5 ranking subject choice for its students. Irish females ranked mathematics lower than Irish males as a higher level subject in Leaving Certificate. The DES (2013) identify that there is a definite need to promote mathematics amongst female students. Kearney (2011) outlines an approach that some countries take in the hope of increasing the number of women in science, technology, engineering and mathematics (STEM) which is providing workshops and summer schools for females in both primary and secondary level education. Female STEM teachers' are paired with female students and STEM professionals to discuss their career paths. In the planned intervention for this research both male and female students will be participants therefore it is important to understand that differences exist between male and female students study level in mathematics and performance and what may help to combat these differences.

From Conway and Sloane's (2005) research they have identified this gender gap performance as an international phenomenon. They have suggested that gender differences in spatial visualisation is one of the reasons for the difference in performance of male and female students in mathematics. They suggest social influences such as mathematics achievement being traditionally a male dominated subject, classroom culture and how a teacher may treat male and female students differently, as other possible reasons for the difference in performance of male and female students in mathematics. Schafer and Gray (1981) admit that there have also been attempts by scientists to identify a gene in males that could contribute to the difference in performance, however this has not proven to be successful to date.

Since the author has looked at mathematics issues nationally, it is necessary to now gain an international perspective of mathematics education and the issues identified outside of the region where this project is situated.

2.4 Issues Facing Mathematics Education Internationally

From an international perspective, the United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2012) recognise that when many pupils complete their education they still do not have sufficient knowledge and skills in mathematics. Of those students who do, many have little interest or value in the subject. Conway and Sloane (2005, p.15) have identified two main issues in international trends in mathematics education, "*poor levels of understanding and achievement gaps*" and "*the need for 21st century skills*" which they refer to as the push and pull factors respectively. The push factors refer to lack of ability among post-primary students to apply mathematical knowledge to real life situations and gaps in achievement between male and females, different ethnic groups and different nationalities. UNESCO (2012) also recognises that there is a perception that mathematics is more suited to male students and that the study of mathematics bears no relevance to real life. Conway and Sloane (2005) discuss that teaching mathematics in a procedural, inflexible way and not providing a contextual link is to blame for students' poor level of understanding. Gaps in achievement in ethnic groups are an issue in countries that have a large amount of ethnic diversity such as USA, Canada, Australia and Germany. Conway and Sloane (2005) state that this gap in achievement is attributed to cultural differences and educational inequality. From the PISA 2012 results, a wide variation in countries' mean scores in mathematics is evident. Conway and Sloane (2005) feel that the importance placed on PISA ranking is far greater in some countries than others and this could be a factor in each countries ranking. Ernest et al. (2009) state that there is a huge variance in achievement amongst different countries world-wide and they maintain that these differences are largely attributed to the difference in resources available to these countries. With regard to the pull factors, Conway and Sloane (2005, p.23) identify "*analytical and creative thinking, and problem solving*" as the 21st century skills required.

Since PISA began in 2000, Conway and Sloane (2005, p.34) have identified growth in the "*comparative movement*" in mathematics education internationally. OECD (2011, p.18) state that "*comparative international assessments can extend and enrich the national picture by providing a larger context within which to interpret national performance*". It is important to this study that a more detailed comparison is made between issues facing mathematics education nationally and issues facing mathematics education internationally as it is imperative to have an understanding of whether or not the issues facing mathematics education in Ireland are just national issues or are issues that other countries also face. For the purpose of comparison we will look at our nearest neighbours, the United Kingdom (UK) (specifically England), and a country with a similar demographic to Ireland, New Zealand. The author will also look at mathematics education in Shanghai-China as this is the region that continues to perform best in the PISA mathematics assessment.

2.4.1. Issues Facing Mathematics Education in the UK (England)

Paterson et al. (2010) report on improving numeracy in England. They state that to be numerate means to be confident with numbers and be able to use mathematics in different situations. They outline that the rote learning of mathematics limits a person and understanding is key to becoming numerate. The structure of the post-primary education system in the UK up to the age of 16 is similar to that in Ireland, however there is variance in education post 16. General Certificate of Secondary Education (GCSE) students (aged approximately 14-16) select eight or more subjects to study for two years, these years being referred to as year 10 and year 11. GCSE is the UK's equivalent to Ireland's Junior Certificate. Mathematics, as well as English and science are compulsory. Advanced level (A-level) students (aged approximately 16-18) have the option of continuing their education and Cooper and Maughan (2010) state that students usually study four subjects, none of which are compulsory.

In the UK, Smith (2004, p.V) acknowledges how important mathematics is to their society stating that "*it provides the language and analytical tools underpinning much of our scientific and industrial research and development*". Paterson et al. (2010) outline the government's commitment to improving numeracy standards over the past decade and further acknowledge that poor numeracy skills not only has a negative impact on an individual's life but is also damaging to the economy. Hoyles et al. (2002) developed a report which identified that mathematical skills in the workplace are in great demand. However, they also identified the fact that the number of students taking A-level mathematics (second level final state examination) is lower than the government would like and as a result the number of students studying mathematics at university is low. For this reason, among others that will be discussed subsequently, the Government have made efforts to reform post-primary mathematics.

Reform of Post-Primary Mathematics in the UK

Like Ireland, the Department of Education (2013) in the UK have announced a reform in the national curriculum for mathematics in key stage 4 (year 10 and 11, which is GCSE years) which will be introduced in a phased bases starting in September 2015. The aim of this reform is to

> "*develop fluent knowledge, skills and understanding of mathematical methods and concepts, acquire, select and apply mathematical techniques to solve problems, reason mathematically, make deductions and inferences and draw conclusions and comprehend, interpret and communicate mathematical information in a variety of forms appropriate to the information and context*" (Department of Education, 2013, p. 3).

The Department of Education (2013) have stated that number, algebra, ratio, proportion, rates of change, geometry, measures, probability and statistics is the topics being taught on the reformed curriculum. The Schools Network (2013) feels that there are many reasons behind reform of mathematics in the UK, such as a dated exam structure, belief that numeracy standards are below average nationally and to coincide with best practice internationally. Some of these reasons will now be discussed.

Numeracy Standards and the Uptake of Mathematics

In relation to numeracy standards, the UK's ranking in PISA 2012 is 26th which is below average. UK students are performing at a far weaker level than that of Shanghai, who top the PISA table and the UK are also trailing Ireland who are performing above average. Furthermore, Vorderman (2011) explains that half of the students who sit GCSE mathematics fail it. She also states that only 15% of students study mathematics beyond GCSE level which in comparison to virtually 100% of Irish students, is low. Voderman (2011) explains that as a result many students attend university without sufficient mathematical knowledge which puts universities under pressure to offer degrees that meet International standards. Hillman (2014) maintains that the greatest incentive for students to progress their study of mathematics is if it is required for university or employment and he suggests that Universities should have a mathematical requirement for entry. However Hillman (2014) outlines that Universities will resist this suggestion, as having a mathematical requirement may deter students from applying for courses at these Universities.

Hodgen et al. (2010) compared the UK's uptake of mathematics post 16 to 24 other countries. England, Wales and Northern Ireland had the lowest uptake with less than 20% of its students studying mathematics post GCSE. Scotland uptake was higher than the other UK countries, but this was still below average. In comparison, 18 of the countries studied had more than half of their students studying mathematics post 16 and 8 countries had almost full uptake of mathematics. This is as a result of mathematics being a compulsory subject post 16 in these countries. Post GCSE, mathematics can be studied at AS and A level. A-levels normally take 2 years. The first year is called an AS level. At the end of the second year the student has an A level qualification. Figures have shown that the majority of students who study A-level mathematics have achieved either an A or A* grade at GCSE level. These grades are the 2 highest possible grades, and generally, anyone who scores lower is not encouraged to take A-level mathematics as it may be too difficult for them. Another area worth mentioning is the gender discrepancy of students who study A-level mathematics.

The Further Maths Support Group (FMSP) (2015) state that in 2014 40% of the students who study mathematics to AS or A-level are female and 30% of the students who study Further Mathematics to AS or A-level are female. They further state that in 2014 mathematics was the most favoured AS and A-level subject amongst boys, whereas for girls mathematics was the fourth most favoured subject at A-level and third most popular at AS level. As discussed previously, this gender discrepancy is also apparent in mathematics education in Ireland in relation to higher level mathematics uptake. Smith (2014) explains that a country is at an economic advantage if it has a larger population with good mathematical skills. A way of increasing the number of people with these skills is to increase the number of females studying STEM subjects and she acknowledges this fact and comments that this is an area which needs to be developed.

As well as the reasons discussed, school accountability is another factor linked with mathematics education reform in the UK.

School Accountability

The Schools Network (2013) maintains that another reason for reform is because of school and teacher accountability. In the UK, there are a number of companies who prepare examination papers for state examinations. Some schools choose the easiest examination papers so as to improve results. The Government uses accountability to assess the performance of public sector workers. As a result of these high stakes, Copper and Maughan (2010) state that schools are performance driven and focus on the skills and content that will enable students to pass their exam rather than other important elements of the curriculum. From the Office for Standards in Education (Ofsted) (2008) inspections in mathematics classrooms they found that a lot of the teaching they saw was teaching towards a test. The National Centre for Excellence in the Teaching of Mathematics (NCETM) (2008) in England feels that this hinders innovation in the teaching and learning of mathematics.

Teachers of Mathematics

Another concern in the UK is mathematics teacher's qualifications. OECD (2011) highlights the fact that you do not need a mathematics degree in order to teach mathematics in the UK. This is in contrast to top performing PISA countries like Shanghai and Finland which require the teacher to hold a mathematics degree and mathematics master's degree respectively. As discussed in Section 2.3.3, with the introduction of the teaching council and also the post-graduate diploma in mathematics for teaching in Ireland, advances have been made to ensure that teachers of mathematics are qualified to teach the subject. OECD (2011) identifies that in England there has been some difficulty in recruiting teachers, in particular mathematics teachers. Hillman's (2014) research found that in 2012, 0.7% of mathematics teaching posts were not filled, which amounts to 140 vacancies. Another worrying figure is that 18% of mathematics classes were taught by teachers who were not qualified to teach mathematics. To combat this problem the government developed a shrewd advertising campaign offering generous financial relief. This advertising campaign targeted both national and international teachers and centred around the theme 'making a difference'. In 2014/2015 a mathematics training bursary of up to a maximum of

£25,000 (depending on your previous qualifications) is being offered in order to recruit top graduates into the teaching profession. OECD (2011) explains that a 'golden hello', which is an extra financial bonus, is also offered to mathematics teachers when they begin their second year of teaching as an incentive to keep teachers in the profession.

Vorderman (2011) reiterates the idea that teacher training needs to change so as to attract the most mathematically talented into the mathematics classroom. She also strongly supports the idea that the teaching of mathematics should be a main focus in primary education. Her report findings outline that many primary teachers lack a sufficient knowledge of mathematics. In 2006, 9,937 enrolled in a primary teaching course with only 227 having a degree in one of the STEM areas. The majority of these primary teachers gave up mathematics at GCSE level. This contrasts with Ireland whereby, as previously stated, all teachers study and must pass mathematics in order to enrol in a primary teacher training course.

Having now discussed some current developments in the UK, the author will now address some issues facing mathematics education in New Zealand. New Zealand has a similar demographic to Ireland which makes it a good source for comparison.

2.4.2 Issues Facing Mathematics Education in New Zealand

The New Zealand Qualifications Authority (NZQA) (2015, p.1) identifies numeracy as the key link between mathematics and day to day life. They acknowledge that what is learned in mathematics classes must be applicable to day to day living. The Nutfield Foundation (2012) explains that similar to Ireland, New Zealand's education is compulsory for all children between the ages of 6 and 16, however there are current discussions underway with regard to the Minister for Education increasing this age to 17 or 18. The Ministry for Education (2007) revised the primary school curriculum in 2007. In relation to mathematics, the course content (titled Mathematics and Statistics) is divided into 3 strands; number and algebra, geometry and measurement, and statistics. The course aims to develop student's investigative, interpretative and explanatory skills and to use these skills to make sense of the world in which they live. They continue to explain that English, mathematics and statistics, science, technology, social sciences, the arts and health and physical education are all compulsory subjects up to year 10. However from Years 11 to 13 students choose subjects that they study in greater detail. There is no specific number of subjects that each student must choose and students often study a wide variety of subjects.

The Education and Science Committee (2013) explain that the main post-primary qualification in New Zealand is called the National Certificate of Educational Achievement (NCEA) and this qualification has been in place since 2002. This qualification is very different to the qualifications gained in Irish post-primary schools. Then NCEA (2015) explain that it is comprised of 3 Certificates. NCEA Certificate 1 is worth 80 credits, Certificate 2 is worth 60 credits plus 20 more if to be studied to level 1, and Certificate 3 is worth 60 credits plus 20 more credits if studied at level 2 or above. Each credit is equivalent to ten hours of teaching and learning. Level one of this qualification is being awarded to students in Year l1. Students are not required to complete the qualification in 1 year, they can build up credits over several years. On average a course generates between 18 and 24 credits and an average student would achieve 120 credits. The content areas assessed are calculus, fundamental mathematics and statistics. NCEA is said to have a very modern approach as it recognises a diverse range of skills and competencies. A major difference in mathematics education in New Zealand in comparison to both Ireland and the UK is that both schools and students are given a degree of flexibility in relation to how this mathematics courses is designed and assessed in. Also, the Education and Science Committee (2013) state that for Year 11 to 13, each school can decide on what subjects they deem compulsory. Many schools make mathematics compulsory in year 11, along with English and science, however English tends to be the only compulsory subject for year 12 students while no subject is compulsory in year 13. The Education and Science Committee (2013) state that the reason behind subjects not being compulsory in year 13 is that it is believed that students achieve greater satisfaction and perform better academically if they get to choose the subjects themselves and it is further believed that if students perform well in post-primary education they then tend to perform well in University.

Considering that mathematics is only compulsory up to year 10, the author will examine the uptake of mathematics in New Zealand from year 11 onwards and compare the difference in uptake between male and female students. Prior to this however, the author will discuss New Zealand's performance in PISA to see where they rank in comparison to the OECD average.

PISA Performance

PISA (2012) shows that New Zealand's performance in mathematics was above the OECD average in 2012 with a score of 500, which was 6 points above the average score. Ireland ranked 3 places higher with an average score of 501. The Ministry for Education (2013) explains that New Zealand's performance in mathematics has declined from PISA 2009 to PISA 2012. Figure 2.3 shows that students in New Zealand average scores had decreased considerably between 2003 and 2012. While once significantly higher than average, New Zealand's score is now just above average. From examining Figure 2.3 below, it is evident that only a small decline occurred between 2003 and 2009 but from 2009 and 2012 this decline was much more prominent. As such a major decline is evident from 2009 to 2012.

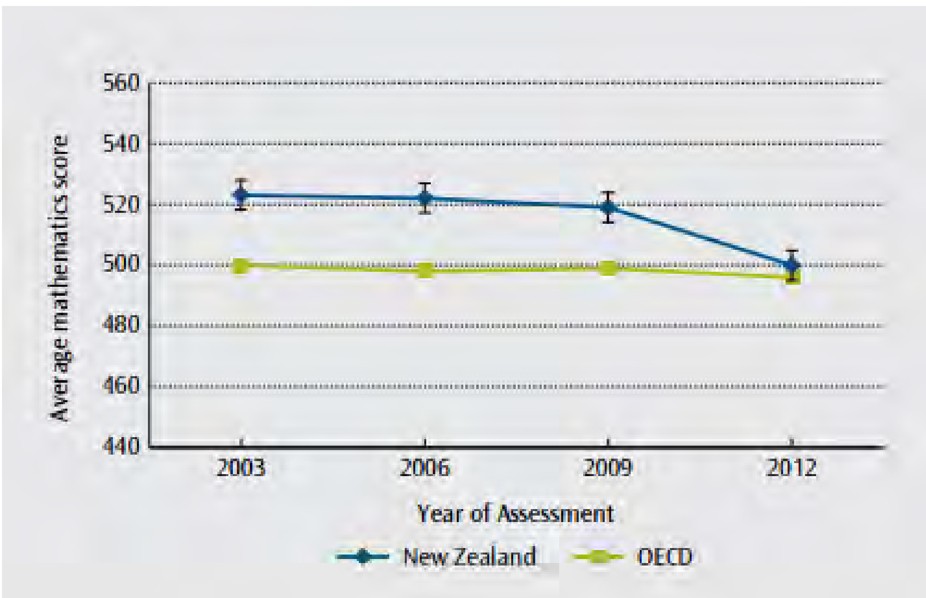


Figure 2.3: Trends in New Zealand's Average Mathematics Score.

While New Zealand's performance in mathematics has always remained above average, it is observed that the decline from 2009 to 2012, which is clearly evident in Figure 2.3 above, can be attributed to many factors. The Ministry for Education (2013) states that the students who took part in PISA in New Zealand began school in 2002. At this time there were many changes in schooling and education in the country such as the recruitment of new teachers from oversees as a result of an increase in the teacher student ratio, more academically focused teacher training courses and new leadership structures and school improvement plans being put in place.

Ministry for Education (2013) have since developed new initiatives to combat New Zealand's decline in PISA mathematics and to improve the numerate abilities of their students. The initiatives suggested include encouraging individual student achievement, developing the quality of teachers and also further developing leadership in education. New Zealand will have to wait until December 2016 to see if the changes they made have an impact on PISA 2015's results.

Having examined New Zealand's PISA performance in mathematics, the author will now look at the uptake of mathematics in New Zealand post 16.

Uptake of Mathematics

The Education and Science Committee (2013) explains that there needs to be reform in New Zealand's school curricula in the light of its changing economy. They believe that participation in mathematics is becoming an increasingly important issue. As it is not compulsory in all schools post 16, many students choose not to study mathematics post 16. Ministry of Education (2015) explain that there are 3 areas assessed in mathematics post-primary education: mathematics; calculus and statistics. However not every school offers all of these courses. In 2014, 516 schools offered mathematics, up from 505 in 2010, 319 schools offered calculus down from 334 in 2010 and 341 schools offered statistics, down from 361 in 2010. A drop in schools offering mathematical subjects is of concern as this means that less students have the opportunity to study the subject. This is evident in some of the statistics made available by the Ministry of Education (2015). In post-primary in 2010, 94.7% of the population studied mathematics to Certificate level which decreased to 90% in 2014. Similarly 87.9% studied calculus to Certificate level in 2010 and 86.9% studied it in 2014. A decline, however small, is still of concern. However the area of statistics saw an increase with 74.5% studying it to Certificate level in 2010 and 82.16% studying it in 2014.

After examining the uptake of mathematics in general, it is now worthwhile to see is there any gender discrepancy in the uptake of mathematics in New Zealand and is there a difference in student performance in mathematics among male and female students in New Zealand.

Gender Issues

The Ministry for Education (2013) examined the difference between male and female students in PISA 2012. It was evident that male students had a higher mathematics average than girls, 507 and 492 respectively. This difference in performance is evident since the beginning of PISA in 2003 and is depicted in Figure 2.4 below.

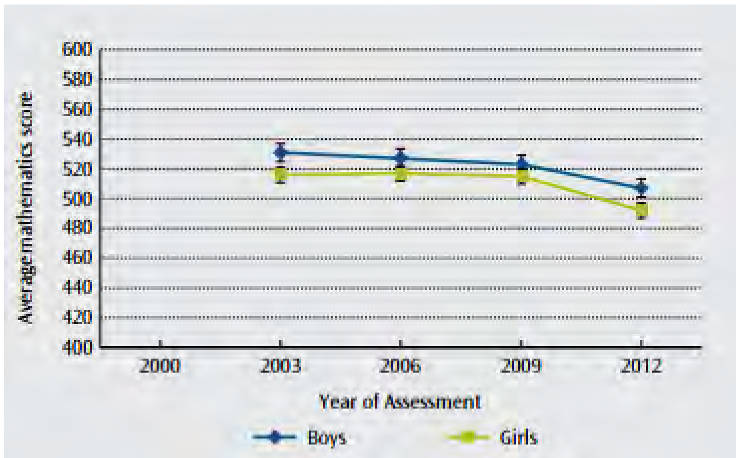


Figure 2.4 Average PISA Mathematics Performances of Boys and Girls in New Zealand

Both boys and girls results declined between 2003 and 2012 by 24 points, suggesting that while a gap exists it is not widening. These results are not dissimilar to other countries. As previously discussed, Irish males continue to outperform Irish females in PISA mathematics.

The author also examined the uptake of the 3 mathematics modules in years 11, 12 and 13. In 2010 the overall uptake of mathematics was greater amongst males for all the 3 modules. However in 2014, more females studied statistics than boys. This main difference was observed in both year 12 and year 13. While it is positive to see that the uptake of certain areas of mathematics is not monopolised by male students the ideal situation is a balance between the number of male and female students studying mathematics.

Now that curriculum and uptake of mathematics have been discussed, a very important aspect of education in New Zealand to discuss is teachers of mathematics.

Teachers of Mathematics

In New Zealand, Morris and Patterson (2012) acknowledge its countries teachers as its educations system most valuable asset and further acknowledge that they are the integral factor that influences student's interest and achievement in education. As a result they explain that it is imperative to put in place structures to attract the most skilled and educated professionals into the classroom. Morris and Patterson (2012) explain that there is a strong link between teachers subject knowledge and students achievement in a subject. The Ministry of Education (1992) states that the different strategies that teachers use to teach their students has a notable effect on how their students learn. Those students who have teachers who have a tertiary qualification in the subject they are teaching them on average perform better in that subject. Morris and Patterson (2012, p.ii) describe effective teachers as having "*a strong subject knowledge, knowledge and skills in teaching that subject matter (pedagogical knowledge), the personal qualities required for developing children and young people, and a passion for teaching*". However, while they maintain that the teachers are highly qualified in New Zealand they explain that teachers may not be qualified in the subject that they teach. They state that 19% of teacher vacancies in New Zealand are in mathematics. They also explain that one third of year 9 students teachers are not qualified to teach mathematics. Morris and Patterson (2012) outline that only 15% of primary teachers specialise in mathematics.

Morris and Patterson (2014) discuss new developments which New Zealand's Prime Minister announced in early 2014 involving changing the career structure of teaching. Extra leadership roles within the school system with extra remuneration is set to become a reality in New Zealand, with the hope of making the teaching profession a more attractive one. In relation to mathematics, teachers of mathematics, science technology and literacy will be titled "expert teachers" and they will be based in one school but may work in other primary or secondary schools in the area two days a week. These teachers will receive an extra $20,000 per year.

Having looked at issues related to mathematics education both in the UK and New Zealand, the author will now look at issues facing mathematics education in a top performing PISA country, Shanghai China.

2.4.3 Issues Facing Mathematics Education in Shanghai-China

OECD (2010) state that education has always been valued highly amongst the Chinese people. Although Shanghai is a city and not a country, it is a region in China that has a population of over 20 million people. Since Shanghai joined PISA in 2009 it has out-performed all other participants in the area of mathematics. As a result Shanghai's mathematics education has become a focus of interest for researchers over the past few years. Yanming Wang (2001) states that being numerate in China means to be able to extend your way of thinking develop skills in problem solving and provide mathematical knowledge and skills that can be developed on. The Research Base (2014) explains that education in China consists of 6 years in primary and 6 years in post-primary education. Post-primary education is divided into lower and upper secondary with 3 years in each. When students complete lower secondary (at approximately 15 years of age) they sit an entrance exam. The results of this exam dictate whether the students enrol in an academic or vocational programme of study or else leave full time education altogether. The Research Base (2014) also explains that mathematics is compulsory for all students at all levels of primary and post-primary education and is studied every day. They state that the content studied is similar to that studied in the UK, except the content in China is deemed more difficult.

The National Education Authority (2008) outline that numerous research discusses the topic of the ideal number of students that should be placed in each class and the research reiterates the theory that the smaller the class size, the more likely students are to achieve. However in Shanghai, classrooms are crowded and classes are large. OECD (2010) state that in Shanghai there is on average 50 students in each class, yet the paradox is that from PISA 2012 it is clear that their students are the highest achieving in the OECD. As a result of this paradox, the author examines Shanghai's outstanding performance in PISA and discusses what they are doing differently in comparison to many other PISA participants.

PISA Performance

In PISA (2012) Shanghai outperformed all other OECD countries in mathematics with a score of 613. This score is 119 points above average and 116 above Ireland's score. The Research Base (2014) state there is only a small difference between the highest and lowest scores of Shanghai students in their PISA results which means that their student's performance is consistently strong. Shanghai also ranked number 1 in PISA mathematics (2009) with a score of 600. This proves that Shanghai's performance is continuing to improve.

Qualitative data was also collected for PISA 2012. OECD (2013) found students in Shanghai have a strong belief that their personal success is within their control and they also have a strong work ethic which enables them to reach their goals. This belief differs from the beliefs discussed by students in many other OECD countries. OECD (2013) state that the number of Shanghai students who are late for school, miss class or are absent is the lowest among OECD countries. PISA (2013) claim that the importance placed on equality for all level of learners is one of the major reasons behind Shanghai's PISA success.

OECD (2011) identifies many reasons as to why Shanghai's performance in mathematics surpasses other countries. Firstly teachers of mathematics are credited with playing a large role in students' mathematics performance.

Teachers of Mathematics

OECD (2010) state that in Shanghai, the government place great worth on teachers, proving this by increasing their pay and improving teachers standards and training. As a result, OECD (2011) maintains teaching is one of the most favoured of professions in Shanghai. They feel that teachers' standards and education have improved and that rote learning is kept to a minimum.

OECD (2009) identifies that teachers performance is monitored in China. Teacher's lessons can be observed by the principal and a district education officer. From Tucker's (2014) interviews it was observed that there are often numerous adults in Chinese classrooms. Teachers often observe each other's lessons so that they can learn from each other particularly at the beginning of a teachers' career. This is not common practice in Ireland, however the Teaching Council (2015) are currently piloting a new system of inducting newly qualified teachers (NQT's) into schools. This will involve the NQT observing experienced teachers classes, the NQT being observed by the established teachers as well as the NQT and experienced teacher planning lessons together. One of the aims of this new structure is to improve teachers' professional practice and develop a culture of teachers learning from one another. In Chinese classrooms teachers demonstrate their teaching to other teachers and allow them to make comments. Student teachers observe master teachers regularly and often teachers from other schools observe their teaching also. In Tucker's (2014, p.9) research, he outlines the Westwood's belief that continued observation of teaching encourages teachers to perform to the best of their abilities and also allows them to learn from other teachers. The OECD (2011, p.88) outline that this approach used in Chinese schools is "*a major platform for professional enhancement*". In Tucker's (2014, p.27) research, he describes this strategy as "*the best professional learning I've ever seen*". It is often said that we learn a lot from our peers (see Section 2.7 on peer tutoring) so this approach is a cost efficient way of continuing professional development. Teachers are encouraged to conduct research within their school and share their findings amongst the school staff. The Research Base (2014) state that one afternoon per week is set aside in schools for mathematics teachers to work collaboratively.

Despite the perceived importance of teaching, it is not the only factor that has contributed to the performance of Shanghai students in international comparison tests. Other factors now must also be considered.

Curriculum

Sam Lim (2007) explains that both primary and post-primary schools in Shanghai use the same mathematics curriculum document which was introduced in 2004 called 'The Shanghai City Primary and Secondary Mathematics Curriculum Standard'. The key areas of study are numbers and operations, algebra and equations, graphs and geometry, statistics and probability, functions and analysis. As students' progress through their education the content in each section becomes broader. The aforementioned document is detailed, outlining clearly the aims and objectives of each area of study and how they should be taught. Many recommendations and examples of how each area should be taught are given. However, Sam Lim (2007) continues to explain that the curriculum document does not have to be adhered to rigidly. Teachers and students are encouraged to teach and learn the subject content in many innovative ways, using diverse activities like investigative projects, day to day contexts, puzzles and games. Teaching for understanding and developing student's creative thinking and problem solving abilities are the norm. Furthermore, each local authority can decide on examination content which therefore makes both curriculum and instruction less repressed (Tucker, 2014).

Although Shanghai's mathematics education is of a very high standard, there are still areas of concern. Research has pointed out the fact that a lot of pressure is put on Chinese students to achieve. The OECD (2011) maintains that Shanghai's schools work their students for very long hours during the week and the students often have to attend school at weekends for exam preparation and tutorials. However one of the plans in China's National Medium and Long-term Talent Development Plan (2010–2020) is to reduce this workload.

Another area of interest is a gender divide amongst students' performance in mathematics.

Gender Issues

According to OECD (2010) males outperformed females in mathematics in 35 out of the 65 nations that participated in PISA 2009. Only in 5 countries did females outperform males. However there was little to no difference in performance of male and female students in Shanghai in PISA 2009 mathematics. PISA 2012 yielded similar results with boys outperforming girls in 38 participating countries by an average of 11 points, however the male and female students in Shanghai still performed as well as each other. OECD (2014) also highlights the fact that the average girl in Shanghai outperformed boys' average in every other participating region in PISA.

2.5 Developing Interest in Mathematics

Hidi (2006, p.70) defines interest as "*a unique motivational variable, as well as a psychological state that occurs during interactions between persons and their objects of interest, and is characterised by increased attention, concentration and affect*". Hidi and Harackiewicz (2000, p. 152) believe interest "*can be viewed both as a state and as a disposition of a person*". The effects that developing interest has on students has been proven. There is research to back up the fact that interest has a positive effect on cognitive functioning. For example Hidi and Harackiewicz (2000) state that it is apparent that interest influences people's academic achievements. It has been suggested that interest is the key to children's early stages of learning and can also be the difference between average and expert performers (Renninger et al., 1992). Hidi and Renninger (2010) state that interest has a positive effect on student's attention, goals and learning levels.

Hidi (2006) explains that there are two categories of interest, situational and individual. Each category is divided into two sub groups. There is triggered situational interest, maintained situational interest, emerging individual interest and well developed individual interest. Hidi and Renninger (2010) found interest to develop in that order.

2.5.1 Situational Interest

Hidi (2006) describes situational interest as interest triggered by the surroundings you are in and it warrants you to react and focus your attention. Mitchell (1992) describes it to be something that you achieve through participation and a conducive environment is needed for this participation to occur. It is stated that situational interest can develop relatively quickly as a result of environmental factors (Hidi and Harackiewicz, 2000). Hidi and Renninger (2006) explain that situational interest involves 2 phases, triggering interest and maintaining interest. Hidi and Baird (1986) outline that once you have triggered interest you need to ensure there are suitable conditions in place to maintain it, otherwise conditions may be short lived. Mitchell (1993) researched the idea that situational interest can be subdivided into catching interest and holding interest, which is indistinguishable to that of the trigger and maintain interest phases. Catching interest involves creating a way that stimulates interest whereas holding interest involves empowering students through meaningfulness and involvement. This is illustrated in figure 2.5 below.

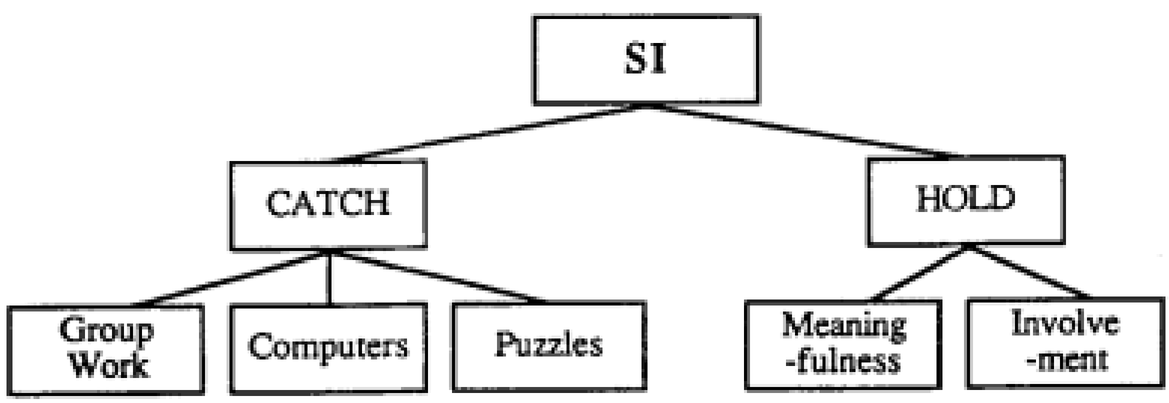


Figure 2.5: Situational Interest **(Mitchell, 1993, p.426)**

From Figure 2.5 it can be seen that examples of ways of catching (triggering) interest are group work, ICT and puzzles. Hidi and Harackiewicz (2000, p.155) support this by stating that group activities, games, puzzles and the use of ICT stimulate interest amongst students. However, maintaining this interest is not sustainable without a deeper root. Mitchell (1993, p.426) describes holding interest as using a variable that "*empowers the student*". This is done through meaningfulness and involvement. Mitchell (1993) believes that if the content is made meaningful, it will empower the student to achieve their personal goals and interest will be maintained after the content has been taught. Mitchell (1993) states that involvement refers to "*the degree to which students feel they are active participants in the learning process*" (Mitchell, 1993, p.428). Mitchell (1993) outlines that in a lesson lecturing should be kept to a minimum, no more than 10 minutes, and there should be varying activities in the class to enable students to learn and develop skills. Research from Hidi and Berndorff (1998) and Lepper and Henderlong (2000) show that improving teaching materials and strategies as well as improving how tasks are taught, can aid situational interest. Hidi (1990) maintains that situational interest can have positive effects on students' motivation, especially those who show very little motivation to begin with.

2.5.2 Individual Interest

Hidi and Renninger (2006) define 'individual interest' as one that develops over time and it is the willingness to attend and return to content. It is linked with positive feelings, increased worth and knowledge. Research from Ainley (1998) and Prenzel (1988) shows that when individual interest is triggered students tend to focus for longer periods of time, learn more and enjoy the work more. Hidi and Renninger (2010) explain that individual interest can be sub divided into emerging individual interest and well-developed individual interest. Emerging individual interest occurs first and as a result of increasing emerging interest well-developed individual interest is achieved. Hidi and Renninger (2006) ascertain that emerging individual interest is apparent when students pursue repeated reengagement with a specific area. The student displays positive feelings and increased knowledge of the area and displays curiosity to engage further with the content. Although emerging individual interest is predominantly self-motivated, engagement and encouragement from peers and experts in the area can further develop this interest and leads to well-developed interest. Hidi and Renninger (2006) explain that well developed individual interest is similar to emerging individual interest however well-developed individual interest is a persistent and committed engagement with the area in question. It displays all the signs discussed in emerging individual interest except a student with well-developed individual interest will continue to work through content despite coming across difficulties and challenges.

Although situational and individual interests are independent, they can also be linked. Mitchell (1993) proved that in an educational setting if there is continued situational interest, over time individual interest can be cultivated. So while at the beginning of the school year a teacher has no control over students' individual interest, through ongoing promotion of situational interest in the classroom, students' individual interest can be influenced.

2.5.3 Interest in Mathematics

Taking Hidi's (1990 and 2006) research into account, one could surmise that if a student's interest has been developed they are far more likely to attend and concentrate. This is true for all subjects including mathematics. Mitchell (1993) believes that building interest in mathematics will improve the teaching and learning of the subject. Rubin and Hebert (1998, p.26) highlight that "*learners getting involved in their learning instead of passively receiving information from an instructor has been considered the essence of education*". Ernest (2004, p.11) highlights an age old belief of many that "*mathematics is a difficult, cold, abstract, theoretical, ultra-rational but important and largely masculine*" as well as being "*remote and inaccessible to all but a few super intelligent beings with 'mathematical minds*'". He claims that this belief can cloud student's interest in, and attitude towards the subject. Students who have negative attitudes towards a subject will find it very difficult to do well in this subject (Hembree, 1990; Zeidner, 1991). In relation to a teacher's work in the classroom, they have less influence over their students' individual interests as they do over situational interest so their main concern is to work and develop situational interest (Mitchell, 2009).

Interest in mathematics at post-primary level is relatively poor in relation to other subjects on the curriculum (Mitchell, 1993). Such a finding is not exclusive to Ireland. Internationally, it is commonly known that mathematics is one of the least popular subjects amongst post-primary school students. Buxton (1981) states that out of all the subjects taught in school, mathematics is the subject that is viewed most negatively by the students and can sometimes develop into a refusal to engage with mathematical content. Anton and Klisch (1995) and Watson and Sutton (1996) state that many students have negative attitudes towards mathematics. Brush (1981) outlines that there is also evidence to suggest that changing attitudes towards mathematics is very difficult and negativity can increase as the student becomes older. Research from both Eccles & Wigfield (1992) and Eccles et al (1998) have also found that children's interest and attitude towards school and specific subject areas, in particular mathematics, declines over time. This proves that now more than ever it is important to work at developing individual and situational interest in each student, so as to maintain their interest throughout their academic life.

Data collected by Martino and Zan (2011) suggest a 3-dimensional model of attitude towards mathematics that includes student's emotional disposition, how they view mathematics and how they view their abilities at mathematics. This refers to each student's innate traits, what they believe mathematics to be about and how good they believe themselves to be at mathematics. All these factors combined contribute to each person's attitude towards mathematics. Goodlad (1995) has found that measuring attitudinal change is extremely difficult which means it is very hard to gain meaningful quantitative data on attitudinal change towards mathematics.

From Mitchell's (1993) research, he found that unlike other subjects, students cannot relate what they learn in mathematics class to real life. A study conducted by the California Mathematics Framework Committee (1992, p.33) outlines that "*the study of mathematics becomes more powerful when students use it to achieve purposes that are meaningful to them*". Kaput (1989) reiterates this statement by explaining that if mathematics is meaninglessness it hinders students motivation to learn and use mathematics. Stodolsky et al. (1991) found that many students are used to the pattern of being taught mathematics in a didactic fashion, while from Mitchells' (1993) research it is evident that students will hold an interest in mathematics if they are active learners.

On a national level, Ireland's performance in mathematics is poor in relation to many other subjects on the schools syllabus. In Section 2.3.7 the author discussed Irish student's interest in mathematics in comparison to those in the UK and Irish students ranked their interest in mathematics far lower than the UK. Berg (2004) suggests that attitudes towards subjects can be changed if interest is triggered in the student. Once interest in mathematics is gained it is important that the increase in interest can be quantified. This leads on to achievement in mathematics. Here the author will discuss student achievement and discuss how achievement in mathematics in Ireland has changed in recent years.

2.6 Achievement in Mathematics

Travers (1970, p.447) describes academic achievement as "*the result of what an individual has learned from some educational experiences*". Scott and Miller (2012) conducted research in the US highlighting 6 of the main ways that student achievement can be measured. The 6 ways described are attainment, gain, student percentile growth, standard value-added, customised value-added and student learning objectives. Attainment measures a student's score on a specific assessment at a fixed point in time whereas gain is the difference in score between pre and post-tests. Student percentile growth allows a comparison to be made among peer groups by finding out each students percentile rank. Standard value-added and customised value-added are ways the school or teachers contribute to student achievement. Student learning objectives are the areas of learning that the teacher wants each student to have achieved by the end of the lesson/week/term. Achievement will be analysed using Scott and Miller's approach.

2.6.1 Attainment & Gain

Sammons et al. (2012) state that there are many areas that influence students' academic attainment such as students' gender, background influences and commitment to homework. Their research found that parents' educational level also has a strong influence on their child's attainment. The more educated the parents are, in particular the mother, the greater the attainment of their children. However The Centre for the Study of Social Policy (2005) state that regardless of parents educational background, if they have high expectations for their children's learning and support them at home as best they can these children will also achieve their potential. Sammons et al. (2012) also state that home environment and family income also influences attainment as well as the neighbourhood in which the student lives in. A happy home environment in a nice neighbourhood affects students' attainment in a positive way. They continue to explain that in relation to mathematics, gender has an influence on attainment with boys performing better than girls. Furthermore they explain that transition from primary to post-primary education also influences students' attainment in their subjects, with those students who have a smoother transition performing better in school. Cooper (2001) states that in post-primary school students there is a positive correlation between the amount of time spent on homework and students attainment. Sammons et al. (2012) reiterates this and explains outlines that the strongest effects are seen on those students who spend 2 to 3 hours on homework per night.

Currently in Ireland strategies towards increasing attainment in mathematics are in progress with the implementation of Project Maths and The National Strategy. Increases in achievement as a result of these initiatives will now be discussed.

2.6.2 Percentile Growth

Seeing more students studying mathematics at a higher level is one way of measuring increased interest in mathematics, however a decrease in the numbers failing is a way of measuring achievement. Hidi and Harackiewicz (2000) explain that interest and goals are now seen as two motivational triggers on academic performances. This makes sense in the light of the traditional mathematics course and third level course requirements. The traditional mathematics course encouraged rote learning and did not trigger interest in many students. If one did not need any more than an ordinary level D3 to enter their preferred course at 3rd level and achieve their goals one may have focused all their efforts on other subjects. Both of these ideas would directly affect academic performance. With the introduction of the new mathematics curriculum, Project Maths, the hope is that students move away from rote learning of mathematics and study mathematics in contexts, with topics being linked frequently. As discussed in Section 2.3.2, The National Strategy set out to increase the number of students who study mathematics at the highest level in post-primary schools in Ireland. This should enable greater uptake of mathematics at a higher level. As discussed in Section 2.3.4, this increase has occurred. From 2010 to 2015 the percentage of students taking higher level mathematics in the Junior Certificate increased by just over 10%. From 2010 to 2015 the percentage of students studying higher level mathematics in the Leaving Certificate has increased by just over 11%. Anderman & Maehr (1994) and Harter (1981) claim that research proves that adolescents motivation towards their studies decrease as they get older. However, the greater increase by students studying higher level mathematics in the Leaving Certificate contradicts this finding. Although the percentage failure rate has increased, this increase is small in comparison to the increase in uptake.

Comparing a countries achievement in mathematics to other countries is also a good way of analysing how our students' are achieving in mathematics. As discussed in Section 2.3.1 Ireland is performing above average in the mathematics element of PISA 2012. However it remains to be seen if both Project Maths and The National Strategy will influence the results of PISA 2015 and raise Ireland's achievement. Another aspect of increasing achievement is the contribution of schools and teachers.

2.6.3 Standard & Customised Value-Added

Grouws and Cebullu (2000) ascertain that the scope of mathematics, time allocated to mathematics, how it is taught and the match between student's current skill and new material all affect student's opportunity to learn. They believe that there is a strong correlation between the aforementioned and students achievement in mathematics. However, Sanders, Wright and Horn's (1997) research claims that teachers were the most significant influence on student's academic achievement. Ball et al. (2001, p.433) noted that "*what teachers and students are able [to] do together with mathematics in classrooms is at the heart of mathematics education*". Both Jepsen (2005) and Rockstroh (2013) state that it is very difficult to isolate the attributes associated with an effective teacher. Rockstroh (2013) found that teacher's education influenced the effectiveness of their teaching, so if a mathematics teacher has a degree in mathematics their students' achievements would be greater than a teacher who does not hold a degree in mathematics. Rockstroh (2013) also found that teachers teaching experience has no effect on students' achievement. However no conclusive evidence exists which specifies the attributes of an effective teacher therefore recent research from Lavy (2011) shifts from teacher attributes to teaching practices. Bietenbeck (2011) found that cooperative style teaching and the use of questioning in class to be positive methods of teaching practices used in the classroom. Both of these strategies are encouraged in the Project Maths curriculum. Sam Lim (2007) states that prior to a lesson, mathematics teachers need to plan their lessons, decide what to teach and how to teach it using the best strategies to enable students to understand the content. He also states that teachers need to be able to motivate students and lesson content needs to trigger their interest and this will lead to an increase in students' achievement. Jepsen (2005) also found that increased homework and good classroom materials have a positive effect on student achievements.

2.6.4 Student Learning Objectives

Achievement in mathematics is not solely concerned with good grades. It can be any achievement by a student whereby they have progressed, whether it is through problem solving or by developing conceptual understanding. The Reform Support Network (2004) state that student learning objectives are used to track progress in a lesson. Students are informed of the objectives at the beginning of the lesson and the teacher then refers to the objectives at the end of a lesson. If students have gained the knowledge or skills that the learning objectives outlined then the student has achieved the learning objectives of the lesson.

In order to increase student interest and achievement in numeracy, teaching approaches that motivate students and get them active in their own learning are vital. Peer tutoring is one such approach.

2.7 Peer Tutoring

Miller (2006, p.5) conceives peer tutoring to be "*an opportunity for students to become active learners and offers a functional way for students to learn mathematical skills*". Topping et al. (2011) state it involves distinct roles being taken, one being the tutor, the other the tutee, with this one to one support improving student's knowledge in some area of the curriculum.

Topping et al. (2011) outlines that peer tutoring can be developed in a number of ways. There is same age and cross age peer tutoring groups. Same age peer tutoring is when the tutor and tutee are of similar age and cross age peer tutoring is when there is a gap of more than two years between the tutor and tutee. Cohen and Kulik (1982) established that cross age tutoring has proven to have greater benefits than similar age tutoring. Topping et al. (2011) claim that more mistakes are made between similar age tutor pairs. While Cohen and Kulik (1982) found a short course of tutoring to be more beneficial, Topping et al. (2011) found the relationship between the length of the peer tutoring programme and the achievement gains to be ambiguous.

There is a lot of evidence to back up the benefits peer tutoring has. Goodlad (1995) found that in the case studies he researched there were common benefits seen for the tutors, tutees and teacher. Tutees found lessons more interesting, easier to follow, more enjoyable and they seemed to learn more. Tutors found their communication skills improved, they enjoyed passing on their knowledge, their self-confidence increased and knowledge of their subject improved. The class teachers found their lessons were easier to handle, teaching was more enjoyable and pupils seemed to learn more. Goodlad (1995) states that both the tutor and tutees confidence in the content area improved.

Schreyer Institute for Teaching Excellence (2007) explains that during peer tutoring tutors can work one-to-one with tutees but students can also work in small groups with the support of one or more tutors. Mitchell (1993, p.427) refers to group work as a type of "*social stimulation that catches interest*". He views this type of work as invaluable as he outlines that students feel more comfortable asking their peers questions and feel their peers are better able to explain concepts than their teachers as they use basic language that they can understand. Good et al. (1992) declares that group work in a mathematics classroom is of benefit as the way group work is designed requires teachers to give students tasks that require higher order thinking and less computation.

Goodlad (1995) affirms that tutoring is an ideal teaching and learning strategy as it has the potential to develop so many skills and traits for both the tutor and tutee such as commitment, responsibility, initiative, cooperation, communication and concentration. With so many benefits to be gained from peer tutoring it is an extremely cost efficient way of educating. Rubin and Herbert (1998, p.30) describe it as "*a flexible method that can be used profitably in a variety of disciplines*".

Goodlad (1995, p.72) conducted a number of case studies during the course of his research into peer tutoring and "*in one case study, the pass rates for under prepared students tutored by student tutors compare very favourably with those for under-prepared students tutored by lecturers*". This shows that although one would expect the student tutors are not as knowledgeable in an area as their lecturers, the method of peer tutoring allows them to pass on their knowledge to their tutees with great success. This finding proves the strength of both the peer tutoring training and the peer tutoring programme.

Rubin and Herbert (1998) research into peer tutoring also found there to be many positive outcomes, one being that the peer tutors found the entire experience to be empowering. For the tutee's Rubin and Hebert (1998, p.30) affirm that listening to student-teachers helped them be "*involved*" and "*pay attention more*" in part because they felt more "*relaxed*" and "*comfortable*" during peer- taught lessons. Bandura (1997) explains that student interest in a subject increases if the atmosphere is positive and if they build supportive social relationships with others. Rubin and Herbert (1998, p.26) explains that "*the kind of environment most conducive to learning is thought to be dialogue, characterized by interaction and cooperation*". Nugent (2008) found that both tutors and tutees social behaviours, school attendance, self-esteem and relationships with other students improve as a result of participating in peer tutoring. Topping (1998) goes on to explain that tutors become proud of their work and develop a sense of accomplishment as a result being involved in peer tutoring. Topping et al. (2011) p.3 also maintain that the engagement between the tutor and tutee develops within each an "*enhanced reflection and motivation*". Topping et al. (2011) describe this as a gaining twice as a result of engaging in the peer tutoring process.

Goodlad's (1995) research questioned some of his student tutors as to what they felt was the greatest benefits of the peer tutoring programme. The majority of responses referred to improving students' interaction with their peers and developing students' confidence so they felt more at ease at expressing their opinions. However, peer tutoring needs to be carefully organised and have clear objectives and desirable outcomes. Goodlad (1995) highlights the idea that peer tutoring should only be adopted as a solution to a problem and not for any other reason. There are several tips in the literature of ways to organise peer tutoring sessions. Firstly each school should choose the model of peer tutoring that suits them, which depends on the age and maturity of the students involved and time tabling and space issues (Nugent, 2008). The National Educational Psychological Services (2009) as well as Nugent (2008) outline that the best model of peer tutoring in post-primary schools in Ireland is TY students working with 1st year students. Some researchers are of the opinion that training the tutors is vital to the success of the programme (Goodlad and Hirst, 1990; Foot, Morgan and Shute, 1990). Person and Graesser (1999) assert that if the tutors are not trained then your programme will be very basic. Training is important so as the tutor has knowledge of the information they are expected to engage in with the tutee. The tutor must be at least 2 years older than the tutee. It is important for there to be this amount of an age gap because if the tutor and tutee were too close in age the tutee may feel embarrassed that they do not have the same knowledge as someone the same age as them (Nugent, 2008).

Research has also shown that it is easier to work with students who have volunteered for peer tutoring. This way they feel as if they are in control of their own education and are more relaxed entering the programme. Often those who become tutors may be academically weak themselves. This does not mean that they should not be tutors. As long as the tutee is of a weaker ability this pairing should work as well as any (Nugent, 2008). The sex of the tutor pair is also very important. Nugent (2008) explains that same sex pairings is socially the best model to choose. Brader-Araje and Jones (2002) also affirm that same sex grouping and an older, more knowledgeable tutor than the tutee, works best. Nugent (2008) further explain that other factors such as students' personality traits and their social circumstances may also be something to consider. If you know the students, you can make a greater effort at matching personalities that may work best together.

Attendance can also be an issue. There needs to be some contingency plans in place to determine what to do with a tutor/tutee if their partner is absent. A way of encouraging attendance is by offering the students an incentive for full attendance and participation such as a Certificate or a school trip (Nugent, 2008). The benefit of peers working and discovering together is backed up by the educational theory of constructivism.

2.8 Educational Theory - Constructivism

Constructivism, known to be identified by Piaget, is the idea that "*all knowledge is tied to action, and knowing an object or an event is to use it by assimilating it to an action scheme*" (Piaget, 1967a, pp.14-15). Brader-Araje and Jones (2002, p.7) explain that the behaviourist theory maintained the teacher to be solely responsible for the learning of the student and focuses on "*knowledge as a product*", unlike constructivism which focuses on "*knowing as a process*". Bodner (1986, p.873) reiterates this by stating that "*knowledge is constructed in the mind of the learner*". Jenkins (2000, p.601) is also behind the concept stating that "*the development of understanding requires active engagement on the part of the learner*". Jones and Brader-Araje (2002) explain the relevance of prior knowledge in students' learning and believe that students often bring with them a lot of prior knowledge and experience which they use to construct new information. This is the main idea behind the constructivist approach. Cobb et al. (1992) outline that this theory of constructivism is an accepted theory worldwide.

Brader-Araje and Jones (2002) explain that constructivism is applied to education in the form of co-operative and collaborative strategies such as jigsaw, numbered heads and peer tutoring. Schreyer Institute for Teaching Excellence (2007) explains that jigsaw involves small groups called home groups set up to resolve a task. Each member in a group become an expert in a topic and then shares their learning with the other members of the group. Kagan (2009) outlines that in numbered heads, students are put into groups and each person in the group is given a number. The teacher poses a question and then asks the students to come together to resolve the question. The teacher calls a number at random to answer the question so all the students have to engage with the question at hand.

Von Glasersfeld (1995, p.21) maintain that "*the human mind can know only what the human mind has made*" so through co-operative and collaborative work, this can be achieved. Bodner (1986, p.874) reinforces this idea that the constructivist approach in the form of collaborative work is effective by stating that *"active students learn more than passive students*". However, Cobb et al. (1992. p.27) highlights the dangers of adhering to the constructivist theory too stringently, acknowledging the fact that teachers can not merely leave their student's to their own devices. They explain that teachers should "*develop external representations to make mathematical structures as transparent as possible*".

Conway and Sloane (2005, p.25) outline that the last two decades movement towards "*real-world, problem-focused mathematics education*" was heavily influenced by Piagetian constructivism. In relation to the teaching of mathematics, Bodner (1986) believes that the constructivist approach is vital in order for the student to learn. It is vital that the teacher creates an environment that encourages the learning process. Bodner (1986, p.877) highlights the importance of "*a two-directional flow of information*" between students and their teachers (tutors). The dialog that is created allows the teacher to guide the students understanding, deepen their knowledge, develop the correct language to use and encourages students to reflect on what they are learning. He believes that this approach is specifically important in the teaching and learning of mathematics. Cobb et al. (1992, p.2) maintain that many mathematics educational theories are of the belief that "*learning is a process of constructing internal mental representations*".

Teachers need to be aware of different models of approach to facilitate students learning. Bodner (1986, p.873) discusses a common misconception in education surrounding teaching and learning. He explains that "*teaching and learning are not synonymous*". You can be an excellent teacher, but that does not mean that the students will learn from you. Bodner (1986) identifies that what the learner already knows is the single most important factor that affects learning. Jones and Brader-Araje (2002, p.4) state that in order to construct new information "*teachers must not only elicit students' prior concepts, but must also build on these concepts during instruction*". Jones and Brader-Araje (2002) explains that many educational theorists use the learning Cycle approach which begins by finding out the students' prior knowledge, then providing situations that will meet these prior conceptions or conflict them in the hope of "*conceptual development*". The learning Cycle will now be discussed.

2.8.1 The Learning Cycle

Kolb (1984, p.26) believes that "*learning is the process whereby knowledge is created through the transformation of experience*". This is called experiential learning. There are many models of experiential learning such as the Lewinian's, John Dewey's and Piaget's. Kolb (1984) developed his own learning Cycle after carefully studying the aforementioned theorists' models of experiential learning. Kolb (1984, p.20) believes that experiential learning emphasises the central role that experience plays in the learning process. Kolb's (1984, p.20) Cycle of Experiential Learning (see Figure 2.6 overleaf) is described as "*a holistic integrative perspective on learning that combines experience, perception, cognition and behaviour*". Russ (1998) explains how it is used worldwide as the basis of learning from experience. He outlines the four stages in the Cycle; concrete experience, reflective observation, abstract conceptualisation and active experimentation. Concrete experience involves eliciting the learners thought and feelings, reflective observation is when these thoughts and feelings being elicited are echoed, abstract conceptualisation is concerned with developing ideas and results and active experimentation involves applying the ideas and results learned.

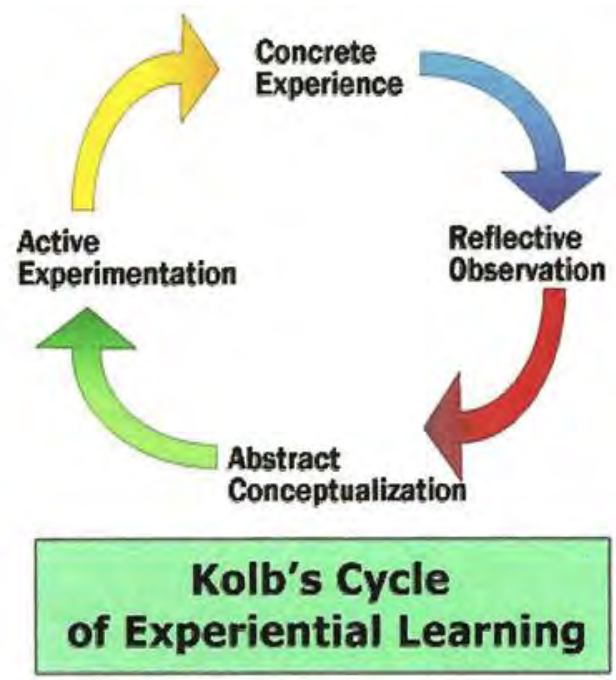


Figure 2.6: Kolb's Learning Cycle
Source: http://academic.regis.edu/ed202/subsequent/kolb2.htm

The learning Cycle is aided by Bruner's concept of scaffolding in the zone of proximal development (ZPD).

2.8.2 Scaffolding in the Zone of Proximal Development

Wood (1983, p.73) defines Bruner's theory of scaffolding as "*one sets the game, provides the scaffold to ensure that the child's ineptitude can be rescued by appropriate intervention, and then removes the scaffold part by part as the reciprocal structure can stand on its own*". By teaching the student in this way the student is being supported and guided through a task they would not have been able to do with support. When they become familiar with the process, the scaffold can be removed part by part until they are able to complete the exercise without too much, if any, assistance. Wood (1998) believes that the great benefit of scaffolding is that students can begin to find patterns and structure in their learning thus becoming confident and capable. Scaffolding helps students attain the next stage of development on the road to independent learning.

Vygotsky as cited in Wood (1998, p.10) labelled the gap between what the child is able to do alone and what can be achieved with the help of a more experienced other "*the zone of proximal development*" (see Figure 2.7 below).

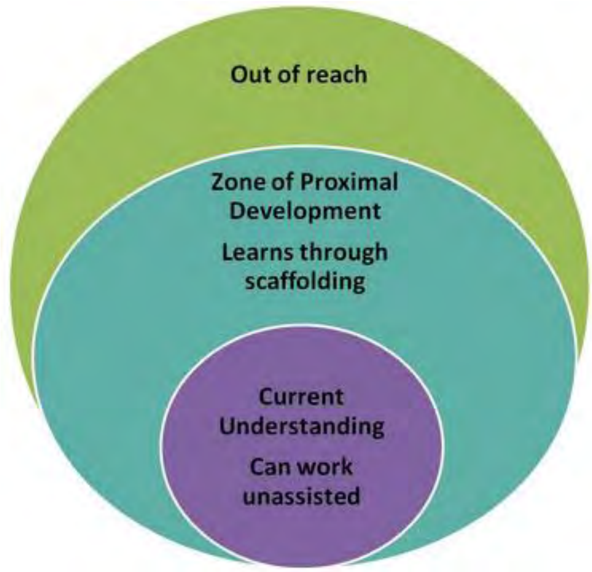


Figure 2.7: Zone of Proximal Development
Source: http://wordplay11.wordpress.com/tag/zpd/

In order to develop effective numeracy strategies to improve interest and achievement in mathematics among students the author is aware that it is imperative that the teaching and learning approaches used are based on educational theories. Using both the learning Cycle and scaffolding allow for deeper learning to occur among students. The learning Cycle allows students to conceptualise concepts for themselves therefore deepening their learning. Scaffolding allows students to build up their knowledge at their own pace with the aid of their teacher/tutor.

2.9 Conclusion

This chapter presents an in-depth analysis of the area of numeracy examining it from a national and international perspective. Developments in mathematics education in Ireland are noted and issues relating to mathematics education in England (UK), New Zealand and Shanghai-China are discussed. Interest and achievement in mathematics are assessed and the new Project Maths syllabus is discussed. Student interest and achievement are outlined and the benefits of an active-learning, peer tutor lead approach to learning mathematics that lead to improved interest and achievement is highlighted. The research states that in order to gain interest, students would benefit from being involved in some type of group work often with some ICT incorporated into the group work. To hold interest students need to engage in meaningful work. Peer tutoring embodies both of these features. Constructivism is also part of peer tutoring as it engages students in work in pairs. Project Maths encourages group work and the use of ICT. With this in mind, the methodologies undertaken to address the research questions are now outlined in chapter 3.

Chapter 3
Methodology

3.1 Introduction

The purpose of this chapter is to discuss how this study was designed and the reasons behind the methods chosen. The review of literature in the previous chapter helped establish the research questions and the methods described in this chapter are those deemed most suitable for answering these questions. The research strategy adopted for this thesis is action research. A pilot study was conducted prior to this intervention.

3.2 Research Aims, Objectives and Questions

The aim of this intervention is to analyse if a structured numeracy programme can improve interest and achievement in mathematics among post-primary school students. The structured numeracy programme involves a numeracy pack and peer tutoring, the reasons for which are outlined in chapter 2.

The main objectives of this study are:

- To implement an intervention that seeks to use peer tutoring as a way of improving interest and achievement in mathematics.
- To gather quantitative data on this intervention by using a pre and post intervention test. This data will allow the author to quantify any increase in students' mathematical abilities they may have achieved after the intervention has occurred.
- To gather qualitative data on this intervention by using a pre intervention survey and post intervention focus group. This data will provide vital feedback on whether or not students' interest in mathematics has increased as a result of the intervention.

Three main research questions guided this project.

- Will 1st year students' interest and achievement in mathematics improve after numeracy strategies have been implemented?

- Is a numeracy programme and peer tutoring, together, an effective type of intervention to achieve an improvement in students' mathematical abilities?

- Will there be an improvement in the TY tutees' interest and achievement in mathematics?

3.3 Action Research

Ferrance (2000, p.1) defines Action Research as "*a process in which participants examine their own educational practice systematically and carefully, using the techniques of research*". Ferrance further outlines that it must be a "disciplined inquiry" which should advise and enhance future teaching and learning and should take place within the teacher's educational setting. Corey (1953) describes himself as one of the earliest users of action research in an educational setting and states that both he and his colleagues believe that it has the ability to change and advance teaching far more than it would if just reading about what another discovered. Cohen, Mannion and Morrison (2011) state that action research is now regularly used in the teaching profession, mainly due to its suitability to this setting. They see it being suitable for individual teachers, groups of teachers working together or teachers working alongside a researcher. Cohen et al. (2011) maintain that action research can be used in many areas such as substituting conventional teaching methods with a discovery method, using a combination of teaching strategies rather than a single strategy, improving student's interests and attitudes in an area and developing new teaching skills and new methods of learning. Zuber-Skerritt (1996) believes action research to be conducted by people who reflect on their practices and engage in ways to improve their practices. Reason and Bradbury (2001. p.2) explain that the main objective of action research is to develop information that can be used frequently in a given area. Ferrance (2000) believes that action research works very well when the authors work is on improving a problem which they themselves have diagnosed. Ferrance (2000, p.3) states that action research involves people "*working to improve their skills, techniques, and strategies*". She outlines that an integral part of action research is that teachers must become engaged in a Cycle of posing questions, gathering data, reflection, and planning a course of action. There are many different action research Cycle models.

Cohen et al. (2011) credit Lewin with arranging the action research process into four main steps; planning, acting, observing and reflecting (see Figure 3.1 below).

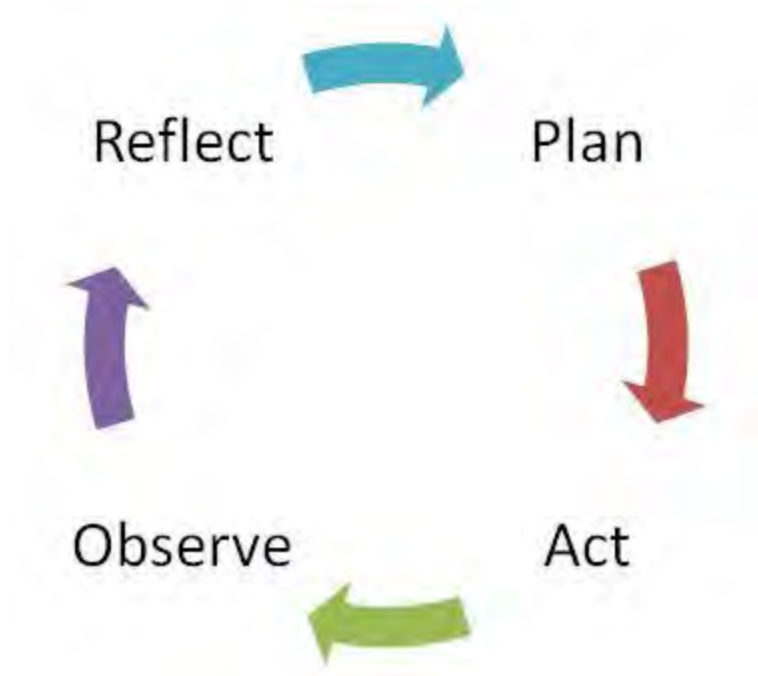


Figure 3.1: Lewin's Action Research Process.

From Lewin's model, other models have evolved, such as the Kemmis and McTaggart model, the Elliot model and the O' Leary model.

Kemmis and McTaggart's (2005) p.276 action research Cycle involves a spiral of self-reflective Cycles of the following; "*Planning a change, acting and observing the process and consequences of the change, reflecting on these processes and consequences, re-planning, acting and observing again reflecting again, and so on*". This is depicted in Figure 3.2 overleaf.

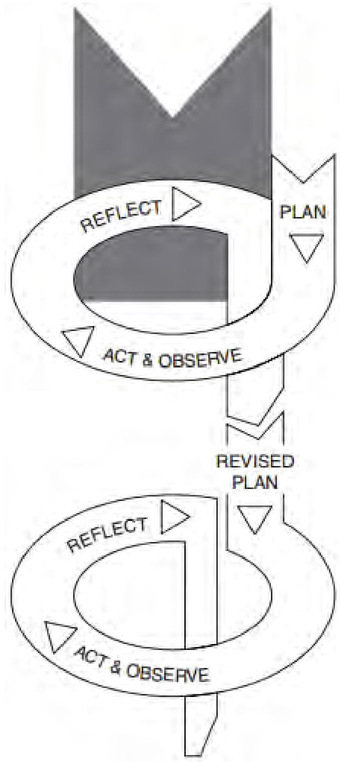


Figure 3.2: Kemmis and McTaggart's Action Research Spiral (2005) p. 278

Kemmis and McTaggart (2005) explain that this model is not fixed. These stages overlap, and original ideas can often become out of date as you reflect on what you have observed. They believe that in reality this model will be able to respond to change. Koshy et al. (2011, p.6) approve of the spiral model as "*it gives an opportunity to visit a phenomenon at a higher level each time and so to progress towards a greater overall understanding*". If carrying out action research using the Kemmis and McTaggart model expect to have a deeper understanding of the context and from there make better decisions due to acquiring a greater understanding.

Another research model used in action research is Elliot's research model (1991) which is not very dissimilar to that proposed by Kemmis and McTaggart. Crotty (2012) outlines that Elliot thought other research models to be too linear so developed a model that encourages regular reflection whereby teachers would consider what they are doing, why they are doing it and take more action to improve their practices (see Figure 3.3 overleaf). Koshy et al. (2011) state that it involves identifying an initial idea, reconnaissance or fact finding, planning, action, evaluation, amending plan and taking second action step and repeating the process. Crotty (2012) states that regular reconnaissance in the form of reading literature, watching relevant YouTube clips, taking photos, make videos and podcast or other relevant approaches to develop deeper learning among students is integral to the success of this action research. Observing and evaluating change and amending where necessary completes the model.

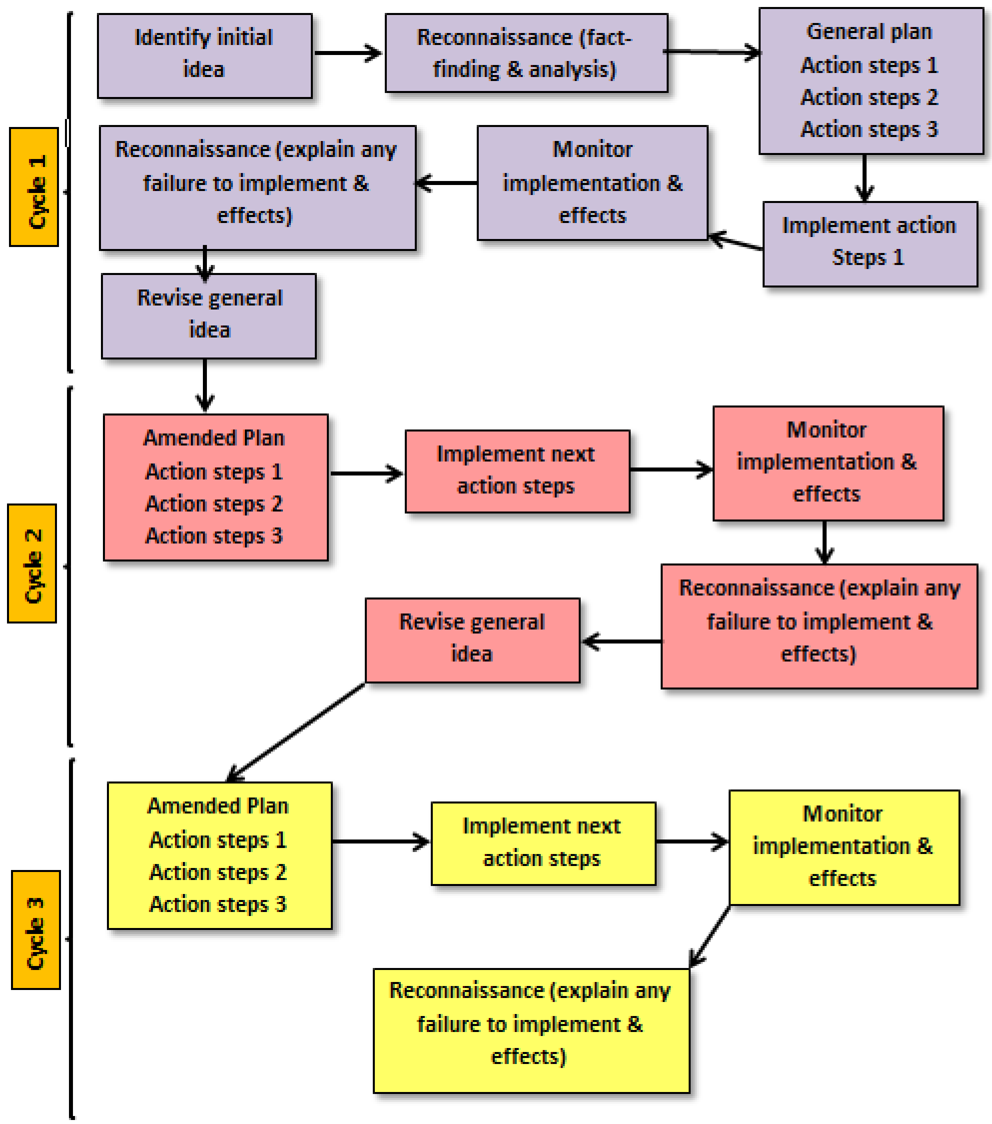


Figure 3.3: Elliot's action research model. **Adapted from Koshy (2005)**

Nelson (2013) explains that O' Leary's model (see Figure 3.4 overleaf) develops as new knowledge becomes apparent. Each Cycle develops greater understanding, improved ideas and strategies, better implementation and encourages evaluation so as to improve the research. Nelson (2013) further explains that this model involves change based on knowledge and experience gained from the previous Cycle.

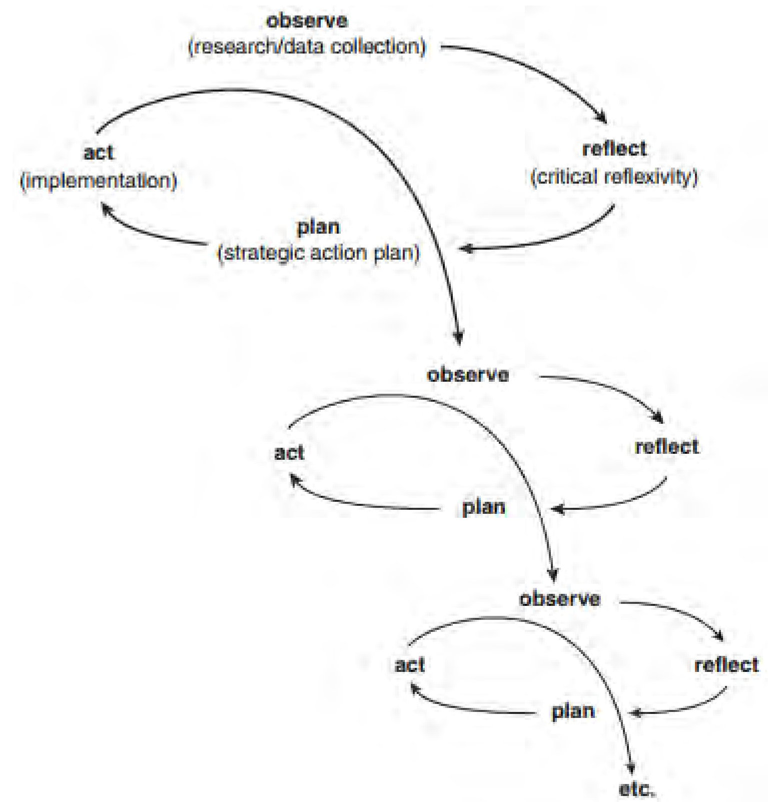


Figure 3.4: O'Leary's Cycles of Research. **Source: (Action Research Centre, 2016)**

3.4 Research Design

The author used Eliot's research model as a means of undertaking her research. The reason for this choice is that it encourages regular reflection and the need to make appropriate changes to improve the research. The theoretical framework was designed as a result of the literature review undertaken in chapter 2 and the aforementioned model. The author developed an intervention which consisted of a numeracy student handbook, numeracy activities, tutor handbook and answer booklet. The details of the intervention materials are discussed in chapter 4.

Figure 3.5: The Research Design Process

***Source: Design of Experiments in Quality Engineering,* by Jeffrey T. Luftig and Victoria S. Jordan, McGraw-Hill, 1998).**

It is important to research the design process prior to conducting the research (see Figure 3.5 above). Luftig and Jordon (1998) developed a four stage design process with the following stages; plan, do, study and act. The planning stage involves identifying research questions, conduct literature review, develop experimental design and identify sample groups and research instruments. The "do" stage is conducting the research and collecting research data. The study phase comprises of data analysis and the act phase involves presenting research findings and developing conclusions to the research. It also involves making recommendations for areas that warrant further research.

3.4.1 Theoretical Perspectives

The author concentrated on important numeracy attributes identified in the literature (see Section 2.2) based on that of Cockroft's (1982) and The DES (2011). Problem solving, meeting day to day numerical demands and strong engagement with mathematics are identified as features of numeracy skills. Constructivism (see Section 2.8) identifies that people learn by doing (Piaget,

1967) while Brader–Araje and Jones (2002) identify co-operative learning and linking prior knowledge as affective ways of improving student's learning experiences. Hidi and Renninger (2006) (see Section 2.5.1) have shown that if content is made personally relevant and meaningful, offers a challenge and triggers curiosity and the learners receive external support in a one-to-one environment or collaboratively then students interest is triggered and maintained. This directly links with achievement (see Section 2.6) which can be realised in the form of improved grades and achieving learning objectives (Scott and Miller, 2012).

The common theme that links all of these ideas together is collaborative work and interesting content. As a result the author developed a numeracy student handbook with content that was created in the hope of capturing the interest of the students. An effort was made to ensure the handbooks content be relevant to teenagers and includes a variety of problem solving questions. High interest content involves the questions being put in contexts which may interest teenagers, for example questions containing high profile sports teams, current pop artists and current TV programmes. The author conducted a large amount of research into the area of peer tutoring as a way of encouraging students to learn collaboratively (see Section 2.7).

3.4.2 Theoretical Framework

From the research conducted in the area of numeracy, pedagogical principles, interest and achievement the author developed a theoretical framework (see Figure 3.6 overleaf) which the intervention followed.

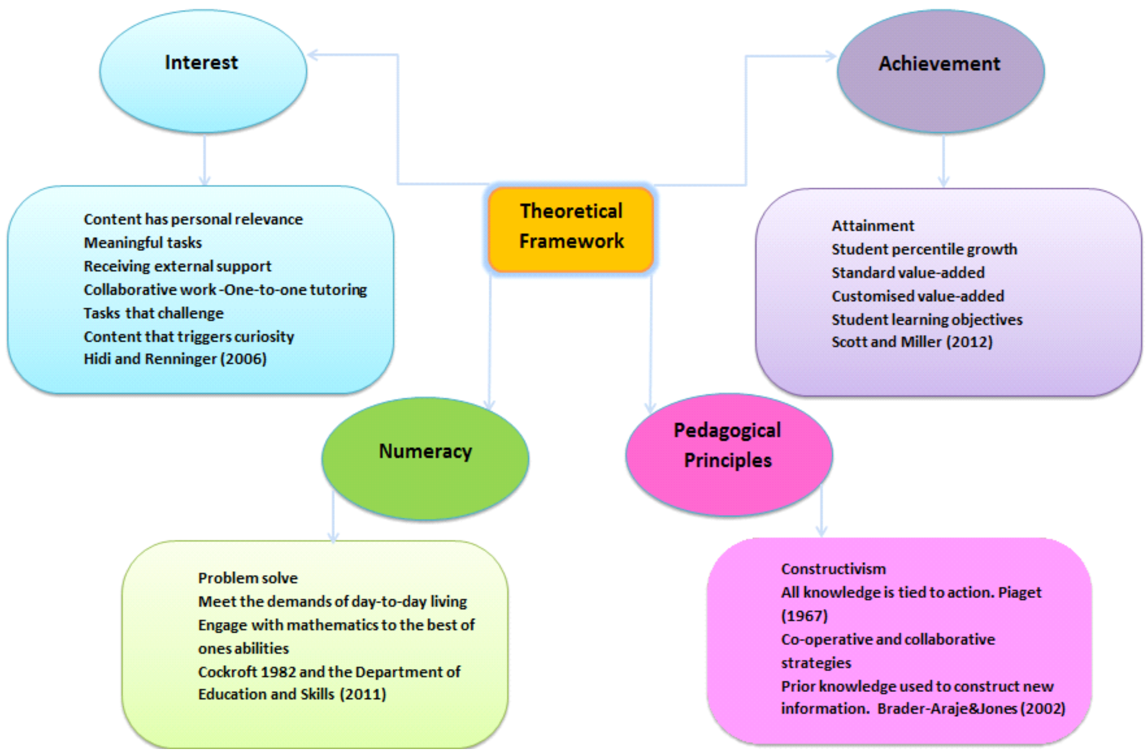


Figure 3.6: Theoretical Framework.

The main aim of this study is to see can an intervention improve interest and achievement in mathematics for both 1st year and TY students. As previously discussed, in order to engage students interest the author insured that the interventions content had personal relevance to students, was meaningful and triggered their curiosity (Hidi and Renninger, 2006). The author aimed to achieve this in the student handbook and resources that she created and used. To further engage students interest the 1st year students received external support by working collaboratively with their TY tutor. All of these strategies link with the pedagogical principle of constructivism, which states that all knowledge is tied to action (Piaget, 1967) and co-operative and collaborative strategies allow students to gain further knowledge. All of the content covered in this intervention is content that these students have been exposed to before which again links with constructivist approach that prior knowledge is used to construct new information (Brader-Araje and Jones, 2002). The content in the numeracy pack and resources are all numeracy related and involve students problem solving, often in real life contexts. During the intervention achievement is measured by students successfully achieving the learning objectives in each area as well as engaging successfully with all intervention tasks. Achievement is also measured by comparing pre and post test results.

The research instruments used to measure the success of this approach is pre and post testing, survey, focus group and comparisons to control group. This is further discussed in Section 3.6.1.

3.4.3 Research Chronology

As the author is a full time teacher, this research took place over a two and a half year period on a part time basis. Overleaf (see Figure 3.7) you will find an outline of a chronology of events that took place during this time.

November 2012 – June 2013
Review of literature Ethical approval granted

July 2013 – September 2013
Design methodology

October 2013 – February 2014
Design of intervention (Student Handbook & Resources) Identify pilot groups Recruitment of pilot groups via letters and consent forms Pilot Intervention Administer pre and post diagnostic tests

February 2014 – May 2014
Conduct pilot study Administer pre and post intervention survey Focus groups

June 2014 – August 2014
Redesign intervention

September 2014 – December 2014
Identify groups Recruitment of groups via letters and consent forms Conduct intervention Administer pre and post tests Administer pre and post intervention survey Focus groups

January 2015 – March 2015
Input of results Write up methodology chapter

April 2015 – May 2015
Analysis of data Write up intervention chapter

June 2015 – November 2015
Write up conclusions and recommendations

Figure 3.7: Research Chronology.

3.5 Research Paradigms

Johnson and Christensen (2011, p.31) describe a research paradigm as "*a perspective about research held by a community of authors that is based on a set of shared assumptions, concepts, values, and practices*". They further describe it as conducting research and identify quantitative, qualitative and mixed method research as the main research paradigms used in education. Johannesson and Perjons (2014, p.167) define a research paradigm as "*a mental model that influences and structures how the members of a research community perceive their field of study*". They believe positivism and interpretivism to be the most widely used research paradigms. The author will examine these paradigms in greater detail and discuss any common features between them.

Johnson et al. (2011) states that quantitative research involves the collection of numerical data, qualitative research involves the collection of non-numerical data whereas mixed method research involves the collection of different types of data, often both quantitative and qualitative data.

3.5.1 Quantitative Research

Brazil et al. (2002) believe that the quantitative paradigm is based on positivism. Sukamolson (2007) states that quantitative data is numerical data. Punch (2009, p.211) believes that quantitative research does 3 things;

- *"Conceptualizes reality in terms of variables*
- *Measures these variables*
- *Studies relationships between these variables".*

Golafshani (2003) explains that a quantitative researcher needs to decide on an appropriate research instrument to use and this instrument must be standardised in order for the responses to fit in to a limited number of categories. There are many tools for collecting this type of data. The author used questionnaires and pre and post-tests to collect this data.

3.5.2 Qualitative Research

Brazil et al. (2002) state that the qualitative paradigm is based on interpretivism and constructivism. Merriam (2009, p.13) describe a qualitative researcher as "*understanding the meaning people have constructed, that is, how people make sense of their world and the experiences they have in the world*".

Golafshani (2003) describes qualitative analysis as any research whose findings are from real life contexts as opposed to statistically procedures. The author decided to use focus groups as a means of collecting qualitative data.

3.5.3 Mixed Method Approach

Cohen, Mannion and Morrison's (2011) research into gathering both qualitative and quantitative data in a research project shows that mixed method research is being used far more frequently in recent years. Their findings indicate that mixed method research allows your research findings to be two dimensional which leads to triangulation of data. Johnson and Christensen's (2012) illustration of the continuum in Figure 3.8, below, highlights the fact that mixed methods research incorporates both qualitative and quantitative research methods.

Figure 3.8: The Research Continuum as cited in Johnson & Christensen (2012, p.32).

Johnson and Onwuegbuzie (2004) describe mixed methods research as a way of using multiple approaches to answer research questions and its findings are far more expansive than if using just one research method.

The variety of research instruments used for the purpose of this study meant that the author employed a mixed method approach to address the research questions.

3.6 Methods Employed

The author employed a variety of methods in order for this study to be thorough and valid.

3.6.1 Research Instruments

Development of pre-post test

In order to assess the success of the intervention in this study a pre and post intervention test was used. While consideration was given to using a standardised numeracy test the author decided that using a test that related specifically to Project Maths would be more beneficial. This diagnostic test was developed by the author and 2 of her colleagues as a project during a course taken in the authors local education centre. Zhao (2013, p.43) states that diagnostic tests are used to "*discover learners strengths and weaknesses and provide detailed feedback for both teachers and learners to make decisions*". The test was designed with the intention of being a diagnostic test for 1st year students to assess their knowledge at the end of 1st year after they had completed the common introductory mathematics course. However, the concepts being assessed are all concepts that each of the students would have studied in their final year of primary education so therefore appropriate for 1st year students at any stage. The questions were designed by the author and 2 of her colleagues, who are all experienced teachers of mathematics. Firstly the author and her colleagues carefully examined the 1st year Project Maths curriculum and identified the basic concepts in each of the Project Maths strands. They then developed their own questions on each basic concept incorporating both concepts and skill and context and applications style questions. The test was originally piloted with the lowest streamed mathematics class in 1st year, just over half way through the academic year. The information from this pilot lead to revision of the test content and removal of a number of questions that the large majority of students answered correctly.

The author decided to use this test as a pre and post intervention test, editing it slightly so as to include only the material that would be worked on during the intervention. During the pilot of this intervention it was found imperative to reduce the questions in the test further so as to narrow the focus of the intervention and also to reduce the length of the intervention. The author felt that it was not necessary to create a separate pre and post-test due to the amount of time between both test sittings. The International Training and Education Centre for Health (I-TECH, 2010) explain that pre and post-test scores provide information on what students know and what they have learned during an intervention and if developed correctly can be diagnostic in nature by highlighting students strengths and weaknesses. The test in question incorporates the basic numerical skills in 4 of the 5 Project Maths strands; probability and statistics, geometry and trigonometry, number and algebra. The fifth strand, functions, is not on the 1st year Common Introductory Course [CIC]. While the strands included are on the 1st year common introductory course, these basic numeracy skills would also have been part of the primary school mathematics curriculum.

From Table 3.1 overleaf, one can see that the results are divided into 6 areas, strands 1 to 4 and concepts and skills and contexts and applications. The questions on the test, like the Project Maths state examination, are divided into 2 sections, concepts and skills and contexts and applications. The maximum score that can be achieved in strand 1 is 22, strand 2 is 14, strand 3 is 30 and strand 4 is 26. The maximum score in the concepts and skills questions is 54 while the maximum for context and applications questions is 38. When originally developed, the test had an equal number of questions in each strand. However, as previously stated, once the test was piloted, a number of questions were deleted thus making the total score in each strand unequal. Once the test is completed it gives you a good profile of each student's areas of strength, areas for improvement and areas of concern in each of the 4 Project Maths strands. Getting less that two thirds of the questions correct means that the student needs to put more work into this strand of Project Maths, getting less than one third of the questions correct means that the student needs to work a lot harder to develop their knowledge of this strand of Project Maths.

	Strength	Area for Improvement	Area of concern
Strand 1: Probability & Statistics	22 – 16	15 – 8	<8
Strand 2: Geometry & Trigonometry	14 – 11	10 – 5	<5
Strand 3: Number	30 – 20	18 – 10	<10
Strand 4: Algebra	26 – 18	17 – 10	<9
Concepts & skills	54 – 37	36 – 40	<18
Contexts & applications	38 – 27	26 – 13	<13

Table 3.1: Test Profile.

From each student's scores you can see if that particular area is considered a strength, an area for improvement or an area of concern. This categorisation was achieved by dividing the total score by 3 and categorising the first third as an area of concern, the second third as an area for improvement and the final area as an area of strength for the student. The information you gain from the concepts and skills part of the test is in relation to the students' ability to;

- Demonstrate knowledge of terminology, definitions, facts and results
- Demonstrate use of tools such as calculators, geometrical instruments, etc.
- Present, or read, information in tabular, graphical or pictorial form
- Within a mathematical context, execute routine procedures

(www.projectmaths.ie)

The information you gain from the contexts and applications part of the test is in relation to the students' ability to;

- Within a mathematical context, demonstrate understanding of concepts and connections, including relevant conditions, implications, etc.;
- In a non-mathematical context, apply routine procedures, interpreting the solutions in the original context;

- In a non-mathematical context, apply understanding of concepts and connections, interpreting solutions, conditions, and implications in the original context;
- Explore patterns, formulate conjectures, explain findings and justify conclusions.

(www.projectmaths.ie)

After completing the test the student's scores can be entered into Excel (see Table 3.2).

Name: Liam   Class: 1st Year

	Concepts & Skills		Contexts & App		Total	
	Score	*Out Of*	Score	*Out Of*	Score	Out Of
Strand 1	9	***12***	7	***10***	16	22
Strand 2	9	***10***	2	***4***	10	14
Strand 3	11	***16***	7	***14***	18	30
Strand 4	6	***16***	3	***10***	9	26
Total	35	**54**	19	**38**	53	**92**

Table 3.2: Student Profile

A graphical representation (see Figure 3.9) of the student's results can be created which gives a clear indication of how the student performed. For example, Liam's main area of concern is the context and application style questions. He performed poorly in Strand 4 Algebra and his strongest area is Strand 2, Geometry and Trigonometry.

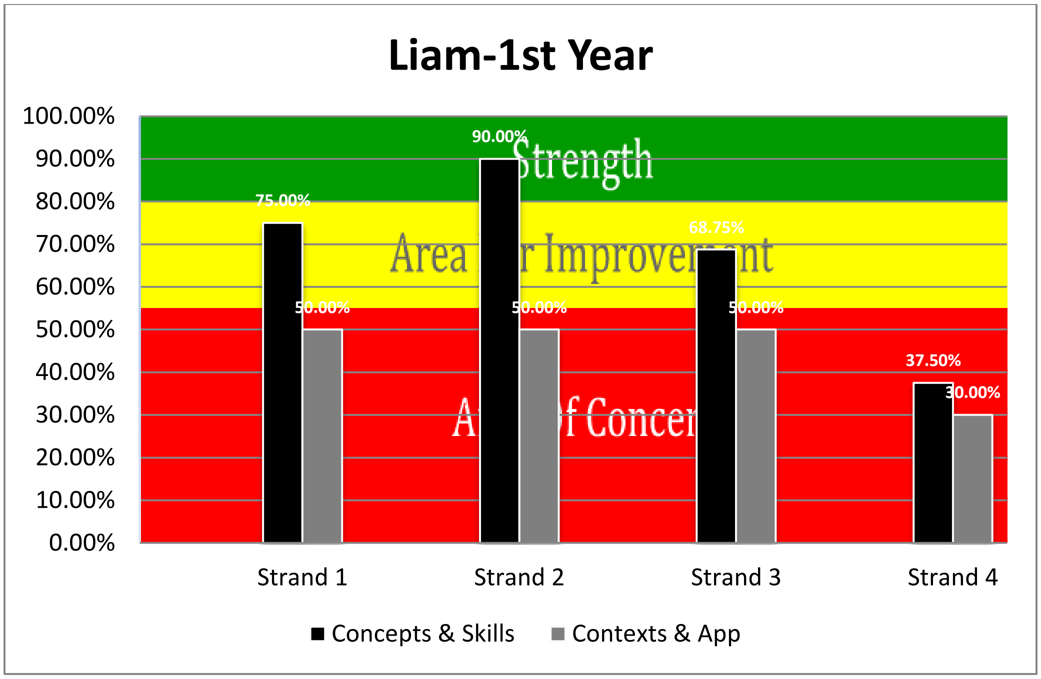


Figure 3.9: Graphical Representation of Students Results

For this study both the pre and post-tests for all three groups (control, test and TY groups) were administered on a Tuesday afternoon from 2pm to 3:10pm, giving each student seventy minutes to complete the test. The pre-test took place exactly one week prior to the intervention beginning and the post-test took place exactly one week after the intervention ceased for the control group, test group and TY group.

The peer tutors took their pre-test a week before they began engaging with the numeracy intervention with the author. They took the post test at the same time as the other two groups. As the control group are all one base class they took both the pre and post-test in their base classroom being supervised by their class teacher at that time. According to Watt and Van den Berg (2002) research studies that consist of a control group allow for comparisons between groups and strengthen the validity of your research. During the test, the students were supplied with all the necessary instructions and equipment (rulers etc.) required. The TY groups pre-test were supervised by the author as was the test groups pre-test. The TY and the test group did their post-test in the same room supervised by the author and another colleague. Again they were supplied with all necessary instructions and equipment. The author corrected all the tests using the marking scheme created (see Appendix H). The author validated this test by getting other mathematics teachers to scrutinise the test and marking scheme and also by piloting the test.

Attitudinal Survey

A survey was developed, by the author based on the Fennema-Sherman attitudinal survey (1976), which sought to assess students' interest and achievements in mathematics. Cohen et al. (2011) states that surveys are a frequently used instrument in data collection. Wilson and Mclean (1994) explain that they are a useful source of information, providing a lot of data and are very easy to administer. Their value however, depends on the quality of the survey and Cohen (2011) argues that it takes a very long time to create a survey as you must pilot and redraft the questions. They also believe that a survey can limit the responses that people can give. Phellas et al. (2011) see one advantage of a survey being that it can be easily administered and a large amount of data can be gathered over a short period of time. They further believe that people are more likely to answer truthfully in comparison to an interview. However they also outline that a negative factor associated with the survey approach of collecting data is that you have no opportunity to probe further responses.

The author considered other attitudinal surveys during the survey design phase, such as the student attitude survey by Mislevy et al. (2013) and Aiken's (1974) scale of measuring the enjoyment and value of mathematics. The student attitude survey by Mislevy et al. (2012) consists of likert scale type questions about attitudes and beliefs about mathematics, school and technology. Aiken's (1974) survey measures attitudes towards mathematics and is comprised of two subscales, the value of mathematics scale and the enjoyment of mathematics scale. Tapia et al. (2004) describe the Fennema-Sherman attitudinal survey (1976) as the most popular research instrument used to collect data on attitude towards mathematics. Fennema-Sherman's original survey is divided into nine different domains; attitude toward success in mathematics scale, mathematics as male domain scale, mother/father Scale, teacher scale, confidence in learning mathematics scale, mathematics anxiety scale, effectance motivation scale in mathematics and mathematics usefulness Scale. Due to the large variety of questions in the Fennema-Sherman's attitudinal survey and because of its popularity as an effective research instrument the author decided to use this survey for this research, however modify it in order to have a more specific focus in relation to this studies research questions.

The author divided the questions in the survey into 4 sections, self-belief in mathematics, mathematics and pedagogy, interest in mathematics and mathematics achievement. As this research focuses on interest and achievement in mathematics these were two obvious sections to the survey. Students' self-belief in mathematics is important to ascertain as well as how the teachers have been taught mathematics thus far. The author added 2 questions to the survey, one questioning whether or not students' use group work in their mathematics class as well as a question about whether or not students felt mathematics was important for their future career. As working in groups is a methodology used in this research the author believed it important to ascertain if students had ever worked in groups in mathematics class in the past. The author also believed it may be of interest to discover it students felt that mathematics would be of importance to them in their future careers. Due to only two questions being added to the survey which contains 76 questions in total and because these questions were part of the pilot, the validity and reliability of the original scale should not be affected. Some minor restructuring of some of the questions occurred due to students having trouble understanding some words during the pilot of the survey. It is vital that survey questions provide the researcher with relevant data for the study. Brinkman (2009, pp.32-33) provides the following guidelines about how to formulate questions in a questionnaire;

- "*Pose one question at a time;*
- *Questions should be unambiguous;*
- *The language and expected knowledge should fit the target group;*
- *Formulate questions neutrally, avoid leading questions;*
- *Avoid unnecessary sensitive questions;*
- *Avoid negative or double negative questions*".

These guidelines were all adhered to for the attitudinal survey developed for the purpose of this study.

Another aspect to consider in a survey is whether the questions are open ended or closed questions. Cohen et al. (2011) explains that open ended questions allow the person answering the survey to respond to the question in whatever way they see fit whereas closed questions gives the person completing the questionnaire a range of answers to choose from. Brinkman (2009) and Cohen et al. (2011) both see positive and negatives to the 2 question styles. Open ended questions can often give you richer data however analysing this data is far more difficult. Also, answering open ended questions is more difficult for the respondent. Closed questions, while not giving you as rich a data as open ended questions, are far easier for the respondent to answer and far easier for the author to analyse. The Fennema-Sherman attitudinal survey (1976) contains closed questions only and any additional questions added to the author's survey followed the same format. As the survey contains 76 questions in total, the author believes that the data collected will be rich regardless.

The author looked at different ways in which the survey questions could be answered prior to choosing the Fennema-Sherman attitudinal survey (1976) and believed that a rating scale approach would work best as it would be easier for students to understand and allows for ease of answering. Cohen et al. (2011) discuss 4 different types of rating scale; Likert scales, semantic differential scales, Thurstone scales and Guttman scaling. The survey uses the Likert scale to enable students to answer it. The Likert scale, created by Likert in 1932, allows for a range of responses from strongly disagree (1) to strongly agree (5) (see Table 3.3). Cohen et al. (2011) state that this type of scale allows for a range of responses and is very easy to interpret.

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

Table 3.3: The Likert Scale.

The author chose this scale for her survey as the Fennema-Sherman (1976) attitude scale adopted this approach.

These surveys were administered to both the test and control group the day prior to the start of the intervention and the day after the completion of the intervention. The peer tutors were administered the survey's before engaging with intervention material and the day after completion of the intervention. During the pilot of the survey no time limit was put on how long it should take to complete the survey. All students had completed the survey within 20 minutes. As a result the students were given twenty five minutes to complete the survey for this research. The author compared pre and post survey results for the test group, control group and TYs to identify any change in attitude and interest of the students towards mathematics that occurred over the course of the intervention.

Focus Groups

Cohen et al. (2011) describe focus groups as a type of group interview. Cohen et al. (2011) state that focus groups are time efficient and produce a large amount of data in a small amount of time. Stewart and Shamdasani (2015) state that it is now a widely used tool in research which gathers rich qualitative data. Cohen et al. (2011) explain that focus groups begin by a group being given a topic which they then discuss. The group comes up with a view between them. Through this discussion between peers the author would expect to get honest data. However Morgan (1997, p.5) states that "*the quality of the data depends on the quality of the preparation: Careful planning cannot guarantee insightful results, but a cavalier approach to the design and execution of the research is almost certain to produce poor results*".

Morgan (1997) believes that successful focus groups are well structured with a large amount of participation from the interviewer, have 6 to 10 group members, and have a total of three to five groups in total and that each group member is unknown to one another. Morgan also states however that it is rare for focus groups to have all four of the named features. Morgan also agrees that thought must go into the mix of sex, gender and personalities in each group. Cohen et al. (2011, p.437) states that "*sampling is a major key to the success of focus groups*". Cohen et al. (2007) also identifies a problem that can occur when one focus group member is more dominant in the group. This can suppress the voices of the more introverted group members. Cohen et al. (2007) states that the interviewer must be prepared for this eventuality.

Focus groups are often used instead of individual interviews as a method of collecting qualitative data. Cohen et al. (2011) argue that focus groups are time efficient and produce a large amount of data in a small amount of time. He also believes them to yield less data than individual interviews.

In this study, focus groups were conducted with the test group and the TY group. They took place approximately a week after the intervention ceased. The questions used for the focus group were carefully created by the author in order to gain an insight into the success, or lack thereof, of the intervention. There were 20 questions created for the 1st year focus group and 15 questions created for the TY focus group. The focus groups lasted approximately 45 minutes each. The author hoped to gain an insight into whether the students enjoyed the intervention, did their interest in mathematics increase and did their achievement in mathematics increase. This data can be triangulated with both the surveys and the pre and post-test. In both the TY group and the test group there were 4 focus groups, each consisting of 6 to 7 students and 1 interviewer. The interviewer for the peer tutor group was the author. The interviewers for the test group were 4 of the more mature and reliable members of the peer tutor group under the moderation of the author. The reason for this was the hope that the test group would feel more comfortable communicating honestly to a peer. The author spent a double class with the TY interviewers discussing how to successfully conduct a focus group. The author conducted a random sample to ascertain who would take part in the focus group and once these students were selected the author spent a large amount of time deciding on the members of each group. Careful consideration was given to ensure that there was an equal mix of personality types in each group.

Data Analysis

The author used SPSS to analyse the quantitative data from the survey and the pre and post-test. All questions were given individual codes and a code was also given to missing data. When entering data, students were allocated pseudonyms to ensure anonymity. The qualitative data from the focus groups was analysed by transcribing each interview and identifying the common themes that emerge from the students' opinions and their conversations. Again, students were allocated pseudonyms to ensure anonymity.

Pilot Study

The author piloted the intervention in this research. The intervention was developed after the author conducted her literature review. The author's findings indicate collaborative work in the form of peer tutoring as a good way of gaining students interests (Goodlad, 1995; Mitchell, 1993). Making content relevant to the group also involved triggering interest (Mitchell, 1993).

Maintaining interest leads to achievement (Mitchell, 1993). The author used this information to create a student handbook which was used during peer tutoring sessions. The student handbook was divided into ten sessions which would be delivered over ten weeks. Each session is expected to last 1 hour and 10 minutes. The content in the handbook was created in a way that it is relevant to young people. This was achieved by creating questions that incorporate topics that interest students, such as pop stars and musicians, high profile sports teams and players and mobile phones. It contains problem solving questions and numeracy activities. Throughout the intervention the author acted as the intervention facilitator and TY students were encouraged to ask for help when required.

At the beginning of piloting this study, the author spent 3 weeks teaching the content of the student handbook to the peer tutors. This involved getting the tutors to work in pairs while attempt each task and then discuss as a group how to best solve the task. The intervention facilitator made an effort to help students to articulate their explanations to each task as best they could. During this time careful consideration was made to pairing tutors and tutees, for example same sex pairings where possible and pairing the more mature tutors with the more challenging tutees. During the pilot of the intervention a TY student tutored a 1st year student through the handbook. TY students also did some whole class teaching at the beginning of each lesson. During the intervention the tutees were withdrawn from their mainstream class which was a double class of either science, German, French, Spanish, home economics, woodwork, technical drawing or art. The control group were in one of the aforementioned classes while the intervention was taking place. As part of the pilot study both TY students and 1st year students sat a pre and post intervention test and survey. A focus group was held on completion of the pilot study intervention. The information gained from the research instruments used during the pilot study and the information from the pilot study itself led to the refinement of the intervention.

The pilot study helped the author to address problems with the intervention. The biggest problem with the initial intervention was that the content to be covered was too vast. This was made evident by the fact that all intervention material was not completed in the 10 weeks allocated. From the pre and post-test the author identified some areas that the majority of students got correct in the pre-test intervention. As a result it was decided that this content would be removed from the student handbook and the test. This, while reducing the content in each workshop, also allowed for the intervention to be reduced to 7 weeks which proved to be more appropriate as many students reported that 10 weeks for the intervention was excessive and the intervention began to lose its value.

The pilot study also highlighted the issue of the TY students teaching the entire test group. A large number of TY students struggled to explain basic concepts when teaching in front of the entire class. They found it to be stressful and did not enjoy the experience. Therefore it was decided that TYs teaching content to the entire test group prior to them working through the student handbook be removed and instead each tutor would work through the content with their tutee. The author also created a tutor handbook for TY tutors. This handbook offers step by step instructions for tutors on how to explain content to their tutee as well as prompts to give them when necessary to help guide their tutee through their work. An answer booklet was also developed. As well as this the pre intervention teaching time with TYs was extended to six weeks. This allowed for a more thorough analysis of the student handbook and tutor handbook which in turn increased the confidence of the TY tutors. The revised intervention materials are presented in chapter 4.

3.7 Validity, Reliability & Triangulation

Validity is imperative to worthwhile research. Cohen et al. (2011) explain that validity is necessary for both qualitative and quantitative data and if your data is invalid then your research is worthless. Winter (2000) outlines that in order for qualitative data to be valid the data collected must be honest, have depth and allow for triangulation. For quantitative data to be valid, careful sampling and data collection must be used. However, they do explain that it is impossible for data to be 100% valid and a degree of error is to be expected. Once the degree of error is kept to a minimum the research findings will be seen as valid.

During this research the author collected both quantitative and qualitative data. The author believes the data to be honest and have depth. Cohen et al. (2007) believes that focus groups are an effective way to triangulate with other research instruments such as surveys. The author used focus groups, surveys, pre and post-tests and a control group in order to ensure that triangulation of data could occur and that the data collected has depth.

Cohen et al. (2011) describe reliability as dependability, consistency and replicability over time, over instruments and over groups of respondents. They believe it to be largely concerned with precision and accuracy. Heffner (2014) states that in order for data to be reliable there should be a strong positive correlation between any pre and post-testing. Heffner believes that "the memory effect" can test the reliability of data collected. If pre and post testing occur within a short period of time between them then this can impact on the reliability of your data. Due to a minimum of 9 weeks between pre and post testing for this study, the author believes the data collected to be reliable. Replicability and dependability are also factors that impact on reliability. Joppe (2015) explains that replicability refers to idea that the results obtained can be reproduced, will be consistent over time and represent the total population. Golafshani (2003) explains that in order to deem the research reliable both how the research is conducted and the results of the research must be examined.

Triangulation of data is defined by Cohen et al. (2011, p.195) as "*the use of two or more methods of data collection in the study of some aspect of human behaviour*". Bryman (2003) states that you can have more confidence in the data you collect if triangulation of data has occurred. The author used methodological triangulation (Bryman, 2003) in her research by using a survey, pre and post testing and focus groups as her research instruments.

3.8 Ethical Issues

Cohen et al. (2011) identifies that there is now greater recognition being given to ethical concerns in research. Hammersley and Traianou (2012, pp.2-3) identify the following as some of the main ethical issues that need to be considered;

- "*Minimising Harm*
- *Respecting Autonomy*
- *Protecting Privacy*
- *Offering Reciprocity*
- *Treating People Equitably*".

The author received ethical approval from ULREC for this study in March 2013. Preceding this, the author supplied her principal with an information sheet (Appendix I) and a consent form

(Appendix J). The author then supplied the same to all participants in the study (Appendix K and Appendix L respectively). In the information sheet all necessary information was given to the participants and they were made aware that they could withdraw from the study at any time. They were also made aware that no information that could identify them in the study would be used. All participants were assigned pseudonyms and all data collected is stored in a locked filing cabinet in the author's school.

3.9 School and Student's profiles

The research sample for this study consisted of students from the same school. The author has been teaching in this school full time since 2009. The school is located in a large town in Munster on the west coast of Ireland. It is a co-educational school and the research sample is made up of a mixture of male and female students. The 1st year test group and control group are all students between the ages of 12 and 13. The TY group are all between the ages of 15 and 16 (See Table 3.4 overleaf for profiles of test, control and TY groups).

Class groupings in 1st year are predominantly mixed ability however often there is one group that are identified from their entrance exam (Cognitive Ability Test – CAT) as needing extra support and are grouped accordingly. These students (streamed class) could not be selected as the test group for this study (but they did act as the control group) due to a timetable constraint. The students selected as the 1st year test group were those who scored lowest on the numeracy section of their entrance exam, excluding the aforementioned group. Both the test and control groups had a similar numeracy profile at the beginning of 1st year which is why the streamed class were chosen as the control group for this study. The TY group were selected in a different manner. 60 students got to choose between peer tutoring and engineering and based on the author's knowledge of the students' personal traits the author affirmed the choice. Student's grades were not taken into account as Topping (2011) believes that as long as the tutor is performing at a more advanced level than the tutee, ability should not hinder TYs' involvement.

Prior to the intervention all the 1st year students had covered the content in lesson 2, 3 and 4 in their main stream mathematics class. This consisted of the following content;

- Order of Operations

- Multiples
- Factors
- Sets
- Prime numbers
- Fractions
- Converting fractions, decimals and percentages

During the intervention the students covered the material in lesson 5, 6, 7 and 8 which consisted of the following content;

- Tally and frequency tables
- Types of data
- Surveys
- Graphical representation of data,
- Outcomes
- Probability
- Vertical, horizontal and oblique lines
- Parallel & perpendicular lines
- Measuring angles
- Vertically opposite angles
- Angles in a triangle
- Read and plot co-ordinates on a cartesian graph

Content from lesson 1, 9 and 10 were not covered in the 1st year students mainstream mathematics class either prior or during the intervention. This consisted of the following content;

- Time and timetables
- Order of operations and visual patterns
- Sequences
- Substitution
- Simplifying expressions
- Creating and solving equations

TY students mainstream mathematics classes largely focused on algebra from September to December.

3.9.1 Study Sample

The students chosen to take part in this study are 1st year and TY post-primary students, aged approximately twelve and sixteen years respectively. The reason for this is that these are the only two groups of students that the author's school can timetable to work together at the one time.

Group	No. of Students	Gender
1st year test group	30	Male: 12 Female: 18
1st year control group	30	Male: 14 Female: 16
TY group	30	Male:11 Female:19

Table 3.4: Profile of Students Participating in this Study.

30 TY students, 30 1st year peer tuttees, and 30 1st years for a control group took part in this intervention. While this is seen as the minimum sample size for quantitative research (Cohen et al., 2011), location constraints did not allow for a larger sample size. The author was never the mainstream class teacher of any of the students in the TY, 1st year test group or control group.

The 1st year students selected for this intervention were selected from their school entrance exams called the Cognitive Ability Tests (CAT). The author selected the students who performed lowest in the numerical component of this test. An information letter was sent home to parents as well as a letter of consent to take part in this research. The TY students who took part in this study are students who chose to become involved in peer tutoring.

Another group of 1st years, with similar CAT profiles to the peer tutoring 1st year group were selected as a control group to improve the reliability of the interventions data. Using this data the author can account for external influences on 1st year students' pre and post test results.

3.9.2 Response rate

Consent forms were given to all members of the research sample and their guardians. The entire control group and the TY groups completed the consent forms and returned them. However 2 of the guardians in the 1st year test group did not give consent. As a result 2 more students were selected and consent was given. 100% of the students completed the pre and post-test and survey. 24 TY and 1st year students from the test group took part in the focus groups.

3.9.3 Attendance rate

Attendance for the duration of the intervention was very good. This could be due to many factors, one being that students were told that they would be allowed to attend a party in the school at the end of the intervention if they achieved full attendance. Also the TY co-ordinator informed the TY students that this class was a priority for the duration of the intervention and they were not permitted to miss it for any other activity. It was reiterated to TY students that they were committing themselves to working with their tutee for the duration of the intervention and it was their responsibility to complete the intervention with their tutee. 3 1st year students missed 1 class and 1 1st year student missed 2 classes. 2 TYs students missed 1 class. As the sample size in the test group was unavoidably small, and because the students who missed classes still sat the pre and post-test and pre and post survey, the data associated with these students was used in this research findings.

The data for this study was collected from September to December 2014.

3.10 Limitations of the Study

There are a small number of limitations identified in this study. This study took place in 1 school, where the author works, which means the sample is taken from a small population. Due to the small sample size in this research the results may not be representative of the entire population. Time-tabling constraints meant that the student's got to meet for 1 double period (70 minutes) only per week. While every effort was made by the author to gain a test group and a control group with similar entrance test scores, some variances are apparent. All groups are being taught mathematics outside of the intervention which may have some impact on data gathered. However, this is the same for both the control group and the test group so it is likely that discrepancies recorded can be attributed to the intervention. Another limitation to this study is that the author was unable to retest the sample groups some months after the intervention This means that the author is unaware as to whether or not students maintained their increase in interest and achievement in mathematics. Although the intervention was designed to take place over the course of 7consecutive weeks, due to a fixed event in the TY calendar, the intervention took place over 8 weeks. A final limitation to this study is that the author did not assess the data and compare performances between male and female students. Considering that the author noted there to be much variation in male and female students interest and achievements in mathematics in the literature review this is a limitation to this study.

Although the aforementioned limitations exist, the author still believes that the mixed method approach used as well as the triangulation of data obtained will allow for the limitations to have little impact.

3.11 Conclusion

This chapter has given an account as to the type of research that was conducted, which was action research. It explains why action research was the most appropriate type of research for this study. The theoretical framework for this study was discussed and the research methods are outlined. The author details the research instruments she uses and validity, reliability and triangulation are considered. Finally ethics and study limitations are outlined.

Chapter 4
Intervention Design & Implementation

4.1 Introduction

The aim of this chapter is to describe how the intervention developed as part of this research. The author will describe how the intervention has been designed and implemented. Yeager and Walton (2011) strongly believe that interventions in education can have a positive impact on students' achievement. The design and implementation of this intervention was heavily grounded in the literature discussed by the author in chapter 2. A student handbook and resources were created to use during the intervention and 1st years were peer tutored by TYs through the content. Peer tutoring was selected as the author has learned from her research that peer tutoring can improve students' interest and achievement in a subject area (Goodlad, 1995; Miller, 2006; Topping, 2011). The intervention took place in addition to the 1st years normal mathematics class so each week the 1st year test group received an additional 70 minutes of mathematics to that of the control group. A detailed account of each aspect of the intervention will be given in this chapter, from all the resources used during the intervention to how and why the intervention was implemented in the way it was.

4.2 Aims of Intervention

The aim of this intervention was to;

- Improve 1st year and TY students' interest in mathematics
- Improve 1st year and TY students' achievement in mathematics.

The literature review guided the author in methods that would allow her to achieve the interventions aims. A peer tutoring programme with a carefully developed numeracy handbook and resources was developed in order to improve both 1st year and TY students' interest and achievement in mathematics.

4.3 Development of Intervention

It was decided that a student handbook and a set of accompanying resources be created and delivered by means of peer tutoring. Once a pilot study was conducted it was also decided that a tutor handbook and tutor answer booklet were necessary. The author will now outline other insights obtained from the pilot study phase of this research project.

4.3.1 Pilot Study

Van-Teijlingen and Hundley (2001) explain that pilot studies are an important element of a good study design. They ascertain that it increases the likelihood of a study being a success as it allows one to trial all intervention materials and research instruments and adapt them where appropriate. A pilot study was conducted for this research from February 2014 to May 2014 and the actual intervention implementation took place from September to December 2014. This allowed the author 3 months to make the necessary changes to the intervention. As explained in detail in chapter 3 many changes to the intervention took place as a result of the feedback obtained from the pilot study. To summarise, as a result of the pilot study findings the following actions were taken;

- Tutor handbooks and answer booklets were developed to support the TY students during peer tutoring as they stated they needed this.
- The amount of time the author spent teaching the content of the intervention to the TY students increased from 3 weeks to 6 weeks as the pilot highlighted that 3 weeks was not enough time for full engagement with the intervention materials. This allowed for a more thorough analysis of the student handbook and tutor handbook which in turn increased the confidence of the TY tutors.
- TY students teaching the entire peer tutoring group during stages of the intervention was eliminated as it was observed that the students did not feel confident doing this and the majority did not enjoy it. It was decided that instead each tutor would teach their own tutee individually, with the support of the handbook and answer booklet.
- The time the TY students spent tutoring 1st year students decreased from 10 to 6 weeks as information from the pilot focus group highlighted that the intervention length was too long and as a result many felt its value diminished towards the end.

- The content in the student handbook was reduced. From analysing the 1st year students' pre-test it was observed that there were some questions which most students answered correctly. As a result this content was removed from the student handbook and the test. The reduction in content also proved necessary due to the aforementioned reason which stated that students found the 10 week intervention too long.

4.4 Intervention Instruments

A description will now be given of the content and format of the tutor guidelines, answer booklet and student hand book.

4.4.1 Content & Format of the Tutor Guidelines & Answer Booklet

Research shows that improving teaching materials and strategies as well as improving how tasks are taught using age appropriate contexts can aid situational interest (Hidi and Berndorff, 1998); Lepper and Henderlong, 2000). From the pilot study it was seen as necessary to create a tutor handbook to give guidelines to the TY tutors on how to teach their 1st year students. The TY students underwent several weeks of training with the author and during this time they used the tutor handbook and answer booklet to aid their learning. The tutor handbook gave each tutor step by step instructions about how to engage with and talk through the student handbook and resources with their student. The author ensured that the wording in the tutor handbook was coherent and easy to follow. Any problems that the students did have were aired during the weeks that the tutors worked with the author.

4.4.2 Content & Format of the Student Handbook

Prior to developing the student handbook the author was acutely aware of the congruence between mathematical skills and numeracy skills. The literature review guided the format of the student handbook. It is divided into 10 lessons which were delivered over 6 weeks. As previously discussed in section 3.6, as a consequence of piloting the diagnostic test and the intervention, some of the content was removed from the student handbook. As a result, during the first double class 2 lessons were worked through, the first on time and timetables and the second on the order of operations. On week 2, 2 of the lessons on number were delivered during the double class. Also, on week 3, time afforded a lesson on statistics and probability to be delivered. The content in each lesson covers aspects from one specific strand of the Project Maths syllabus. The content of the student handbook was decided on during a previous project by the author whereby the basic numeracy skills from each Project Maths strand were identified. The 1st year syllabus guidelines were examined in detail and the basic numeracy skills from each strand were identified. The student handbook was initially created based on the diagnostic test discussed in Chapter 3 and was edited based on the knowledge acquired from the pilot study. The profiling test used in the pilot study showed that some questions in the pre-test were answered correctly by most or all students. As a result these topics were eliminated from the profiling test and the student handbook used during the intervention was edited in light of this. Some further content was removed from the handbook due to information from the pilot focus group stating that the intervention was too long. The content removed was the content that was best answered during the pilot test. Each lesson has a different set of lesson aims and objectives.

One of the intervention objectives was that each student's interest and achievement in mathematics would increase from pre to post intervention. From the literature review Mitchell (1992) outlines that situational interest is triggered quickly if the environment is conducive for the learner. The author aimed to do this by using group work, peer tutoring and mathematics games in this intervention which Hidi and Harackiewicz (2000) also believe to be ways to trigger interest in mathematics. In order to maintain interest, Mitchell (1992) states that the intervention needs to be meaningful to the student and see the student actively involved in the intervention. In this intervention the author aimed to do this by making the material in the student handbook meaningful to the students by contextualising each task and relating tasks to topics teenagers often have an interest in such as chart music, sports teams and technology. Many of the tasks in the student handbook contain real life data from the local community; for example, names of local shops, train timetables, maps, sports teams and so on. Hidi (1990) believes that situational interest can have positive effects on students' motivation, especially those who show very little motivation to begin with, so contextualised tasks should create situational interest for the students. The author used group work, resources, games and hands on resources to ensure that each student was actively involved during the intervention. Individual interest is developed through situational interest and over time this should lead to an increase in achievement (Mitchell, 1993). It should also be noted that the images and pictures used in the student handbook were carefully chosen in order to further interest the students. The author also chose to use the word ‘task’ instead of ‘question’ for each exercise in the student handbook as she felt that the word ‘question’ is used far more regularly in their text books and therefore may hold some negative connotations for some of the students. Completing the numeracy intervention was itself, a mathematical achievement for the students involved as these are students who struggle with mathematics and do not perform well in mathematical assessment. To achieve success in mathematics, for them, is significant.

4.4.3 Student Handbook Challenges

Each lesson begins with the learning objectives for that lesson so that the student is aware of what they should have achieved by the end of the lesson. A challenge is then given to the student. The challenge consists of a question/questions covering some of the content in that lesson and they are procedural style questions. The Special Education Support Service’s (SESS, 2009) research into differentiation and support for learners discusses new ways to think about questioning. They detailed that it may be worth considering moving key questions to the beginning of lessons or topic. They outline that this allows students to analyse the topic, link it to previously acquired knowledge, focus their thinking and develop higher order and more in-depth thinking. On consultation with mathematics education experts the author decided to begin each lesson or topic with a challenge. The idea behind challenges at the beginning of each lesson is that it helps to maintain students’ interest and focus throughout as they are constantly challenged. If the student gets the challenge correct they can then overlook some tasks as it is not necessary for them to complete tasks on areas that they are already competent in. The task the student must move on to will be outlined in the tutor guidelines. The tutor is not to help it’s tutee with the challenges.

4.4.4 Lesson Format

The ten lessons formats will now be discussed.

Lesson 1

The content covered in lesson 1 is time and timetables.

At the end of this lesson each student should be able to;

- Tell the time using the 24 hour clock.
- Read timetables correctly.

Being able to tell the time and read timetables are basic life skills for any person. Task 1 is a procedural task on writing time in the 12 and 24 hours clock. Prior to creating the tasks on timetables the author thought about the most common places that a teenager may be where they may have to read timetables. It was thought that the cinema and the bus/train station were appropriate so tasks were created using timetables from these 2 places. This makes the content more meaningful for the students. In task 2 the local cinema timetable is used and students are asked about the length of movies, finishing times and the time the movie starts, written in the 12 hour clock.

Task 3 is similar but uses the local train timetable from the town to the countries capital city and back. Again, the context of this task makes it more meaningful for the students. This task requires the students to be able to interpret the timetable as they are asked questions regarding the length of time it takes to get from one station to another and what train they need to get in order to be in a certain location by a certain time.

Lesson 2

The content covered in lesson 2 is order of operations.

At the end of this lesson each student should be able to;

- Understand the importance of BIMDAS in the order of operations and apply BIMDAS.

The aim of this lesson is to develop students understanding of the importance of the order of operations. The key mathematical concept that the students are required to understand is that in the order of operations you solve what’s within the brackets first, then indices, followed by multiplication and division and then addition and subtraction (BIMDAS).

Task 1 (see Figure 4.1 below) involves the students developing an understanding of BIMDAS. Part a) is getting the student to develop a numerical expression from a context familiar to them i.e. the nearest shop to the school, Gala. Part b) involves the student solving a numerical expression and part c) involves the student comparing the expression they created in part a) to the expression given to them in part b). From this the hope is that, with the tutors help, a deeper understanding of the relevance of the order of operations will have developed among all students.

Task 1

a) If you go into Gala and buy three large bottles of Sprite for €2 each and 5 packets of crisps for €1, how much do you spend? Please show your workings.

Gala
Your local market

b) Solve the following $2 \times 3 + 1 \times 5$

c) Are you answers to part a and b the same? If so, why do you think this is?

d) Discuss the importance of the order of operations with your tutor.

Figure 4.1: Lesson 2, Task 1.

Task 2 involves deepening students' understanding of the order of operations by showing students a question that apparently 73% of the population get incorrect. A discussion is warranted as to why people answer this incorrectly and this leads to the student attempting to answer this correctly. Task 3 involves procedural questions using BIMDAS to ensure each student has grasped this important concept.

Task 4 involves 2 contextualised questions whereby the student must firstly create an expression from the information in the task and then simplify the expression bearing in mind the order of operations. Both questions deal with a context that intends to interest the student, for example, purchasing Converse shoes and tickets to a football game of the local team.

Task 5 in this lesson involves students using the knowledge they have acquired in a fun way and the entire peer tutoring group work on this task at the same time. As all students may work at different speeds it is unlikely that all students reach this task at the same time. Renandya and Richards (2002) discuss a number of ways to deal with students who complete work at different rates. They outline that one idea is to let the earlier finishers' complete homework or to move on to another assignment while waiting for other students to complete a task. The author decided to apply Renandya and Richards's strategy and allow students to move on to the next task. However the author believes that all group tasks in this intervention are worthwhile therefore the tutors are asked to alert the intervention facilitator when they reach task 5 and then move on to the next lesson and when all students reach task 5 each tutor pair will return to this task for completion. The facilitator uses a PowerPoint version of 'Who Wants to be a Millionaire' (see Figure 4.2 overleaf), to encourage students to use the order of operations correctly. Students are required to work with their tutor and write their answer (a, b, c or d) on their own mini whiteboard. They must all lift up their whiteboards when indicated. If they get an answer incorrect they are out of the game. The students who are eliminated from the game can still attempt to answer the questions with the aid of their tutor however they should not lift their white boards to show their answer to the class. Those students who are not eliminated and get all the questions correct receive a small prize.

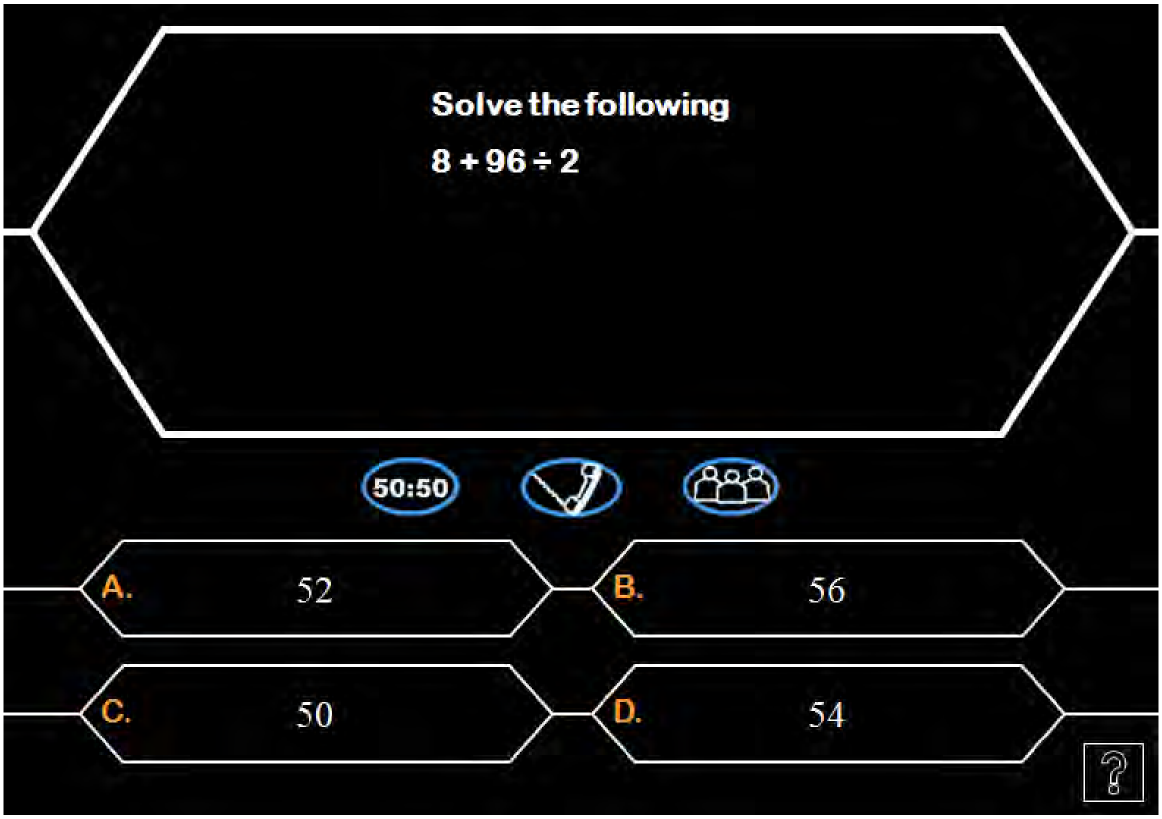


Figure 4.2: Lesson 2, Task 5, Who Wants to be a Millionaire? Sample Question.

Lesson 3

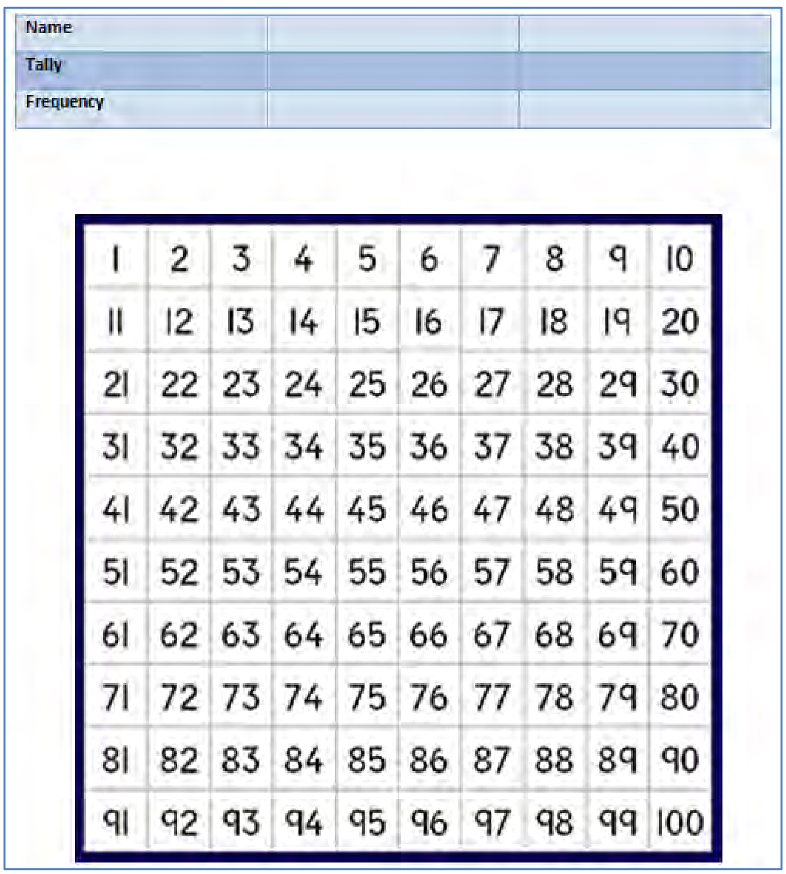
The content covered in lesson 3 is number.

At the end of this lesson each student should be able to;

- Identify multiples.
- Identify factors.
- Identify prime numbers.
- Understand basic set theory.

The aim of task 1 is for each student to develop an understanding of multiples. Firstly they are asked to multiply 5 by 1, then by 2 and so on. They are then asked to describe the relationship between each answer with prompts from their tutor when required, for example, "What is the difference between each number?". From this they should be able to see a pattern and be able to describe it, thus understanding what a multiple is. The student is then given 2 numbers and asked to write down the first 14 multiples of each number. Students are then asked to see if the 2 numbers have any multiples in common, and if yes, what are these multiples? Finally they are asked what is the lowest multiple that the 2 numbers have in common and what do we call this multiple. This is scaffolding the learning for the student which as Wood (1998) explains develops students understanding.

The aim of task 2 is for each student to develop an understanding of factors. Task 2 begins with the student being given the first 4 factors of 15 and they are told that these numbers are factors of 15. From these factors and with the help of their tutor, if required, they must come up with a definition for what the word factor means. Like the previous task, they are then asked to list the factors of 2 numbers and asked to find the highest common factor.



Name		
Tally		
Frequency		

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Figure 4.3: Lesson 3, Task 3, Factors Game.

Task 3 (see Figure 4.3 on the previous page) is a game that 2 1st year students play together under the supervision of their tutors. The instructions to play the game go as follows;

- Both roll a die and the largest number goes first.
- The first player chooses a number and crosses it out on the grid. This number must be a number over 70. It was decided that the game must begin with a large number as if the student picked a low number at the start it may be a number with a small number of factors thus making the game too easy from the outset.
- The second player chooses a number to cross out. This number must be a factor of the first number.
- Players continue to take it in turns to cross out numbers, at each stage choosing a number that is a factor of the number just crossed out by the other player.
- Once a number is crossed out it cannot be reused.
- If a player is unable to cross out a number that is factor of the previous number crossed out then this player's opponent gets a point.
- The person with the most points at the end of the game wins.

The rationale behind this game is that it gets the students to apply what they have learned about factors in a fun context and allows them to solidify their knowledge by finding factors of a variety of numbers.

The aim of task 4 is to develop students understanding of sets. The universal set, set union, set intersection and the number of elements in a set is the set theory included in task 4. As this is a whole class activity, tutors are asked to alert the intervention facilitator when they reach this task and then move on to the next lesson. When all students reach this point each tutor pair will return to this task for completion. The intervention facilitator projects 2 sets on the board (see Figure 4.4 overleaf) one set contains the factors of 9 and the other contains the factors of 12. The teacher puts all the factors of 9 in the far right of that set and the remaining numbers in the far left of the factors of 12 set.

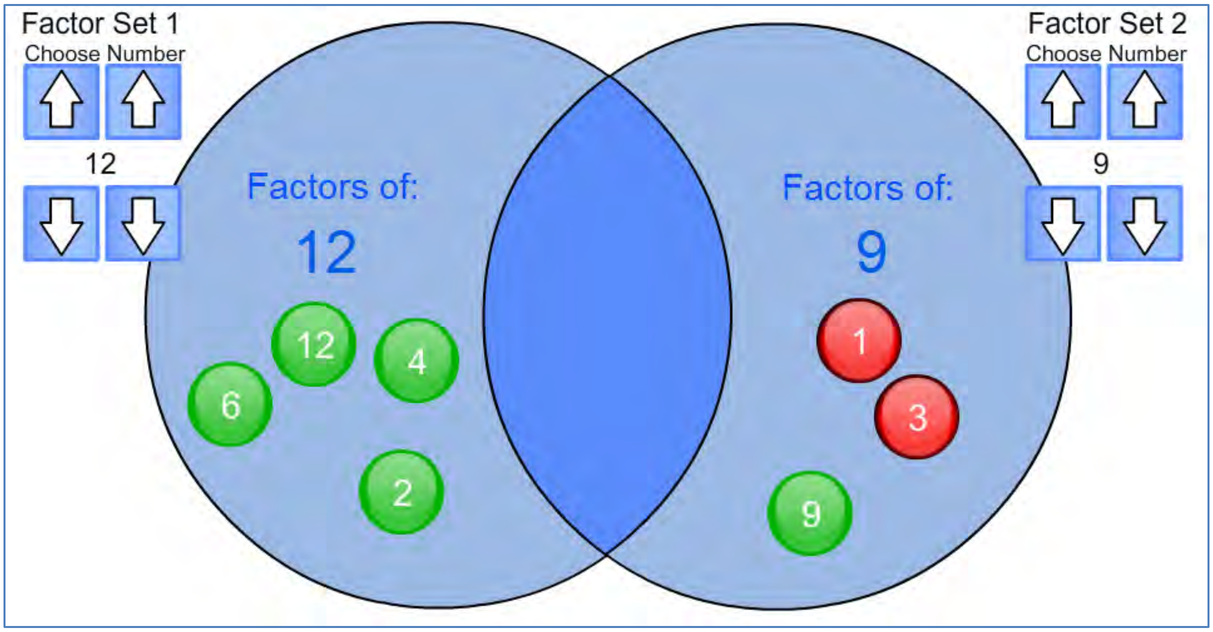


Figure 4.4: Lesson 3, Task 4, Venn Diagram & Factors.

Source: http://www.teacherled.com/resources/vennfactors/vennfactorload.html

The students are firstly asked what type of diagram this is and from there the numbers in the diagram are discussed. The students are then asked why 2 of the numbers turn red. They are also asked what the space that the two circles share represents. The factors of 9 and 12 are then outlined and common factors will be identified. An attempt is then made to fill the numbers in to the Venn diagram correctly. This task facilitates discussion and is interactive, all of which leads to engaging students interests.

The aim of task 5 is to deepen each students understanding of set theory by using a real life example. This is a group task and again the facilitator manages this task. The facilitator counts the number of students in the room and will write this number up on the board for all to see. The facilitator then asks all students who consider their hair colour to be blonde to raise their hand. The number of students who raise their hand will be written on the board. The facilitator asks all students who have blue eyes to raise their hand. The number of students who raise their hand in response to this question will also be written on the board. Finally the facilitator asks all students who consider themselves as having both blond hair and blue eyes to raise their hand. Again the number of students who raise their hand is written on the board. The students are then asked, with the aid of their tutor to attempt to fill in the Venn diagram and answer the questions on set theory that follow. This task is set in the environment that the students are currently in and each student hair and eye colour is data that is used in the task which again makes the task more meaningful for the students.

The aim of task 7 is to deepen each student's knowledge of prime numbers as they are required to be able to identify prime numbers between 1 and 100. This is done through a game (see Figure 4.5 overleaf) whereby 2 1st year students, under the supervision of their tutors, compete against one another. Both roll a dice and the largest number goes first. They start at zero and take turns rolling the two dice. Any single number rolled or any combination of numbers on the dice (addition or subtraction) can be used to try to reach another prime number. Example: Marker is on 5 and the player rolls a 6 and a 2.Their best choice is to move (6+2=8) to 13. They can also move 6 to 11 or move 2 to 7. It is not possible (6-2=4) to move to 9 as 9 is not a prime number. Players cannot move backwards. If no move can be made to a prime number, player stays on the original spot. First player to reach 97 wins.

Figure 4.5: Lesson 3, Task 7, Prime Numbers Game.

Source: http://mathcentral.uregina.ca/RR/database/RR.09.99/sawatzky1/primeboard.html

Lesson 4

The content covered in lesson 4 is again number.

At the end of this lesson each student should be able to;

- See how fractions add up to make one whole.
- Convert fractions, decimals and percentages.
- Calculate the percentage of a quantity.

The aim of task 1 is to develop each students understanding of what a fraction is in relation to one whole and what fractions add up to make up one whole. It begins with a discussion of their prior knowledge of fractions. Christensen (1991, p.16) believes that discussion in the classroom "*requires students to become profoundly and actively involved in their own learning, to discover for themselves rather than accept verbal or written pronouncements*". Further discussion is elicited when the tutor and tutee examine the fractions table (see Figure 4.6 overleaf). Both the tutor and tutee work together to discover how many of each fraction makes up 1 whole.

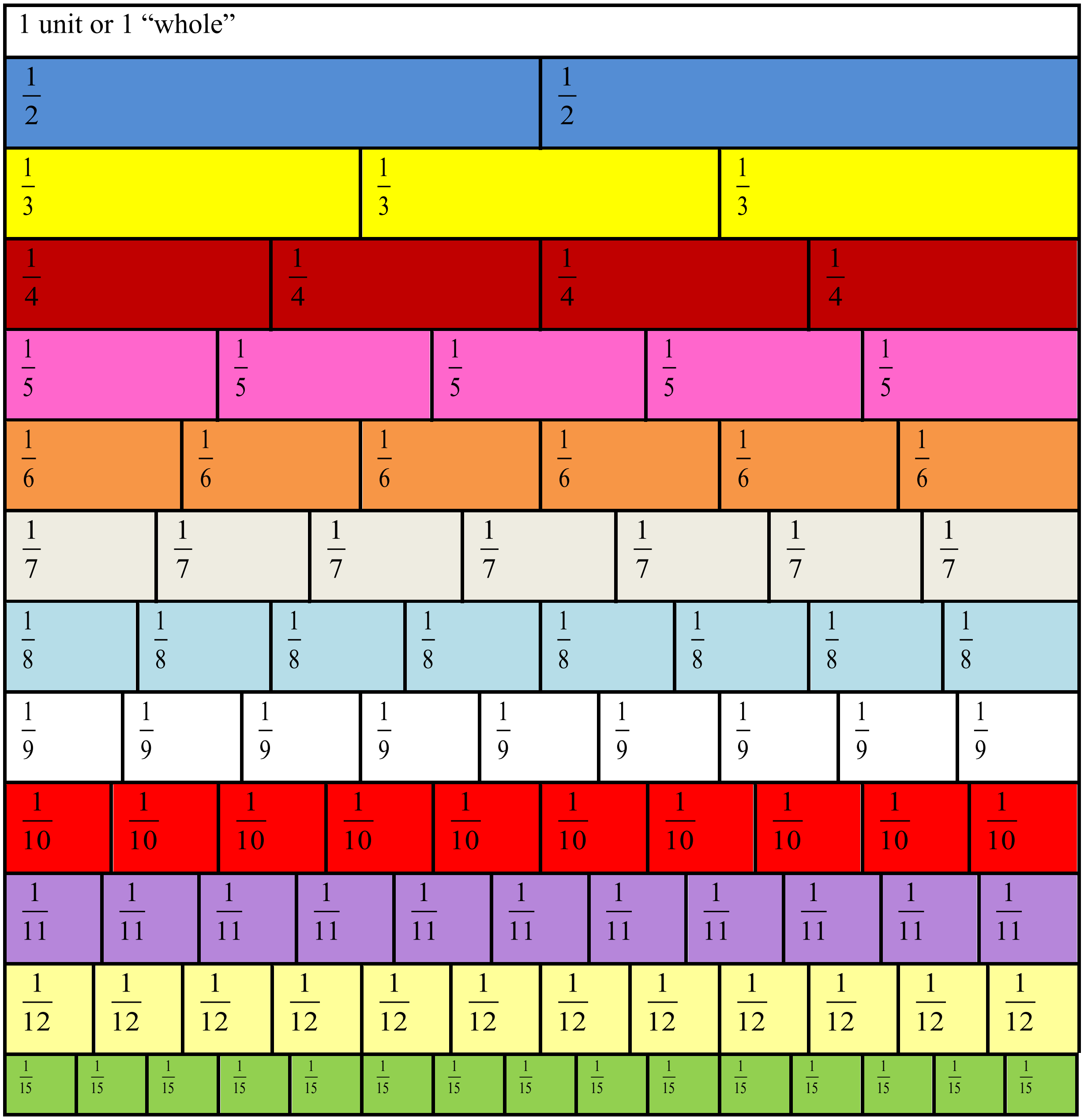


Figure 4.6: Lesson 4, Task 1, Fractions Table.

Students are then given 2 cardboard circles of the same size. They are required to fold the circle over several times, each time identifying what they have divided the card into. This is a good visual exercise for students to help them develop a deeper understanding of fractions. The final question requires students to compare 2 fractions to see which is greater in size. The 2 fractions are $\frac{1}{8}$ and $\frac{1}{4}$. The numerator of both fractions is one, however their denominators are different. The student must use their acquired knowledge to identify which fraction is greater in size.

Research carried out by the Professional Development Service for Teachers into the teaching of fractions (PDST,http://www.pdst.ie/sites/default/files/PDST%20Guide%20to%20Teaching%20Fractions%20in%20Irish%20Primary%20Schools(1).pdf) have found that often students grasp the basic concepts of fractions but they may still believe that $\frac{1}{8}$ is bigger than $\frac{1}{4}$ because of their experience with whole numbers. From folding the circle made of card this misconception should be eradicated.

The aim of task 2 is to develop students understanding of the link between fractions, decimals and percentages and convert fractions to decimals, decimals to percentages, percentages to fractions and vice versa. It begins with a discussion of what they might think is a link between them, for example "What is the difference between giving somebody half a bar of chocolate, 50% of a bar of chocolate or 0.5 of a bar of chocolate?". Methods of conversion are then discussed and each student is asked to fill in a table whereby they must convert fractions to decimals and fractions to percentages.

Task 3 aims to deepen each student's knowledge of fraction, decimal and percentage equivalence. The class teacher hands out dominoes (Appendix N) to each 1st year pair. The students are required to match the dominoes so that equivalent values are beside each other (see Figure 4.7 overleaf).

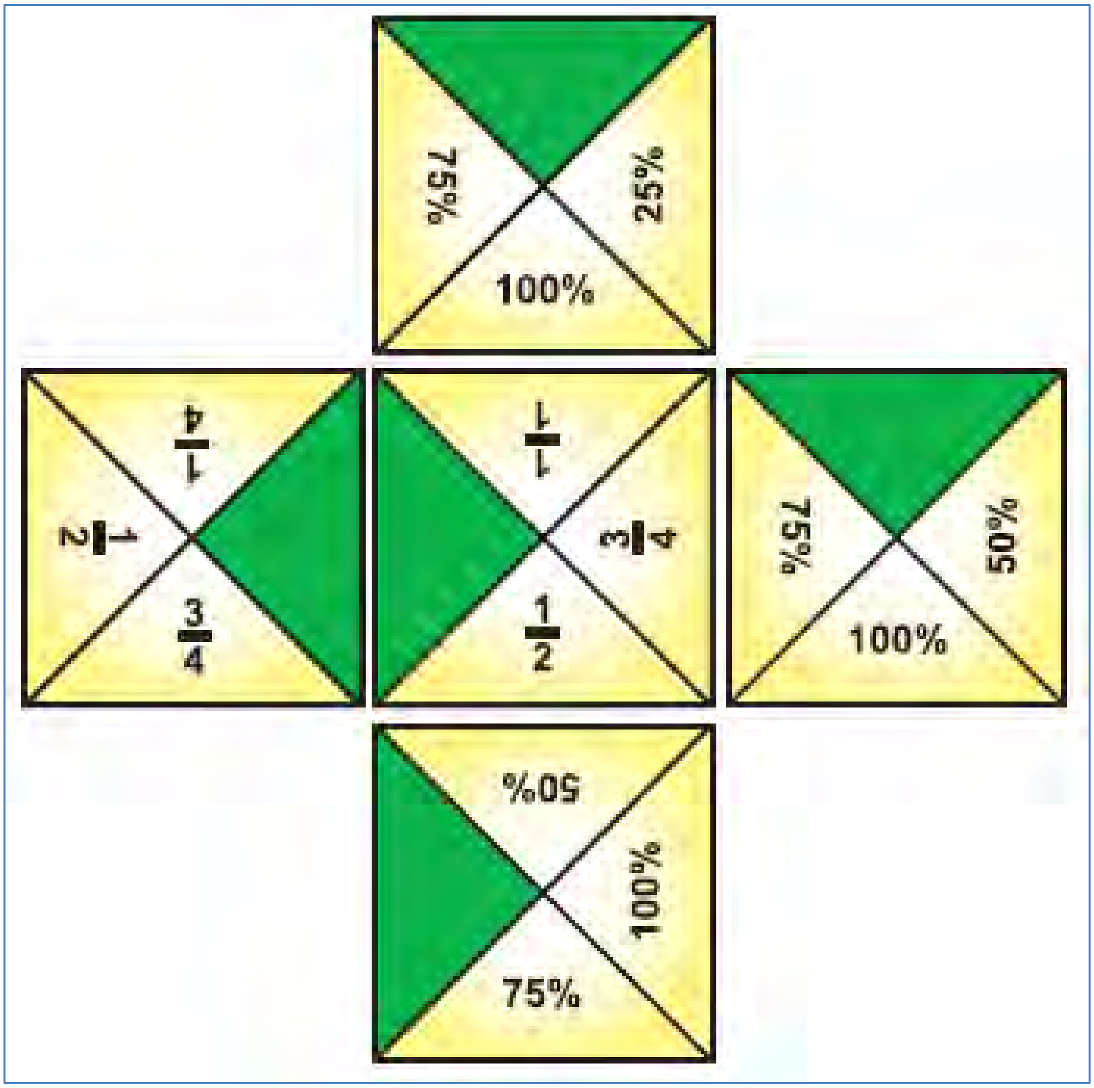


Figure 4.7: Lesson 4, Task 3, Equivalent Dominoes.

The aim of task 4 is to deepen each students understanding of percentages by using real life contexts. This task does not allow the use of a calculator in order to encourage students to develop the skill of being able to calculate the percentage of a quantity in a real life context using mental arithmetic. Students are required to calculate the percentage of a quantity in meaningful situations, such as entering a sports store to buy trainers, high tops, sports jerseys and popular head phones like Beats by Dr Dre etc. There are 5 parts to this task. For example, part (a) is a question about a pair of Nike trainers on sale in Lifestyle Sports. A person has €60 to spend. The trainers are €80 euro but now have 30% off the marked price. The students need to be able to decipher if they can afford the trainers or not. Parts b, c, d and e are all very similar.

Lesson 5

The content covered in lesson 5 is statistics.

At the end of this lesson each student should be able to;

- Tally data and record its frequency.
- Understand the different types of data.
- Identify bias in a survey and create a survey question that shows no bias.
- Identify the best graph to use to represent different types of data.

The aim of task 1 is to develop each students understanding of tallying data and using frequency tables. This is a group activity. The facilitator plays a short video clip of the 2014 All Ireland football final between Kerry and Donegal. Each student is required to carefully observe the clip and tally whenever they notice a point, goal, wide, free, pass and yellow card. This should develop students' skills on how to tally correctly using a video clip that they can relate to.

The aim of task 2 is to develop students understanding of different types of data, numerical and categorical. It begins with a discussion of what data actually is. Students are then given 2 articles and asked to read one of the articles, whichever one is of greater interest to them. They then must identify some data from this article and then decide if the data they have chosen is numerical or categorical data.

The aim of task 3 is to develop each students understanding of the type of information gathered from a survey question. They are shown a survey question that appeared in Teen Vogue magazine. The celebrities mentioned in this question are currently popular actors which should heighten the interest of students. The question in Teen Vogue asks its readers "From the following 5 movie stars, which is your favourite?" The students need to identify if the data gathered from this question is numerical or categorical.

The aim of task 4 is to develop each students understanding of how to correctly phrase survey questions so as to avoid bias. They are given a biased survey question and asked to identify anything that they see which may be wrong with the question. From here they must come up with their own survey question. The question must be multiple choice questions whereby each question has four options with only one of these options being correct. The question can be on any topic. They then get the opportunity to engage with other students in the room by asking them the question and recording their responses. Rubin and Herbert (1998) state that being actively involved in this fashion holds the students interest. Finally they get to apply what they learned in a previous lesson by writing the number of people who select each answer as a fraction of the total number of people who take part in their survey.

The aim of task 5 is to develop each students understanding of different ways to represent data graphically. While in some cases one can use a variety of graphs to represent given data some graphs are better depending on the type of data you have collected. An effort was made by the author to make all of the data to be plotted interesting to the students by using meaningful contexts to them. Firstly the tutor will guide their student through the different features of each graph. The students then examine all the data represented in each graph and develop a reason why this type of graph was used for this data. The students then go on to describe what type of data is represented in each diagram. Finally a discussion as to whether you can represent both numerical and categorical data on all of the different types of graphs featured is discussed.

Lesson 6

The content covered in lesson 6 is probability.

At the end of this lesson each student should be able to;

- List outcomes and identify the number of outcomes.
- Calculate the probability of an event occurring.

The aim of task 1 is to develop student's ability to see the difference between listing outcomes and knowing the number of outcomes. A person has juice and cereal for breakfast. There is an option of 3 different juices and 5 different cereals. The students are asked to list all possible breakfast options the person could have. The students are then asked how many different options the person can have for breakfast. The author has regular seen students struggling to decipher between these 2 types of questions in her teaching of probability and this problem was also clearly evident from the pre-test in the pilot study.

The aim of task 2 is to develop student's ability to calculate the probability of an event occurring. Students are given a packet of Skittles which they must count to see how many of each colour is in their packet and then note the total number of Skittles in their own packet. They then must write down the probability that they will get each colour Skittle if they put their hand in their packet. This is a fun way of getting students to learn and engage with the concept of probability and also allows them to revisit fractions which they should have done some work on earlier in the intervention.

Lesson 7

The content covered in lesson 7 is geometry.

At the end of this lesson each student should be able to;

- Identify vertical, horizontal and oblique lines.
- Distinguish between parallel and perpendicular lines.
- Measure angles.

The aim of task 1 is to develop students understanding of the differences between vertical, horizontal and oblique lines. Students are firstly asked to discuss these terms with their tutor. The discussion centres around whether they have heard of these terms before or not, in what context and so on. They are then given a number of images and asked which of the aforementioned terms describe a feature of the image best. These images include pictures of popular pop stars and movie stars wearing clothes with either vertical or horizontal lines, again heightening the interest for the students. They are then given a series of oblique lines and from these lines they are asked to develop a definition for the term oblique. Finally they are asked to create a simple picture using vertical, horizontal and oblique lines. Vertical lines must be red, horizontal lines must be black and oblique lines must be blue. This activity requires the students to be actively involved and allows them to display their creative side.

The aim of task 2 is to develop students understanding of parallel and perpendicular lines. It begins by asking the students if they have ever heard the terms parallel and perpendicular and in what context. 4 images are then given and the students have to decide which are parallel lines and which are perpendicular lines. From here they must attempt to develop definitions for parallel and perpendicular by describing a feature of each pair of lines.

The aim of task 3 is to deepen students understanding of parallel and perpendicular lines by putting them in a context. A map is given of Cork city, the closest city to students in this study, so it should be familiar to most of them. Students need to be able to identify streets that are parallel to one another and streets that are perpendicular to one another.

The aim of task 4 is to develop each student's ability to estimate and measure angles in context. From each image, the tutor will identify clearly an angle that they want their student to measure (see Figure 4.8 below). Before measuring the angle, the student will be required to guess the size of each angle. They then will attempt to use their protractor to measure the angles. They are also asked to identify what angle the floor is to the wall and why.

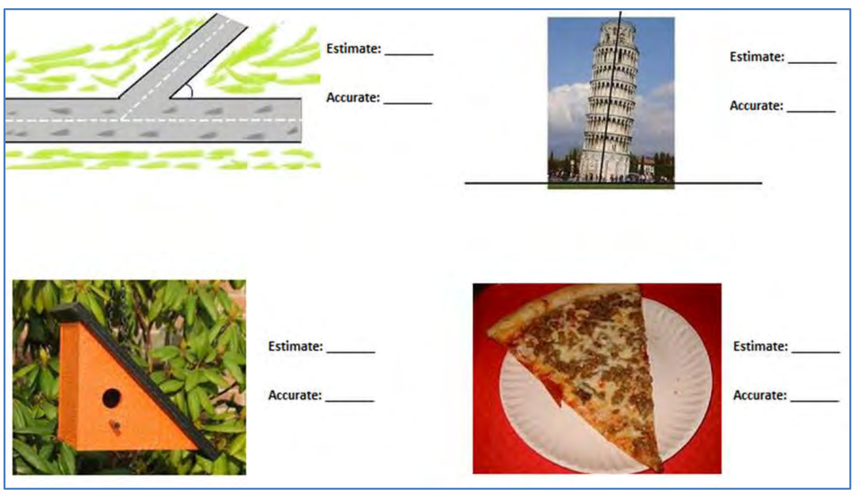


Figure 4.8: Lesson 7, Task 4, Estimating and Measuring Angles in a Context.

Lesson 8

The content covered in lesson 8 is geometry.

At the end of this lesson each student should be able to;

- Understand what vertically opposite angles are.
- Identify the size of the angles in a triangle.

- Plot co-ordinates on a Cartesian graph and be able to read co-ordinates from a Cartesian graph.

The aim of task 1 is to develop student's ability to identify that vertically opposite angles are equal and understand that angles around a point add up to 360°. Mini whiteboards, markers, dusters and geo-strips are required for this task and are handed out to each student by the intervention facilitator. This task involves the use of equipment that many students may not get to use in their regular mathematics class and therefore the author believes that interest is immediately triggered in the students.

Angle 1	Angle 2	Angle 3	Angle 4	Total

Figure 4.9: Lesson 8, Task 1, Geo-strips with Mini Whiteboard and Vertically Opposite Angles.

Students are initially asked to create vertically opposite angles with their geo-strips (see Figure 4.9 above) on the mini whiteboard. Their tutor may need to help with this concept to begin with. They then must label the angles 1, 2, 3 or 4 and ensure that they colour in each angle. They must then measure their angles with a protractor and fill in the angle sizes in the table given and record the total of all the 4 angles. They must repeat this process 3 times with different size angles. A discussion about the total angle size and vertically opposite angles follows with their tutor. Guiding questions are provided to tutors in the tutor handbook to aid this discussion.

The aim of task 2 is to develop each students understanding that angles in a triangle sum to 180°. Similar to task 2, mini whiteboards, markers, dusters and geo-strips (see Figure 4.10 below) are required for this task and are distributed to each student by the intervention facilitator.

	Angle 1	Angle 2	Angle 3	Total
Triangle 1				
Triangle 2				
Triangle 3				

Figure 4.10: Lesson 8, Task 2, Geo-strips with Mini Whiteboard, Angles in a Triangle.

The procedure for this task is the same as the previous task but students are instead required to create 3 different size triangles with their geo-strips (see Figure 4.10 above) on the mini whiteboard. A discussion about the total size of all the 3 angles in each triangle must then occur with their tutor. Again, guiding questions are provided to tutors in their tutor handbook to aid discussion.

The aim of task 3 is to develop each student's ability to read co-ordinates that have been plotted on a Cartesian graph. A Cartesian graph is given with points plotted on it labelled with a letter. The student is required to give the coordinate number pair for each letter.

The aim of task 4 is to develop each student's ability to plot co-ordinates on a Cartesian graph. They are given a number of points to plot and they must join these points up to reveal an image. The element of mystery in this task adds to the interest for the student (Strand, 2004).

Lesson 9

The content covered in lesson 9 is algebra.

At the end of this lesson each student should be able to;

- Identify, complete and compose visual patterns.
- Describe what is happening in a sequence in their own words. Students are given a sequence in word form and asked to write down the first few terms of the sequence.
- Substitute into an expression.
- Simplify an expression.

The aim of task 1 is to develop students' ability to see a pattern in a sequence of images. Students are given four shapes and they are asked to draw the next shape in the sequence. Students are then asked to relate back to their own experiences and describe any patterns that they have ever come across. They are then asked to create their own pattern and give it to the 1st year student nearest to them who must figure out the next term. This is a fun activity for students and allows them to be creative.

The aim of task 2 is to develop student's understanding of number patterns in a real life context. Students are given two real life scenarios, one in relation to the growth of a plant and the other in relation to rate at which toys are being made in a factory. In part a) the height of a plant is given and the amount the height of the plant increases each week is also given. The question asks how tall the plant is after week 1, week 2 etc. Part b) explains the running total of the amount of rubiks cube produced by a shop per day. From this running total the student has to deduce how many rubiks cubes are produced per day, therefor finding out how much the pattern increased by each dat.

The key concept in task 3 is that each student will be able to come up with a formula to find any term in the pattern. There are 4 people sitting at a table and then a table is added at the end. Students are required to figure out how many people are sitting at the tables now. This continues with several more tables being added and the student has to come up with an expression to represent the pattern and then use this to find out how many tables are needed to seat 20 people. This task challenges the students but deep learning can be experienced once completed successfully.

The aim of task 4 is for students to develop an understanding of substitution. The intervention facilitator hands out a board game (see Figure 4.11 overleaf), dice and counters to each pair who plays the game together, under the supervision of their tutors. When the students roll the dice they substitute the number they roll into the expression that their counter is on. They evaluate the expression for the value rolled on the dice and move that number of spaces. If the answer is a negative number they move back that number of spaces. The student who reaches the end of the board first wins.

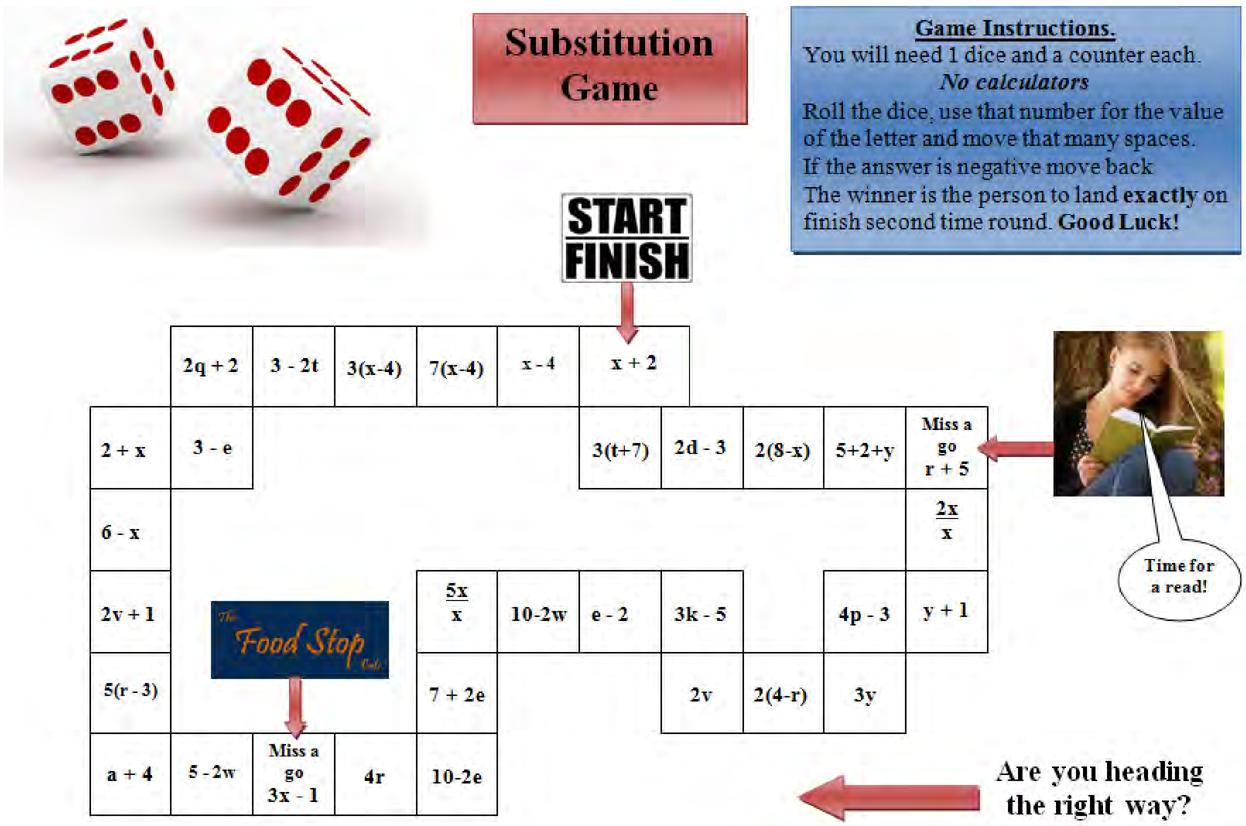


Figure 4.11: Lesson 9, Task 4, Substitution Board Game.
Source: (http://www.mrbartonmaths.com/algebra.htm).

This task promotes active involvement and is fun, therefore maintaining students' interest. The aim of task 5 is to further develop each students understanding of substitution in a real life context. These questions involve substitution in a game of snooker and a game of rugby.

The aim of task 6 is to further develop each student's ability at simplifying expressions as well as understand the correct algebraic terms to use. Firstly the student is introduced to some of the basic terms associated with algebra. Students are then given algebraic pyramids whereby they add the 2 connecting boxes to fill in the one below it. This is an alternative way for students to practice adding terms.

The aim of task 7 is to further develop each student's ability at simplifying expressions in a real life context. The context of a basketball court is used as a way of simplify expressions by finding the perimeter and area of a basketball court. Providing a context for students aids their understanding of a topic.

Lesson 10

The content covered in lesson 10 is again algebra.

At the end of this lesson each student should be able to;

- Solve an equation.
- Create an equation and solve it.

The aim of task 1 is to develop each student's ability to solve equations. Firstly this task questions students on the difference between an expression and an equation. Then students are given some simple equations to solve with the help of their tutor. Tutors are given instructions in their tutor pack as to ensure that they introduce equations by explaining the concept that in an equation both sides of the equation are equal and balance with one another.

The aim of task 2 is to further develop each student's skills at solving equations. They are asked to solve each equation using the same strategy as they did in the previous task. In this task however, the value acquired for each variable is written above the number below that variable. At the end of the task each student should be able to read the sentence which again adds an element of interest to the task.

The aim of task 3 is to develop each students' skills at solving equations in a fun context.

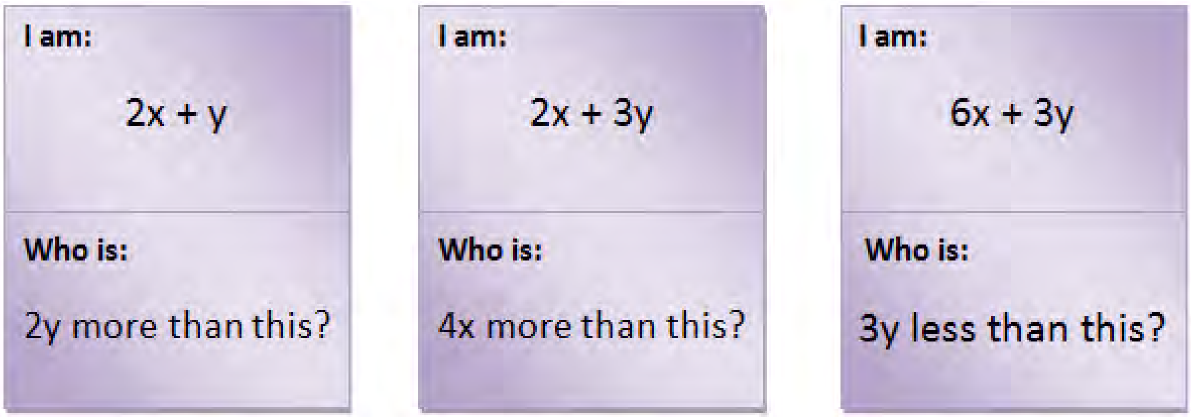


Figure 4.12: Lesson 10 Task 3, Sample of Loop Cards.

The class teacher will give each student a loop card (see Figure 4.12 above). All students are relying on each other to complete the loop. Tutors must ensure that their student stays on task during this activity so that the loop runs efficiently.

The aim of task 4 is to develop each student's skills at creating and solving equations. This is done in familiar contexts for students which heightens their interest and engagement in the task. The contexts include measuring weight on a scales, DVD rentals, dimensions of a football pitch, sharing maltesers and family members ages.

4.5 Problems Encountered with the Implementation of the Intervention

Following the literature review and methodology chapter the student handbook and accompanying resources were created. At all times, the author kept in mind the idea that the content must be of interest and meaningful to the students as well as encourage active learning and group work. On piloting the intervention the author saw flaws that needed to be addressed and these flaws were addressed as discussed previously. However, despite piloting this intervention, some did persist.

While the author made an effort to correctly match tutors and tutees the author was not familiar with all the students and therefore some of the pairings could have been better matched. For example a more mature TY student would be best matched with a more vulnerable 1st year and vice versa. While most pairings worked well, two pairings encountered this problem which meant that the second classroom teacher in the room had to closely monitor these pairings to ensure that the intervention was completed successfully.

Absenteeism was kept to a minimum due to the incentives given to the students prior to the intervention that have already been discussed. However, three 1st year students missed 1 class, one 1st year missed 2 classes and 2 TY students missed 1 class. When the 1st year student was absent their tutor supported another TY tutor. When the TY students were absent the 1st year students worked with another TY tutor which means that one tutor worked with two 1st year students. While this still seemed to work well this meant there was a lack of consistency for 2 1st year students.

There are some whole class tasks in this intervention. While the author believes this to be worthwhile some minor problems were encountered during the implementation of these tasks. As different peer tutor pairings worked at different paces, not everyone reached these group activities at the same time. The facilitator had to allow some pairings to work ahead until each pair reached the group task. While this made the lesson a little disjointed it did not affect the overall coherence of the lesson. In some of the lessons a range of topics were covered. In order for the basic numeracy skills to be addressed in the six week intervention, more than one topic had to be covered in each lesson. However an effort was made by the author to ensure that the mixture of topics got covered in the given time frame.

The peer tutoring element of this intervention occurred for a double period each week for 7 weeks. Regrettably this was not over 7 consecutive weeks due to TY commitments, instead it took place in 8 weeks. However this did not seem to impact on the students' engagement with the intervention.

4.6 Conclusion

The author used peer tutoring, a student handbook and accompanying resources to attempt to improve interest and achievement amongst 1st year and TY students. A detailed outline of all the intervention materials was given in this chapter. The author explained how the intervention was validated by the theory presented in the literature review.

A pre and post intervention tests was administered to the students, a pre and post attitudinal survey was also given to the students and a post intervention focus group was conducted with the students. This data was analysed. Chapter 5 will now discuss the research findings from the intervention.

Chapter 5
Research Findings

5.1 Introduction

In this chapter, the author will present and discuss the findings that emerged from this study. The author collected quantitative data from both a pre and post survey and a pre and post-test and analysed this data using SPSS. Parametric tests (T-Tests) were carried out on normally distributed data whereas non parametric tests (Wilcoxon-Signed-Ranks tests) were carried out on data which was not normally distributed. The author also collected qualitative data by using focus groups and analysed this data for similar trends in both the quantitative and qualitative data. The author compares pre and post surveys for the test group, the control group and the tutor group to assess any change in attitude towards mathematics amongst these students. The author also compares pre and post academic tests for each group to assess any change in mathematics achievement amongst these students. A comparison is also made between both the test groups' and the control groups' data. This is necessary in order to be able to attribute the intervention with any improvement in the test group's scores that are greater than the control groups. The author uses the qualitative data from the focus group and the control group to reinforce the quantitative findings.

5.2 Quantitative Analysis (Survey and Test)

5.2.1 The Survey

For this study, the author's analysis of the survey is reliant on the answers that the students gave on the Likert scale. The author uses the mean as the measure of central tendency that shows any change in attitude from pre to post survey. It is important to note that during analysis, the author reversed the negatively phrased questions. Some researchers work, such as Allen and Seaman (2007), Jamieson (2004) and Cohen et al. (2000) question the use of the mean for data collected using the Likert scales. Some believe that the Likert scale data is ordinal data and that the intervals between each number on the scale are equal. They maintain that for this reason the mean should not be used for this type of data and instead the mode or median is a better average to use. However Jamieson (2004) believes that the intervals between each number are not equal therefore deeming the mean as an appropriate measure of central tendency for the Likert scale. Much debate over this issue still continues.

Another question over the use of the Likert scale is if 5 answer options are enough. Dawes (2008) conducted research into different scales involving 5, 7 and 10 answer options per question. 3 groups of people were given the same 8 questions but one of the groups were given the Likert scale as answering options, one group were given 7 answer options and another group were given 10 answer options. After statistical analysis it was found that each groups' mean answers were comparable which shows that the 5 options in the Likert scale are an adequate number of responses. Variation about the mean and skewness were also comparable.

5.2.2 Reliability of Scales

Pallant (2013) believes that a way of testing reliability is by giving a test to the same group of people on 2 separate occasions and calculating the correlation between the 2 results. Cronbach's reliability values are used to assess the reliability of the pre and post survey. Ritter (2010) states that Cronbach's alpha is one of the most commonly used measures of reliability. There are varying ideas of how reliable each alpha value is, however the Cohen et al. (2011) description, which is seen below in Table 5.1 is what the author used in her analysis:

$\alpha \geq 0.9$	Very Highly Reliable
$0.8 \leq \alpha < 0.9$	Highly Reliable
$0.7 \leq \alpha < 0.79$	Reliable
$0.6 \leq \alpha < 0.69$	Marginally/Minimally Reliable
$\alpha < 0.6$	Unacceptably Low Reliability

Table 5.1: Cronbach Reliability Analysis.

Table 5.2 overleaf, shows the reliability of the survey for the 1st year test group. From this table it is apparent that the reliability of the survey for this group of students is marginally reliable to reliable. It can therefore be said that all data produced by the survey for the 1st year test group is reliable.

Reliability Analysis	Cronbach's Alpha Pre	Cronbach's Alpha Post
Self-belief in Mathematics	0.644	0.639
Mathematics & Pedagogy	0.619	0.660
Interest in Mathematics	0.701	0.681
Mathematics Achievement	0.696	0.621
Test Total	0.665	0.650

Table 5.2: 1st Year Test Group Reliability Analysis of Survey.

Table 5.3 below, shows the reliability for the control group's pre and post survey. Again it is evident from the table that the reliability of the survey for this group of students is marginally reliable to reliable. This also means that all the data produced by the survey for the control group is reliable.

Reliability Analysis	Cronbach's Alpha Pre	Cronbach's Alpha Post
Self-belief in Mathematics	0.617	0.613
Mathematics & Pedagogy	0.790	0.781
Interest in Mathematics	0.646	0.731
Mathematics Achievement	0.627	0.639
Test Total	0.670	0.691

Table 5.3: Control Group Reliability Analysis of Survey.

Table 5.4 overleaf, shows the reliability for the TY group pre and post survey. From this table we can see that the reliability of the survey for this group of students ranges from marginally reliable to highly reliable, which again means that data produced is reliable.

Reliability Analysis	Cronbach's Alpha Pre	Cronbach's Alpha Post
Self-belief in Mathematics	0.966	0.966
Mathematics & Pedagogy	0.685	0.628
Interest in Mathematics	0.958	0.959
Mathematics Achievement	0.941	0.946
Test Total	0.889	0.875

Table 5.4: TY Group Reliability Analysis of Survey.

5.2.3 The Academic Test

Similar to the structure of the Project Maths State Examination the pre and post-test is divided into 2 sections; Section A focuses on concepts and skills while Section B concentrates on contexts and applications. On the test there are questions to assess each of the 4 strands that are covered in the 1st year course, i.e., probability and statistics, number, geometry and trigonometry and algebra. The test was given to all groups prior to the intervention and after the intervention and the data collected was analysed. Changes in mean score in each strand were examined as well as changes in mean overall score in both concepts and skills and context and application questions.

5.3 Qualitative Analysis (Focus group)

The focus group questions are divided into 4 sections. Section 1 questions specifically relate to the effectiveness of peer tutoring. The questions in section 2 ask students about their interest in mathematics and numeracy. In this section students are specifically asked whether their interest in mathematics has changed as a result of participation in the intervention. Section 3 questions students on how they view their mathematical achievements and seeks to ascertain whether their mathematical ability has improved over the course of the intervention. This data was analysed and common themes were identified.

5.4 Intervention Evaluation

The author uses Shapiro's (1987) model of intervention evaluation as a means of assessing the intervention. Shapiro's model is divided into 4 different areas; intervention effectiveness, intervention acceptability, intervention integrity and social validity. Intervention effectiveness involves assessing the amount of change, the immediacy of change and the strength of the change. Intervention acceptability assesses the time and costs associated with the intervention, the method of delivery of the intervention and the effectiveness and integrity of the intervention. It also involves looking at possible side effects of the intervention as well as gaining an understanding of the intervention and investigating the possibility of replicating it in the future in other schools. Intervention integrity begins by looking at the importance of the outcome of the study, the significance of the goals and the appropriateness of the procedures followed in reaching those goals. Finally social validity examines the immediacy of change, the effort involved in implementing the intervention, the degree of change visible, the theoretical orientation and the intervention facilitator. This information is summarised in Figure 5.1, overleaf.

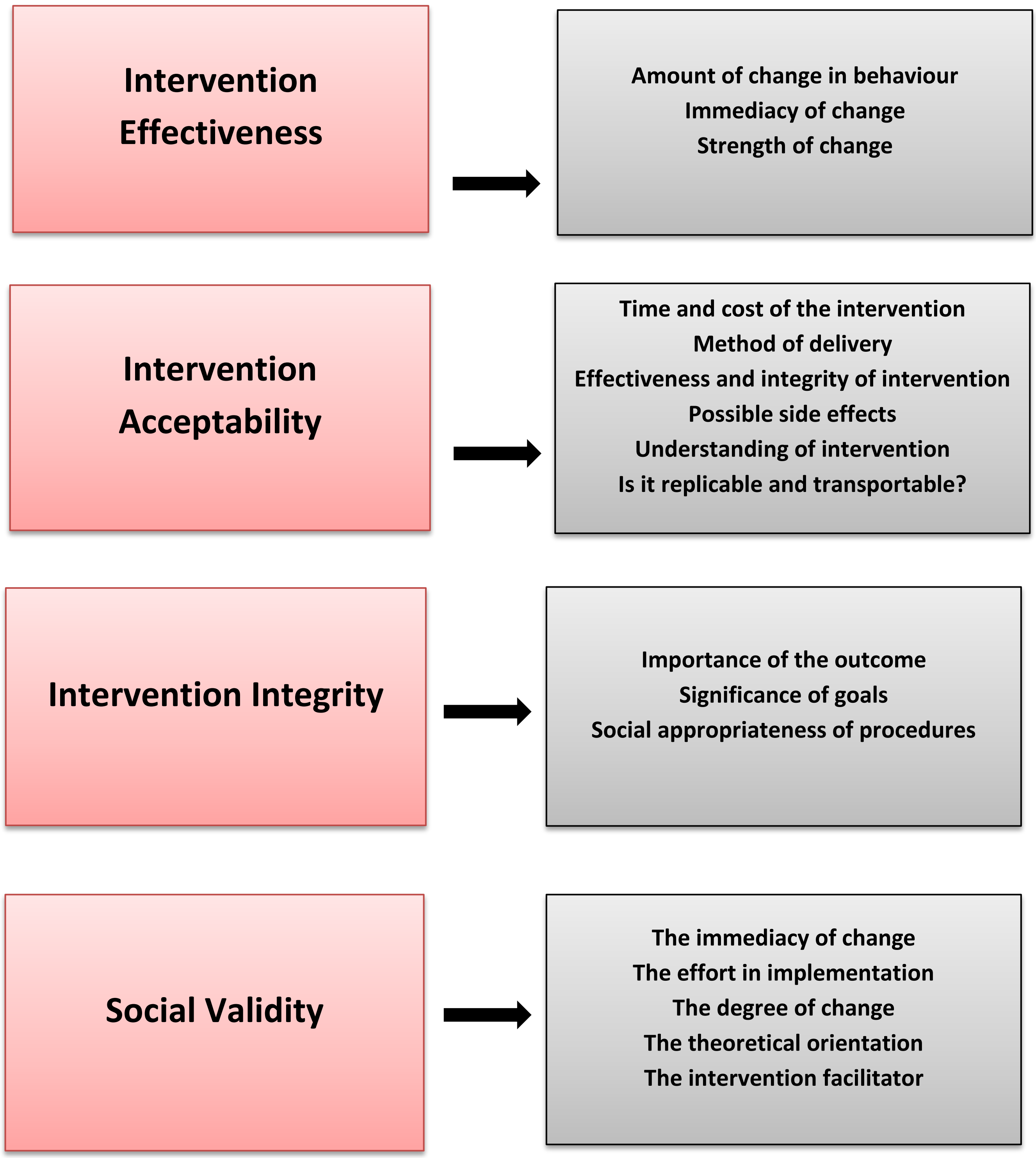


Figure 5.1: Shapiro's Model for Intervention Evaluation (1987) (Adapted from O'Meara, 2010)

5.4.1 Intervention Effectiveness

Amount of change

Shapiro (1987) maintains that if there is a significant improvement in behaviour post intervention this suggests that the intervention has been successful. The survey and test data will be examined for any changes from pre to post intervention. The strength of any changes found will also be scrutinised. In order to assess the strength of the change it is necessary to test our data to observe if it is statistically significant. Kirk (1999) states that if data is statistically significant it means that the results obtained are unlikely to have occurred by chance. Cohen et al. (2011) explain that all research begins with a null hypothesis, i.e. that there is no relationship between the data. If the difference is statistically significant, with probability values (p-values) of less than 0.05, 0.01 or 0.001 it shows that the hypothesis is not supported by 95%, 99% or 99.9% of the population respectively. Therefore the null hypothesis is rejected and a statistically significant relationship between the data is achieved.

The Survey – Amount of Change & Strength of Change

In Table 5.5 overleaf, the survey results are analysed for all groups. As previously explained, the survey is divided into 4 sections and pre and post mean and standard deviation scores are outlined for each section. The final column in the table gives the optimal score for each section, i.e. the highest score that could be achieved if students gave the most favourable response to each question (i.e. a positive response). It should also be noted that for any question in the survey that is worded negatively, the scores are reversed to allow a score of 5 to be the most favourable answer to the question.

Attitudinal Survey	Test Mean (SD) Pre	Test Mean (SD) Post	Control Mean (SD) Pre	Control Mean (SD) Post	TY Mean (SD) Pre	TY Mean (SD) Post	Optimal Score
Self-belief in Mathematics	62.90 (5.18)	80.03 (5.12)	61.27 (4.60)	58.73 (3.33)	82.60 (19.90)	93.13 (16.17)	130
Mathematics Pedagogy	37.30 (3.68)	45.57 (3.65)	36.03 (3.91)	34.17 (3.09)	43.70 (6.77)	51.37 (4.57)	75
Interest in Mathematics	46.17 (4.73)	58.77 (3.93)	43.97 (3.84)	43.13 (3.62)	53.14 (16.74)	64.27 (13.54)	95
Mathematics Achievement	33.40 (4.07)	40.97 (2.79)	38.27 (4.19)	37.10 (4.47)	40.97 (10.44)	46.43 (9.27)	80
(SD) = Standard Deviation							

Table 5.5: Attitudinal Survey Analysis for Study Groups.

Firstly we examine the test groups' survey results. In each section of the survey their mean score increased considerably with the greatest increase being visible in students' self-belief in mathematics (increasing by a score of 17.13) and interest in mathematics (increasing by a score of 12.6). The standard deviations in the post survey results are less than the pre survey which suggests that all students' results are closer to the mean value. In relation to the control group, their mean scores in each section of the survey have actually decreased from pre to post survey. The decrease however is small, with the largest mean decrease being 2.54. The standard deviation has decreased in three of the four sections. The TY students mean scores in each section have all increased from pre to post survey with the largest increase evident in their interest in mathematics (increasing by a score of 11.13) followed by their self-belief in mathematics (increasing by a score of 10.53). The standard deviation has decreased from pre to post in each section of the TYs survey.

Interest and self-belief are the two sections that see the greatest increase from pre to post survey for both 1st year and TY students. The focus group data backs up these finding as the qualitative data collected also indicates that the students' interest and achievement in mathematics was enhanced as a result of the intervention:

1st Yr. - S25: *In class all we do is use the book. I like how maths can be fun too.*

1st Yr. - S5: *I am better at algebra, I didn't understand it before.*

1st Yr. - S2: *I couldn't do equations before peer tutoring*.

1st Yr. - S16: *I learned things I didn't get in class. I found it easier to listen to my TY teacher*.

Students also commented on the fact that the resources that they used during the intervention kept and held their interest. One student stated that;

1st Yr. - S9: *I see that maths can be interesting but we need to do this kinda stuff* [maths activities and games] *in our maths class now too*.

From the TY focus group interviews it was apparent that their interest in mathematics also increased.

TY - S4: *The questions had some interesting topics, like sports and music and stuff like that.*

TY - S2: *We all got to do things* [maths activities and games] *that we wouldn't get to do in maths class. I like maths more now that I know you can have some real fun with it.*

TY - S12: *I can see how maths can be fun now. Using games, whiteboards and stuff like that kept us all entertained.*

Further comments made by TY students' made it apparent that their self-belief in their mathematical ability also improved. One student stated that;

TY - S12: *I liked being able to help my 1st year improve her maths. I think she finds maths really hard but she said I really helped her understand.*

TY - S9: *My 1st year told me I helped her a lot and she is doing way better in class now…. You feel good after helping a younger student.*

Both the test group and the TY groups' attitude towards their mathematics achievement improved from pre to post survey. Again these findings are further backed up by evidence from the focus group. Many test group students feel that they are better at maths as a result of participating in the intervention with the areas of algebra and Venn diagrams frequently mentioned as areas they felt they improved in.

1st Yr. - S4: *Sometimes in class the teacher goes through stuff too fast. Some things I did not get in class I learned in peer tutoring.*

1st Yr. - S10: *I find algebra easier … I now know how to put points on a graph.*

1st Yr. - S9: *We are doing statistics in class now and I know it better than the others in the class.*

1st Yr. - S18: [In relation to the post-test] *I found the test way easier the second time we did it*.

Furthermore, the majority of test group students in the focus group stated that their subject knowledge has increased as a result of the intervention. One TY student describes his/ tutees improvement;

TY - S6: *He was often not able to do the challenge but then when we worked through the task questions he could answer them*.

While most of the TY students in the focus group stated that the intervention did not help them with what they were doing in class (stating that their work in class is far harder) many mentioned that the intervention did help their understanding of basic concepts that they did not fully understand in the Junior Cycle;

TY - S3: *"I had forgotten some things since 3rd year and it made me revise hem".*

TY - S1: *I learned some basic stuff that I missed out on in the Junior Cycle.*

TY - S4: *I don't ever remember being taught how to find percentages in my head without using a calculator. I liked learning that.*

Table 5.6 below shows the significance values from pre to post survey for the 1st year group, control group and TYs. The p-values for all sections of the 1st years' survey are <0.001 which means these results are statistically significant and the change that occurred from pre to post survey have a less than 1% possibility of occurring by chance. The p-values for the control group in all 4 areas are not statistically significant. Similar to the 1st year results, all the results in the TY survey proved statistically significant therefore the null hypothesis can be rejected and it can be said with a confidence of 99.9% that the changes in attitude that occurred from pre to post survey did not occur by chance.

Attitudinal Survey	**1st year P-Value**	**Control P-Value**	**TY P-Value**
Self-belief in Mathematics	<0.001	>0.05	<0.001
Mathematics & Pedagogy	<0.001	>0.05	<0.001
Interest in Mathematics	<0.001	>0.05	<0.001
Mathematics Achievement	<0.001	>0.05	<0.001

Table 5.6: Statistical Significance Values of the Attitudinal Survey for Study Groups.

When comparing test and control groups' survey results, significance was also analysed (see Table 5.7 overleaf). For 3 of the 4 sections of the pre-survey, the comparison between the test and control group scores were not statistically significant. This means that there was no notable difference between the two groups mean scores on the attitudinal survey. This is what we expected, as previously stated, prior to intervention the control group were chosen as they had a similar profile to the 1st year group. However, mathematics achievement results are statistically significant which again, contradict the previous statement. When a test for significance occurred on the post survey analysis it was found that all the results were statistically significant.

Attitudinal Survey Comparison between 1st year and Control group	P-Value Pre	P-Value Post
Self-belief in Mathematics	>0.05	<0.001
Mathematics & Pedagogy	>0.05	<0.001
Interest in Mathematics	>0.05	<0.001
Mathematics Achievement	<0.001	<0.001

Table 5.7: Statistical Significance Values for Comparison of Survey between 1st year and Control Group.

The data discussed in this section suggests that the intervention was effective as those participating in the intervention experience a positive change in response whereas the control group did not. The strength of change, for the majority of the areas surveys, backs up the amount of change in findings.

The Academic Test

Table 5.8 overleaf shows the analysis of all the groups mean test scores and standard deviations in each strand of the test as well all concepts and skills and context and application questions.

Test	1st year Mean (SD) Pre	1st year Mean (SD) Post	Control Mean (SD) Pre	Control Mean (SD) Post	TY Mean (SD) Pre	TY Mean (SD) Post	Optimal Score
Strand 1	6.90 (3.68)	9.70 (4.21)	5.37 (3.05)	6.87 (2.52)	17.97 (2.89)	21.97 (0.97)	22
Strand 2	6.90 (3.77)	9.63 (3.85)	3.77 (1.85)	5.00 (2.00)	11.80 (1.81)	13.87 (0.43)	14
Strand 3	8.37 (4.76)	12.79 (5.91)	5.73 (3.00)	6.23 (2.42)	21.93 (5.15)	26.47 (4.40)	30
Strand 4	3.43 (2.25)	6.87 (3.79)	3.20 (2.51)	3.00 (2.21)	20.47 (3.91)	22.43 (3.65)	26
Concepts & Skills	18.40 (6.85)	25.47 (9.10)	12.60 (4.83)	14.43 (4.14)	44.30 (4.99)	51.33 (4.47)	54
Contexts & Applications	7.20 (5.67)	12.33 (7.54)	5.47 (2.98)	6.50 (2.79)	30.10 (4.37)	35.47 (4.00)	38

Table 5.8: Academic Test Analysis for Study Groups.

Overall, test group students performed better in the post-test than the pre-test with their greatest improvement seen in strand 3, Number; with a mean increase of 4.42 in this strand. Their lowest improvement was seen in strand 2, Geometry & Trigonometry, with a mean increase of 2.73. There is a noted increase in both concepts and skills and context and applications style questions, with the greater increase in concepts and skills type question (mean increasing by 7.07). These increases are reinforced in Figure 5.2 overleaf. The standard deviation however, is greater in the post tests, which suggests that although the mean post-test result is higher, the individual scores are more varied. It should be noted however, that despite the increase in score from pre to post-test being statistically significant the scores of students are still far off from the maximum scores that could be achieved.

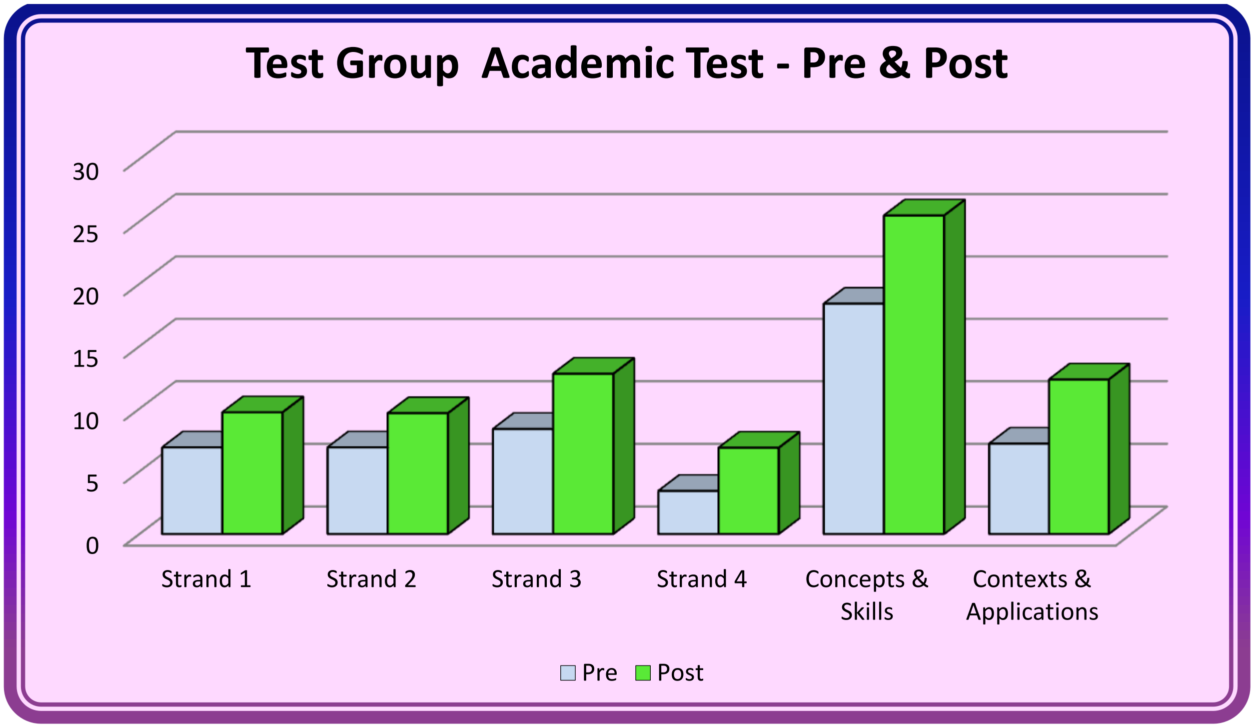


Figure 5.2: Test Group Academic Pre & Post Test.

The increase in the test group students mean results are backed up by findings from the focus group;

TY - S5: *She* [the tutor] *was very good at explaining things, better than my teacher.*

TY - S4: *Sometimes in class the teacher goes through stuff too fast. Some things I did not get in class I learned in peer tutoring.*

TY - S23: *In class we go very fast and I didn't get some stuff. I get them now.*

Another interesting point to note is that the majority of 1st year students did not even recognise that the pre and post-test were the same test with most stating that the post test was far easier than the pre-test. When asked was the test easier the second time around the following responses were heard;

1st Yr. - S2: *That test was a different test.*

1st Yr. - S3: *That test was easier.*

1st Yr. - S16: *Ya it was easier. I didn't think it was the same test until someone else said it.*

The control groups means scores have increased in all strands from pre to post-test bar strand 4, Algebra, whereby the mean score has decreased by 0.2. The greatest increase is observed in strand 1, statistics & probability, and the increase observed is 1.5. This is considerably lower than the increase of 4.42 for the 1st year test group. A minor increase in mean scores in both concepts and skills and context and applications questions is observed, with the greatest increase apparent in concepts and skills questions (an increase of 1.83). These results are provided in Figure 5.3 below. The standard deviation has decreased post-test for all strands with the exception of strand 2.

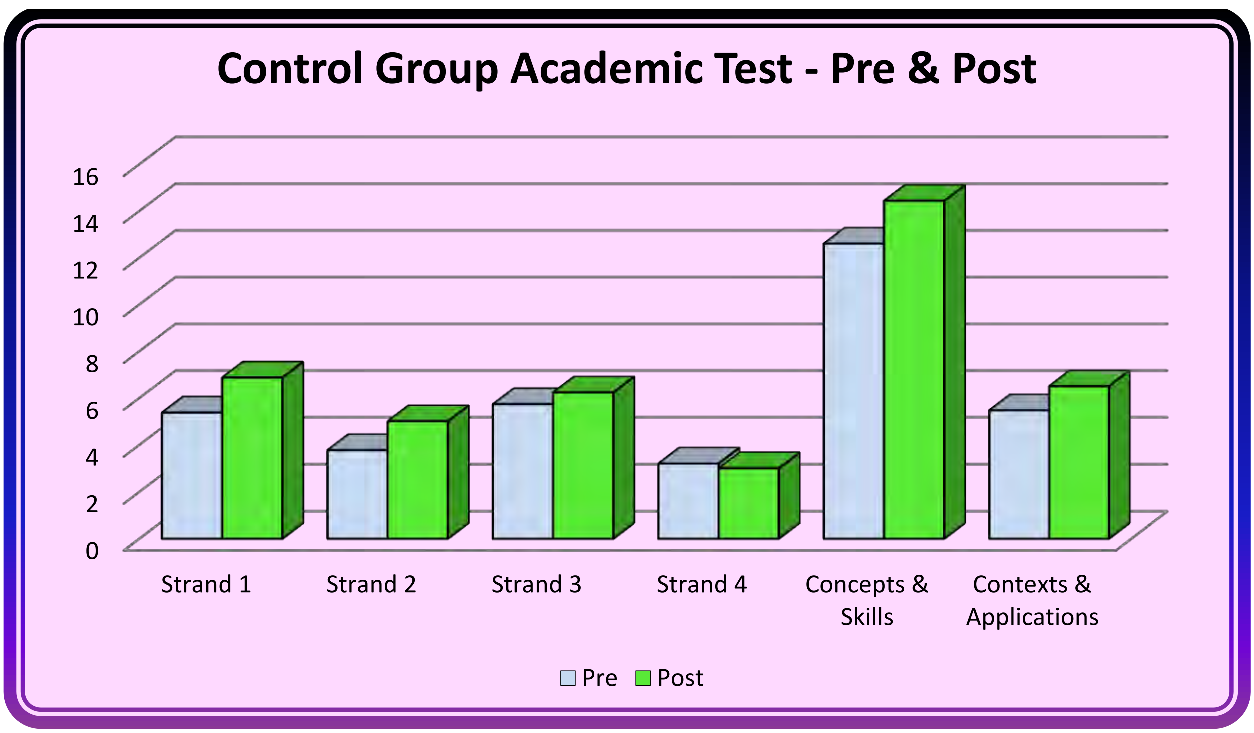


Figure 5.3: Control Group Academic Pre & Post Test.

The mean scores for TY students from pre to post-test have increased for all strands, with the largest increase evident in strand 3, number (an increase of 4.54). The lowest improvement was seen in strand 4, algebra, with a mean improvement of 1.96. Further increases are also seen in both the concepts and skills and context and application questions mean scores with the greatest increase, an increase of 7.03, apparent in the concepts and skills type questions. These increases are clearly visible in Figure 5.4 below. The standard deviation has decreased for all strands of the test.

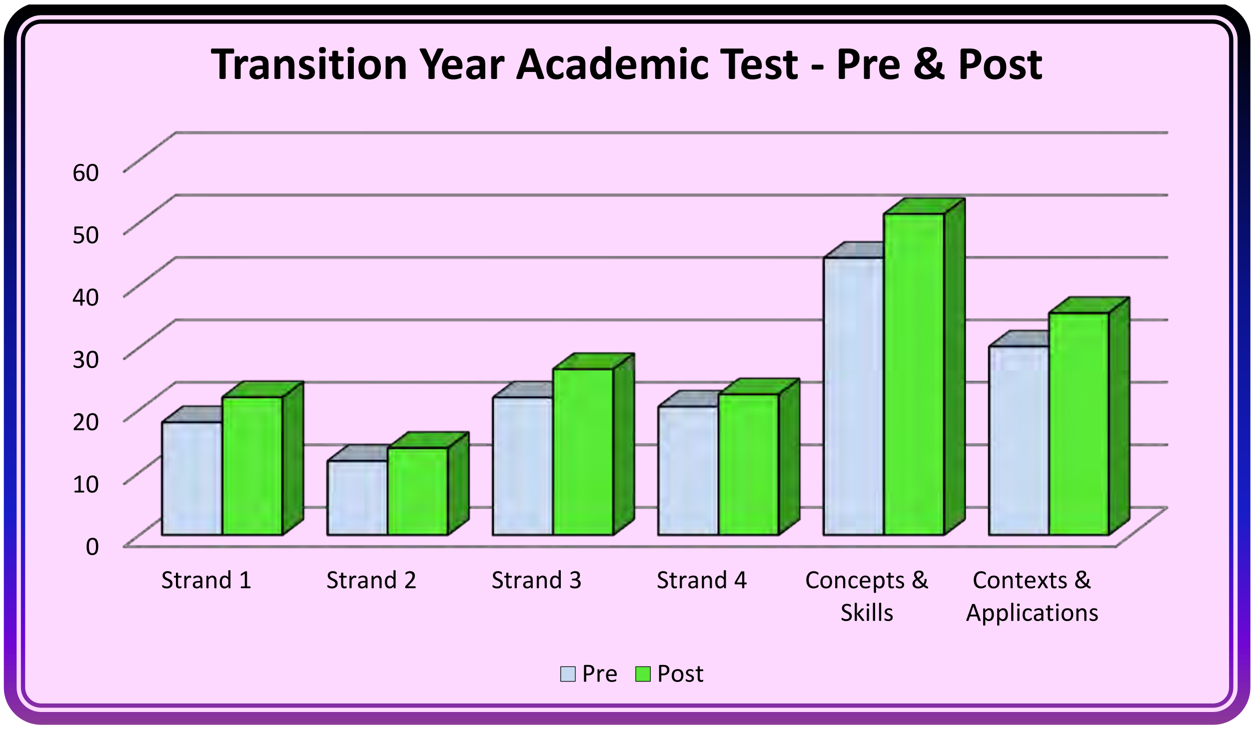


Figure 5.4: TY Academic Pre & Post Test.

While many TY students stated in the focus group that they didn't necessarily learn anything new in peer tutoring, others said that it helped them revise knowledge that they had forgotten.

TY - S10: *I had forgotten some things since 3rd year and it* [peer tutoring] *made me revise them.*

The data obtained from the test and the focus group would suggest that the intervention had a positive impact on TY students.

Table 5.9 overleaf, displays the p values from pre to post test for the 1st year test group, control group and TYs. All the results obtained from the 1st year's pre and post-test proved to be statistically significant with a less than 1% possibility that the changes which occurred were by chance. From the 6 sections analysed for the control group, none of them proved to be statistically significant. Again, like the 1st year results, all the results in the TY test proved statistically significant therefore the change that occurred from pre to post-test did not occur by chance.

Test	1st year P-Value	Control P-Value	TY P-Value
Strand 1	<0.001	>0.05	<0.001
Strand 2	<0.001	>0.05	<0.001
Strand 3	<0.001	>0.05	<0.001
Strand 4	<0.001	>0.05	≤0.05
Concepts & Skills	<0.001	>0.05	<0.001
Contexts & Applications	<0.001	>0.05	<0.001

Table 5.9: Statistical Significance Values of the Academic Test for Study Groups.

In order to examine the strength of the change it is also important to compare the test and control group results. The author has already examined their mean scores and standard deviation in both the survey and the test. Figure 5.5 overleaf, displays trend graphs of both the test and control groups' pre and post mean test scores. This graph gives a visual comparison of the two groups' scores and allow, at a cursory glance, to see that the difference between scores from pre to post test is visibly larger with the results of the test group to be greater.

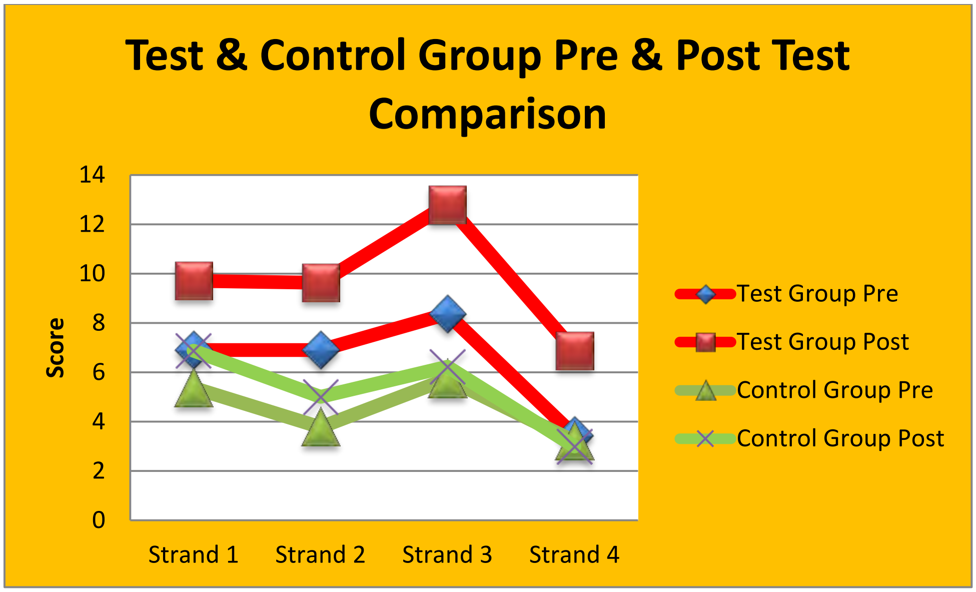


Figure 5.5: Test Group and Control Group Pre and Post Test Mean Comparison.

When comparing 1st year and control groups' test results, significance was also analysed (see Table 5.10 overleaf). The differences between the control and test group pre-test scores were not statistically significant in 3 of the 6 sections. This means that there was no notable difference between the 2 groups mean scores. This is what we expected, as prior to intervention the control group were chosen as they had a similar profile to the test group. However, 3 of the sections results are statistically significant which contradict the previous statement that there is no significant difference between the two groups' results. When a test for significance occurred on the post-test analysis it was found that all the results were statistically significant. This means that there was a significant difference in the level of improvement among the test group when compared with the control group.

Academic Test Comparison between 1st year and Control group	P-Value Pre	P-Value Post
Strand 1	>0.05	<0.01
Strand 2	<0.001	<0.001
Strand 3	<0.05	<0.001
Strand 4	>0.05	<0.001
Concepts & Skills	<0.001	<0.001
Contexts & Applications	>0.05	<0.001

Table 5.10: Statistical Significance Values for Comparison of Test between 1st year & Control Group.

The data discussed in this section suggests that the intervention was effective as those participating in the intervention experienced a more substantial increase in mean test scores than the control group. Furthermore, the control group's performance actually dis-improved in one of the test strands while their mean improvements in the other strands were not comparable to that of the test or the TY group. Although the control group and the TY groups' improvements are similar the TY group scores are far greater. As the TY students would have studied and revised these basic concepts several times over the course of their three previous years in education the author did not expect the TY improvements to be as great as the test groups. It was expected that their mean increase would only be marginal.

Immediacy of change

All changes discussed in the previous section occurred over a relatively short period of time. The intervention was 7 weeks in duration, with the pre and post tests and survey for 1st years and the control groups taking place a week prior and post intervention. The TY group sat the pre-test several weeks prior to the beginning of the intervention as they were undertaking training in the numeracy intervention materials from that date. The focus group session occurred the week after the intervention was completed. The fact that the intervention took place over a short number of weeks shows the immediacy of the changes discussed.

Strength of change

The author has discussed the strength of change previously in Section 5.4.1.

5.4.2 Intervention Acceptability

According to Shapiro (1987) intervention acceptability involves taking into account the time and cost of the intervention, the method of delivery, the effectiveness and integrity of the intervention. It also involves being aware of possible side effects, having an understanding of the intervention and being able to recognise if it is replicable and transportable.

Time & Cost of Intervention

There was a large investment of time in developing this intervention. It took approximately a year to prepare all materials with 10 weeks afforded to piloting the intervention. The costs accrued were relatively low. Printing and binding of the student handbook, answer booklet and tutor handbook accounted for the majority of the costs. Creating and laminating resources also attributed to the costs. Purchasing geometry equipment like rulers, protractors and geo strips as well as the mini whiteboards were also necessary expenses. However, apart from the student handbooks, all other resources can be re-used. The intervention took place during the school day so none of the parties involved required financial remuneration. Due to the flexibility of the TY programme and the low costs involved, any post-primary school in Ireland could run a similar intervention with 1st year and TY students.

Method of Delivery

The method of delivery for this intervention was through a peer tutoring method which involved 1st year students working with TY students. The test group students had never been taught in this way before so this intervention was innovative to them. Their responses in the focus group indicated that they were in favour of this method of delivery;

1st Yr. - S3: *It was better working with a 4th year than a teacher.*

1st Yr. - S13: *They did work with us, but we had fun doing it.*

Overall the focus group information gives the impression that peer tutoring was a successful experience for students. One test group student's description of their tutor echoed by many other students involved is as follows;

1st Yr. - S21: *I really liked my tutor, she was funny and really nice. She was good at explaining stuff too.*

The main response from the test groups' focus group interviews is that the majority of the participating students enjoyed being involved in this intervention. Of the 26 test group students who were part of the focus group interviews all but one states that they did not enjoying peer tutoring. The reason that this student gives for not enjoying peer tutoring is that he did not get on well with his tutor.

TY students had never taught younger students before so it was also a new experience for them. They also seemed to enjoy this method of delivery. Students explain that;

TY - S12: *I liked the buzz of it. There was a really good atmosphere in the room.*

TY - S2: *The board games were hilarious, everyone was so competitive playing them.*

TY - S13: *I liked the activities, like the board games and card matching activities, you don't do those things in your maths class.*

TY - S13: I loved the follow me cards. The way everyone was under pressure each time a question was called out was so funny. Everyone had to stay focused.

This information reinforces the acceptability of peer tutoring as the appropriate method of delivery for this intervention.

Effectiveness and Integrity of Intervention

As discussed in Section 5.4.1 the author believes this intervention to be effective. This is due to the change witnessed in both the test and the TY groups' attitude and achievement. Intervention integrity is discussed in Section 5.6.

Possible Side Effects

TY students were timetabled for peer tutoring. However it was not possible to timetable 1st year students for peer tutoring. As a result, in order for 1st year students' to participate in the intervention they were required to gain permission to leave the two classes that they were timetabled for from 2pm to 3:10pm on Tuesday afternoons for the 7 week period. Some of their class teachers were not happy with this decision as they felt these students were missing valuable contact time in those specific subjects. However as the DES (2011) National Strategy 2011-2020 outlines that schools core responsibility involves students leaving education literate and numerate the author's school principal supported this cohort's involvement in this intervention. Furthermore, no side effects were reported from class teachers, students or parents as a result of these 1st year students absence from these classes during or post intervention.

Understanding of the Intervention

It was a concern for the author that she was relying on TY students to deliver an intervention to 1st year students. However teaching the TYs the intervention material prior to them working with their tutee, equipping them with a tutor handbook and answer booklet as well as offering advice on effective communication skills allowed for the authors concerns to be diminished. From both the significance of the results observed in Section 5.5.1 and statements made by 1st year students in the focus group interviews it is evident that the TYs understanding and delivery of the intervention was successful.

Is the Intervention Replicable and Transportable?

The author deems this intervention to be replicable and transportable. The cost of replicating the intervention is relatively low. All materials developed for the purpose of this study are easily replicated. The handbooks may need updating bi-annually to ensure the contexts of questions and images used are relevant and of interest to students and some questions may need to change depending on where the intervention is taking place. It is also necessary that the persons involved in facilitating this intervention be a teacher of mathematics.

5.4.3 Intervention Integrity

Shapiro (1987) states that intervention integrity relates to the importance of the outcome, the significance of the goals and the social appropriateness of procedures. Intervention effectiveness and acceptability are discussed in Section 5.4.1 and Section 5.4.2 respectively.

Importance of Outcome

The importance of the outcomes of this intervention is unquestionable as the outcomes discussed to date show that the intervention made an impact on the students' interest in mathematics and academic achievements in the subject. Schools need to develop cost and time efficient ways of improving students interest and achievement in mathematics and numeracy so the successful outcomes of this intervention gives schools the confidence to attempt to replicate this style of intervention in the future. From the authors literature review, she saw evidence to suggest that interventions involving peer tutoring and literacy are common whereas peer tutoring and numeracy interventions are not. As a result, outcomes from this intervention will add to the limited amount of evidence currently in this area.

Significance of Goals

To date the author has discussed the change that occurred as a result of this intervention. The improvement noted in the critical numeracy skills which feature in the Project Maths syllabus among the test group will help ensure that these students are numerate and that they reach the goals set for them by the National Strategy. These results are also significant in terms of the goals of post-primary schools as all schools aim to develop, among their students, the numeracy skills which will help them to function on a daily basis. Finally, with such a strong emphasis on improving numeracy nationally, as discussed in Chapter 2, the results of this study are also significant in relation to national priorities.

Social Appropriateness of Procedures

From the data collected in the focus group interviews, it is apparent that both the 1^{st} year and TY students were happy with the procedures in place during this intervention. The author observed that towards the final weeks the contents of the student handbook was being taught to TY students', the students were becoming eager to work with the 1^{st} year students. However the TY students still engaged with the content. The author made the effort to pair tutors and tutees that she anticipated would work well together. As many same sex pairs were made as possible as Nugent (2008) describes same sex pairing as the more favourable pairing with peer tutoring. However due to more female tutors than male, some male test group students had a female tutor. The more mature TY students were paired with the least mature test group students in order to maximise focus throughout the intervention. All the literature that the author discussed in chapter 2 outlines peer tutoring as an appropriate teaching strategy to improve student's interest and achievement in a subject area. Comments from 1^{st} years and TY students discussed in previous sections back up the literature findings and assured the author of the social appropriateness of the methods employed.

5.4.4 Social Validity

In order to determine if an intervention is socially valid the following areas need to be looked at (Shapiro, 1987):

- The immediacy of change
- The effort in implementation
- The degree of change
- The theoretical orientation
- The intervention facilitator.

Immediacy of change and degree of change have been discussed previously in Section 5.4.1.

Effort in Implementation

It is difficult to formally assess the effort in implementation. However, the author believes that a substantial effort was afforded to the implementation of this intervention by all parties involved. The author created all the necessary resources, piloted and edited the intervention, carefully selected 1st year and control groups students, pre-taught intervention materials to TY students and acted as the intervention facilitator throughout the intervention. The 1st year and TY students fulfilled their roles by successfully engaging in the intervention materials and research instruments.

Theoretical Orientation

All areas of this intervention are backed up by theory which is discussed in chapter 2 and chapter 4. The intervention was also piloted in order to increase the effectiveness of the intervention.

The Intervention Facilitator

During this intervention the author acted as the intervention facilitator. The website http://www.nald.ca/library/learning/study/scrole3.htm as well as Harvey (2002) holds the idea that a good a facilitator needs to;

- Be prepared
- Set a relaxed and open tone
- Establish clear ground rules
- Identify the goal and purpose
- Assist the process.

The intervention facilitator must ensure that the intervention runs as smoothly as possible. For this intervention this involved having the room set up prior to the 1st year students' arrival and having all intervention material ready. The facilitator also had to monitor attendance as well as create tutor/tutee pairings in advance. It was also the facilitator's job to ensure that all the tutors had a good knowledge of the numeracy intervention and how to use the tutor hand book prior to the intervention. This was done during the weeks spent working through the intervention with the TY group prior to peer tutoring.

The facilitator also ensures that there is a relaxed and open tone and they should create an environment that is less formal than that of regular class time. This was achieved in this study in a number of ways, one way being changing the seating arrangement to that in a regular classroom so two tutors and tutee pairs worked together around one big table. The facilitator began the intervention by affording time for the tutor and tutee pair to become familiar with one another and discussion and debate was encouraged. This was imperative to the successful engagement of students in this intervention.

It is always important to establish ground rules and boundaries when facilitating an intervention. This will ensure that students know what is expected of them. In this intervention the students were advised of the importance of engagement with the intervention content as well as the importance of regular attendance and the consequences of not attending the entire intervention. TY students were also advised that they were to model good behaviour to the 1st year students and were to act as positive role models for them. They were also advised on the importance of discretion in relation to their involvement in the intervention.

The goal and purpose of the intervention i.e. to improve interest and achievement in mathematics and more specifically in numeracy skills was outlined to all. It was outlined to students why this is important and how we hoped to achieve this.

A final and very important part of being an intervention facilitator is to assist the group process. This involves ensuring that the intervention begins and ends smoothly and that the students ask the facilitator a question at any time if unsure of what they are doing. In order to achieve this, the tutor came to the classroom 15 minutes before the beginning of each lesson. This was easily achieved due to the intervention taking place directly after lunch every Tuesday. During this time the facilitator ensured that TY students were available to set up the room and have appropriate resources on each table. The tutor circulated continuously during peer tutoring and encouraged students to ask questions if they had any difficulty.

5.5 Summary of Findings

The findings were presented, discussed and analysed using Shapiro's model of intervention evaluation (1987). The intervention was deemed effective as both the questionnaire results and the pre and post-test results for the test groups improved considerably in comparison to the control group and the results proved to be statistically significant. This means that the changes observed were not by chance and the intervention is most likely the reason for students' improvement in their interest and achievement in mathematics. The appropriateness of the intervention was verified and the intervention goals were achieved. This shows the strength of the integrity of the intervention. Intervention acceptability was discussed and deemed successful due to the results discussed previously and the fact that the school in which it took place plans on repeating this intervention on a yearly basis. It would also be very easy for another school to adopt this method of intervention as a way of improving interest and achievement in mathematics in their schools. The entire intervention has a strong theoretical orientation which was facilitated effectively by the intervention facilitator ensuring that this intervention is socially valid. Chapter 6 will discuss the research findings in the context of existing literature and will seek to answer the research questions.

Chapter 6
Discussion of Findings

6.1 Introduction

The aim of this chapter is to discuss the key findings from the research data outlined in Chapter 5. This discussion chapter will be used to discuss findings from this research compared to results presented in existing literature. The findings in relation to each research question will be discussed and any other emerging themes will be outlined and examined.

6.2 Key Findings for the Research Questions

As stated previously, 3 research questions guided this study:

1. Is a numeracy programme and peer tutoring, together, an effective type of intervention to achieve an improvement in students' mathematical abilities?

2. Will 1st year students' interest and achievement in mathematics improve after numeracy strategies have been implemented?

3. Will there be an improvement in the TY tutees' interest and achievement in mathematics?

The research findings in relation to each of these questions will now be discussed.

6.2.1 Findings for Research Question 1

'Is a numeracy programme and peer tutoring, together, an effective type of intervention to achieve an improvement in students' mathematical abilities?'

Prior to this study the author was involved in peer tutoring in her school, in both the area of literacy and numeracy. She could see the social benefit for students, which Nguyen (2013) describes as increasing their self-esteem and improvements in their overall behaviour. Nguyen (2013) further explains that peer tutoring increases students' sense of responsibility for their own achievement thus increasing their achievement. However, being a mathematics teacher, the author was eager to assess any improvement in interest and hence achievement specifically in the area of mathematics.

The first accomplishment identified by the author in this intervention is that all the 1st year test group students engaged with and completed the intervention materials successfully. Bean (2004) explains that students' success and achievement is largely attributed to how much the student engages with learning. The first achievement by the students is completing the intervention itself. However what are more quantifiable measures of achievement are the pre and post intervention results. All the 1st year test and TY groups mean results have improved significantly in each strand from the pre to post test. The 1st year groups mean improvement ranges from 2.73 to 4.43, while the TYs mean improvement ranges from 1.96 to 4.54. While the control groups mean results have improved in three of the four strands, the improvement is far less than the other groups with their mean increase ranging from 0.2 to 1.5. The control group actually saw a drop in their mean score in strand 4, algebra, from pre to post-test by 0.2. The 1st year test group saw a greater improvement in their overall mean scores from pre to post-test than the control group. These types of results seem to be common as from the National Educational Psychological Service (NEPS, 2009) research, using peer tutoring, they found that on average the test group makes twice as much progress as the control group. They also state that tutors generally make a marginally better improvement compared to the control group. An important point to note however is that in relation to the test group, the control group received 70 minutes less mathematics exposure over the course of the intervention which sees the test group at an obvious advantage. However, the content in many of the lessons still had been covered in the control groups' mainstream class so therefore the control group should have been familiar with that content if they engaged with it effectively yet there was no significant change in any area of the test results from pre to post.

The author assessed all the mean changes from pre to post to find if they were statistically significant. All 1st year test group and TY students' results were statistically significant. This means that the increase discussed is 99% likely to be as a result of the numeracy intervention therefore it can be stated that this intervention is an effective intervention at raising students' mathematical ability. The same cannot be said for the control group however as all of the six areas assessed proved not to be statistically significant.

In order to attribute these changes to the intervention, a statistical significance value is obtained. As discussed in Chapter 5, all the results obtained from the 1st year's pre and post-test prove to be statistically significant with a less than 0.1% possibility that the changes occurred were by chance. From the six sections analysed for the control group, none proved to be statistically significant. This means that there was no significant change from pre to post-test for the control group. Again, like the 1st year results, all the results in the TY test proved statistically significant with the change that occurred from pre to post-test having a less than 0.1% possibility of having occurred by chance.

The test and control groups post results in the strands were assessed. It was found that there is a significant difference between the 1st year and control groups post results in all of the strands. As a result it can be stated that the intervention influenced this difference and again it can also be stated that a numeracy intervention and peer tutoring, together, are an effective type of intervention to achieve an improvement in students' numeric abilities.

6.2.2 Findings for Research Question 2

'Will 1st year students' interest and achievement in mathematics improve after numeracy strategies have been implemented?'

Southern Regional Educational Board (2002) states that in order to improve student's achievement in a given area then their interest must be acquired. As previously discussed in both the previous section and chapter 2 the intervention developed for this study was carefully designed in order to enhance students' interest and thus improve students' achievement. Achievement was measured using the aforementioned research instruments as well as the pre and post intervention test. From the answers to research question 1 it can be concluded that both the 1st year test group and the TY groups' achievement in mathematics improved after this studies strategies were implemented. However the qualitative data from the attitudinal survey and the focus group need to be examined in order to conclude if the students' interest in numeracy improved as a result of the intervention.

As discussed in Chapter 5, in each section of the survey the 1st years mean score increased considerably with the greatest increase visible in students' self-belief in mathematics (increasing by 17.13) and interest in mathematics (increasing by 12.6). The standard deviations in the post survey results are less than the pre survey which suggests that all students' results are closer to the mean value. The p-values for all sections of the 1st years' survey are <0.001 which means these results are statistically significant and the change that occurred from pre to post survey have a less than 1% possibility of occurring by chance. Tella (2013) research also used peer tutoring in mathematics and his research questions questioned the effects peer tutoring in mathematics had on pupil's ability and gender. Tella's (2013) research also found that a positive increase in students attitude towards mathematics to be statistically significant in his research.

In relation to the control group, their mean scores in each section of the survey have decreased from pre to post survey. The decrease however is small, with the largest mean decrease being 2.54. The standard deviation has decreased in three of the four sections which prove that the scores in these sections of the post survey are less spread out than the pre survey. McLeod (1994) suggests that student's attitudes towards education tend to become more negative as they move from elementary school to secondary school which gives a reason for the control groups' change in attitude from pre to post survey. However, the 1st year test group are in the same age group which may suggest that the intervention may have influenced their attitude towards mathematics. The TY students mean scores in each section have all increased from pre to post survey with the largest increase evident in their interest in mathematics (increasing by 11.13) followed by their self-belief in mathematics (10.53). The standard deviation has decreased from pre to post in each section of the TYs survey which means that the students' scores are less spread out in the post survey so their scores are consistently more positive.

The p-values for the control group proved statistically significant for three of the four sections of the survey. However as the section on interest in mathematics is not statistically significant no claim can be made as to why. From the mean scores and the p-values it can be concluded that students' interest and achievement in mathematics improved after the intervention was implemented. However as the control groups mean scores were also statistically significant it is important to further compare the 1st year and control groups results, even though from the mean scores we can tell that the control groups attitudes actually dis-improved and the 1st year groups' means scores improved. When a test for significance was performed on the post survey analysis it was found that all the results were statistically significant. This rejects the null hypothesis that this occurred by chance. Therefore it can be concluded that interest and achievement in mathematics improved for the 1st year test group after strategies had been implemented.

6.2.3 Findings for Research Question 3

'Will there be an improvement in TY tutees' interest and achievement in mathematics?'

Prior to this intervention the author expected to see a greater improvement in the 1st year test groups' interest and achievement in mathematics. However, the author also hoped for an improvement in TY students' interest and achievement in mathematics. As discussed in Chapter 2, Goodlad (1995) found that in the case studies he researched using peer tutoring, there were common benefits seen for the tutors and tutees. Tutees found lessons more interesting, easier to follow, more enjoyable and they seemed to learn more. Tutors found their communication skills improved, they enjoyed passing on their knowledge, their self-confidence increased and knowledge of their subject improved. McCarthy (2008) credits peer tutoring with many benefits for the tutor, such as increased academic achievements, greater self-esteem, improved social skills and a greater attitude towards school. These findings were reinforced by this study when it was found that on answering the previous two research questions it is evident that not only did the 1st year test group see an improvement in their interest and achievement in mathematics but the TY students also saw an increase in their interest and achievement in mathematics.

As discussed in the previous two sections both the 1st year and TY groups saw an improvement in both their attitude towards mathematics and their achievements in mathematics and all these improvements were deemed statistically significant. Therefore it can be concluded that the intervention implemented developed an improvement in both tutors' and tutees' numeric interest and achievement. These findings are further reinforced as a result of a different outcome for the control group.

6.3 Other Emerging Themes

Other themes emerged in the research findings that are not directly related to the research questions. These themes will now be discussed.

While not participating in peer tutoring, some improvements were noted in the control groups pre and post attitudinal survey and test. It can only be assumed that these improvements were as a result of the mathematical experiences that they are being exposed to. This also highlights the fact that not all the improvements made by the 1st year test group can be attributed to this studies intervention.

From the information presented in Table 5.8 it is apparent that students showed a very slight improvement in algebra from pre to post intervention. Algebra is often the most negatively viewed area of mathematics amongst students with EdSource (2009) outlining the transition from arithmetic to algebra being the most difficult transition in mathematics that students' are required to make. From the focus group it was made apparent that this was the area that students struggled with most during the intervention.

As previously discussed, the questions in each strand on the test are divided into questions on concepts and skills and questions on contexts and applications. On comparing students' performance on both types of questions it was evident that students performed better in the concepts and skills questions than the context and applications questions. There could be many reasons for this. Close and Shiel (2013, p.7) discuss findings from Trends in International Mathematics and Science Study (TIMSS) 2011 and PISA 2012. They explain that in the TIMSS study students in Ireland did better on the "*knowing process*" and less well on "*reasoning*" while in PISA 2011 it was evident that Irish students performed poorly on problem solving questions. However, there is hope that with students having studied Project Maths which has a strong emphasis on understanding and problem solving, that Ireland's performance in these international assessments will improve in the future. Although the students in this study are studying Projects Maths, it may be too early in the life of Project Maths to see an improvement in students understanding and problem solving. Another interesting point to note about the academic test is that from the focus group interviews, it became evident that the majority of 1st year students did not even recognise that the pre and post-test were the same test with most stating that the post test was far easier than the pre-test. This suggests that the students felt far more at ease with the test content the second time around. A final positive point to state is that the control group mean scores increased in all areas except algebra. This could be as a result of not having covered algebra yet during the school year.

Despite the many positive research findings there are some negative findings in this research that are worth noting. Despite statistically significant changes from pre to post-test for both the test group and the TY group, these students have still not reached the optimum test result in each section of the test. While the TY students post test results are close to optimum results, in most strands the test group results are in many cases less than half the optimum results for that strand. This is of concern as it highlights that there is still a lot of basic knowledge the test group have yet to acquire.

6.4 Conclusion

This chapter aimed to answer the research questions posed at the beginning of this study and also discussed any other topics that emerged from the findings. In Chapter 7 the author will draw conclusions from this research as well as discuss how this research contributes to existing research in this area. The author will made recommendations based on the research findings and identify areas that require further research in the future.

Chapter 7
Conclusions, Contributions, Recommendations & Further Research

7.1 Introduction

The aim of this chapter is to bring together and present the findings of this research. A summary of this thesis is given and conclusions are drawn from the research questions. The contributions this research makes to mathematics education are also discussed and recommendations for future research that became apparent as a result of this research are discussed.

7.2 Summary and Conclusions

As previously discussed, prior to this research the author, along with 2 of her colleagues developed a numeracy profiling test for 1st year students. This diagnostic test assessed students' basic numeracy skills in 4 of the Project Maths strands. From correcting this test it became apparent that many students had not grasped these basic skills. As a result, the author decided to develop an intervention that would work to improve students' basic numeracy skills. The National Strategy (2011) outlines that all students should leave school numerate and the author wanted to develop an intervention that would help to do this. The author used her own school to implement this intervention in the form of an action research project. As peer tutoring in literacy already occurred in the author's school, the author decided to use these 2 timetabled periods to implement the intervention.

The author began by conducting a literature review (chapter 2) to develop her initial ideas and inform the design and structure of the intervention. This literature review discussed numeracy issues both nationally and internationally and also discussed interest, achievement and peer tutoring. The author then developed the intervention and decided on the research methodologies and framework to be used (chapter 3). The author implemented the intervention and discussed how the intervention was designed and implemented in chapter 4. Once the intervention was complete and the data gathered was analysed, the research findings were outlined in chapter 5. Chapter 6 sees the findings discussed and the research questions answered.

7.3 Significant Overall Conclusions

The significant overall conclusions in relation to the research question will now be discussed. The numeracy intervention and peer tutoring, together are deemed to be an effective type of intervention to achieve an improvement in students' interest and achievement in mathematics for the following reasons;

- All the 1st year test and TY groups mean results have improved significantly in each strand from the pre to post test. While the control groups mean results have improved in three of the four strands, the improvement is far less than the other groups and the control group actually saw a drop in their mean score in strand 4, algebra.
- All the results obtained from the 1st year's pre and post-test prove to be statistically significant. From the six sections analysed for the control group, none proved statistically significant. This means that there was no significant change from pre to post-test for the control group. The TY test results proved statistically significant with the change that occurred from pre to post-test having a less than 0.1% possibility of having occurred by chance.
- In each section of the survey the 1st years mean score increased considerably. In relation to the control group, their mean scores in each section of the survey have actually decreased from pre to post survey. The TY students mean scores in each section have all increased from pre to post survey. All of this data proved to be statistically significant.

7.4 Thesis Contribution

This thesis makes a contribution to both mathematics education and education in general. Its findings can be related to all levels of education, be it primary, secondary or tertiary education. Firstly, this intervention concludes that peer tutoring is and effective intervention which leads to improvement in interest and achievement in mathematics. Peer tutoring is a teaching strategy that can be used in any level of education as its use relies on having a tutor that is more capable than the tutee. In relation to mathematics education, schools are looking for cost effective ways of improving numeracy within schools. This method is a cost effective approach that uses peer tutoring to develop numeracy. There is very little reference to peer tutoring of mathematics in education so this study is relatively unique from that respect.

7.5 Limitations of the Study

Like all studies, the author identifies some limitations to this research. This study took place in one school only, the school the author works in. Therefore the sample used in this study came from a small population. The sample size for this study could be no larger than 30 due to timetable constraints and classroom size. The larger the sample size, the more likely it is that the results would reflect the entire population. Also due to timetabling constraints the intervention could only take place for one double period per week, which may be seen as a relatively short amount of time.

The author uses a control group to ensure that findings from this research can be attributed to the intervention. However, mainstream class teaching that the students receive throughout the first term of 1st year may also contribute to an increase in each student's proficiency post intervention test. Both the control and test group are being taught mathematics outside of the intervention which may have some impact on data gathered. However, this is the same for both the control group and the test group so any discrepancies recorded may be attributed to the intervention.

Students from the test group all come from different base classes so as a result many of them have different mathematics teachers. The control group are all from the one base class and they have the same mathematics teacher, however this teacher is a different teacher to all the other base classes. The impact different teachers can make to students' interest and achievement can vary so the different mathematics teachers involved in teaching both the test group and the control group is a limitation to this study.

7.6 Recommendations

The author makes several recommendations based on the findings and conclusions drawn from this research;

- Co-operative teaching strategies in the form of peer tutoring should be made common practice in schools as means of developing students' interest and achievement in mathematics. As well as allowing for the implementation of the National Strategy these co-operative approaches are also recommended to ensure the successful implementation of Project Maths.
- The inclusion of numeracy content in the mathematics classroom that develops interest in students is necessary. This includes the content being meaningful, includes the use of puzzles and games as well as hands on manipulatives. These approaches are all in line with those recommended in Project Maths.
- An effort needs to be made by all teachers of mathematics to develop the aforementioned in their classrooms in order to improve their students' interest and achievement in mathematics.
- It would be beneficial if more action research projects occurred in schools around the country in order to advance the National Strategy. Highlighted in this study is the fact that while the test group students test results improved from pre to post test their results were still far from optimal. Further action research into each of the Project Maths strands, in particular algebra could see further improvements for students in these areas

7.7 Further Research

Having conducted this research, the author outlines that there are areas linked with this thesis that warrant further research;

- More research needs to be conducted in the area of peer teaching in mathematics. When conducting her literature review, the author found very little evidence of peer tutoring in the area of mathematics and no research in relation to peer tutoring of mathematics in Ireland.
- Further research could also examine if there are different impacts of peer tutoring in male and female students.

7.8 Final Comments

The author began this study after identifying an issue with students' basic numeracy skills in her school. Once the author identified this problem, she conducted a literature review and developed an intervention aimed to improve students' basic numeracy skills. The author maintains that there are numerous merits to this research. First and foremost the intervention improved both TY and the 1st year test groups' interest and achievement in mathematics. Secondly this intervention exposed these students to innovative strategies to teach and learn mathematics. This intervention also gave TY students the opportunity to develop their communication skill and confidence. Finally, on a personal level, the author believes that conducting this research benefits the author greatly. The author, on conducting this action research affirms the fact that she has a greater knowledge of issues in mathematics on a national and international level and has developed a deep understanding of strategies that improve students' interest and achievement in mathematics. These insights will be invaluable as she progresses in her teaching career.

Bibliography

Action Research Centre (2016) AR Cycle [online], available: http://wordpress.oise.utoronto.ca/arc/ar-clycle/#.VzyJ2vkrJdghttps://charleshuduni.wordpress.com/ [Accessed 8 August 2016].

Aiken, L. R. (1974). Two scales of attitude toward mathematics. Journal for Research in Mathematics Education, 5, 67-71.

Ainley, M.D. (1994) *Motivation and Learning: Psychology and You,* 3rd ed., Victoria: Hawker Bronlow Education.

Ainley, M.D. (1998) 'Interest in learning in the disposition of curiosity in secondary students: Investigating process and context' in Hoffmann, L., Krapp, A., Renninger, K, and Baumert, J., eds., *Interest and learning: Proceedings of the Seeon Conference on interest and gender*, Kiel, Germany: IPN, 257-266.

Aknin, L. B., Anik, L., Dunn, E. W., and Norton, M. I. (2009) *Feeling good about giving: the benefits (and costs) of self-interested charitable behaviour*, Cambridge, Mass: Harvard Business School.

Alexander, P. A. (1997) 'Mapping the multidimensional nature of domain learning: The interplay of cognitive, motivational, and strategic forces' in M. L. Maehr and P. R. Pintrich, eds., *Advances in motivation and achievement Vol. 10*, Greenwich: JAI Press, 213-250.

Allen, E. I. and Seaman, C. (2015) *Likert Scales and Data Analyses* [online], available: http://asq.org/quality-progress/2007/07/statistics/likert-scales-and-data-analyses.html [accessed 29 Jun. 2015].

An Chomhairle Mhúinteoireachta, The Teaching Council (2015) *Droichead A Guide for Schools*, Maynooth, Co. Kildare: An Chomhairle Mhúinteoireachta, The Teaching Council.

An Comhairle Mhúinteoireachta, The Teaching Council (2011) *A new era of professionalism: f.s, forbairt agus foghlaim : strategic plan 2012-2014*, Maynooth: An Chomhairle Mh.i nteoireachta.

Anderman, E. and Maehr, M.L (1994) 'Motivation and Schooling in the Middle Grades', *Review of Educational Research,* 64, 287-309.

Anders, C. and Berg, R. (2005) 'Factors related to observed attitude change toward learning chemistry among university students', *Chemistry Education Research and Practice,* 6(1), 1-18.

Anglo Info - The Global Expat Network (2015) *Examinations and Certificates* [online], available: *http://shanghai.angloinfo.com/information/family/schooling-education/examinations-Certificates/* [accessed 21 June 2015].

Anthony, G. and Walshaw, M. (2009) 'Characteristics of Effective Teaching of Mathematics: A View from the West', *Journal of Mathematics Education,* 2(2), 147-164.

Anton, W.D. and Klisch, M.C. (1995) 'Perspectives on Mathematics Anxiety and Test Anxiety', in Spielberger, C.D. and Vagg, P.R. eds., *Test anxiety: Theory, Assessment, and Treatment.* Washington, D.C.: Taylor and Francis, 93-106.

AQA (2015) *Mathematics Changes* [online], available: http://www.aqa.org.uk/supporting-education/policy/gcse-and-a-level-changes/changes-in-your-subject/mathematics-changes [accessed 24 June 2015].

ASTI Association of Secondary Teachers in Ireland (2015) *Class Sizes*, Dublin: ASTI.

ASTI Association of Secondary Teachers in Ireland (2015) *Class sizes* [online], available: http://www.asti.ie/about-asti/policy/class-sizes/ [accessed 29 June 2015].

Atweh, B. (2009) 'Ethical Responsibility and the "what" and "why" of Mathematics Education in a global context', in Ernest, P., Greer, B. and Sriraman, B. eds., *Critical Issues in Mathematics Education.* Missoula, Montana: Information Age Publishing Inc. & The Montana Council of Teachers of Mathematics, 7-17.

Ball, D. L., Lubienski, S. T., and Mewborn, D. S. (2001) 'Research on teaching mathematics: The unsolved problem of teachers' mathematical knowledge', in Richardson, V., ed., *Handbook of research on teaching, 4th ed.,* Washington, D.C.: American Educational Research Association, 433-456.

Bamford, J. and Topping, K (1998) *The Paired Maths Handbook – Parental Involvement and Peer Tutoring in Mathematics*, London: David Fulton Publishers Ltd.

Bamford, J. and Topping, K.J. (1998) ''Feelings' questionnaire for paired maths with peers', in *The paired maths handbook: parental involvement and peer tutoring in mathematics.* London: Fulton, 35.

Bandura, A. (1997) *Self-efficacy: The Exercise of Control*, New York: W.H. Freeman & Co.

Bean, L. (2004) 'Engaging Students in Learning', *Journal of Business Administration Online,* 2(2).

Bietenbeck, J.C. (2011) *Teaching Practices and Student Achievement: Evidence from TIMSS*, Madrid: Centro de Estudios Monetarios y Financieros.

Boaler, J. (1998) 'Open and closed mathematics: student experiences and understandings', Journal for Research in Mathematics Education*,* 29, 41–62.

Boaler, J. (2002) *Experiencing School Mathematics: Traditional and reform approaches to teaching and their impact on student learning*, Mahwah, NJ: Lawrence Erlbaum Associates.

Bodner, G.M. (1986) 'Constructivism: A Theory of Knowledge', *Journal of Chemical Education,* 63(10), 873.

Brader-Araje, L., Jones, G. (2002) 'The Impact of Constructivism on Education: Language, Discourse, and Meaning', *American Communication Journal,* 5(3).

Brazil, K., Lohfeld, L. H. and Sale, J. E. M. (2002) ‘Revisiting the Quantitative-Qualitative Debate: Implications for Mixed-Methods Research’, *Quality & Quantity,* 36, 43-53.

Brinkman, P.W. (2009) 'Design of a Questionnaire Instrument', in Love, S. ed., *Handbook of Mobile Technology Research Methods,* Portland, Oregon: Nova Science Publishers Inc, 31-57.

Brush, L. R. (1981) 'Some Thoughts for Teachers on Mathematics Anxiety', *Arithmetic Teacher,* 29(4), pp. 37-39.

Bryman, A. (2006) 'Integrating quantitative and qualitative research: how is it done?', *Qualitative Research,* 6(1), 97-113.

Bryman, A. (2011) 'Triangulation', in Lewis-beck, M.S., Bryman, A. and Liao, T.F. *Encyclopedia of Social Science Research Methods,* Thousand Oaks, California: Sage Publications, 1142-1143.

Burke-Johnson, R. and Onwuegbuzie, A. J. (2004) 'Mixed Methods Research: A Research Paradigm Whose Time Has Come', *Educational Researcher,* 33(7), 14-26.

Buxton, L. (1981) *Do you panic about maths?*, London: Heinemann.

California Mathematics Framework Committee (1992) *Mathematics framework for California public Schools*, Sacramento, California: California State Department of Education.

Cassidy, A. (2008) *JCSP Peer Tutoring Project Report Evaluation Report*, Dublin: Junior Certificate School Programme Support Service.

Center for the Study of Social Policy (2003) *POLICY MATTERS: Setting and Measuring Benchmarks for State Policies,* Washington, D.C.: Center for the Study of Social Policy.

Central Applications Office (2012) *Bonus Points for Higher Level Leaving Certificate Mathematics* [online], available: http://www2.cao.ie/otherinfo/calc_points.pdf [accessed 01 July 2014]

Checkland, P. and Holwell, S. (2007) 'Integrated Series in Information Systems', in Kock, N. ed., Information Systems Action Research*,* New York: Springer US, 3-17.

Christensen, C.R. (1991) 'Premises and practices of discussion teaching', in Christensen, C.R., Garvin, D.A., and Sweet, A. eds., *Education for Judgement,* Boston: Harvard Business School Press, 15-36.

Christopher, J. (2005) *Teacher characteristics and student achievement: evidence*, Dublin: Elsevier.

Close, S. and Shiel, G. (2014) *A Comparison of TIMSS 2011 and PISA 2012 mathematics frameworks and performance for Ireland and Selected countries*, St. Patrick's College, Dublin: Educational Research Centre.

Cobb, P., Wood, T. and Yackel, E. (1992) 'A constructivist alternative to the representational view of mind in mathematics education', *Journal for Research in Mathematics Education,* 23(1), 2-23.

Cockcroft Committee (1982) *Mathematics Counts: A Report into the Teaching of Mathematics in Schools*, London: HMSO.

Cohen, L., Manion, L. and Morrison, K. (2000) *Research Methods in Education,* 5th ed., London: Routledge and Falmer.

Cohen, L., Manion, L. and Morrison, K. (2011) *Research Methods in Education,* 7th ed., London: Routledge and Falmer.

Cohen, P. A., Kulik, J. A., and Kulik, C.-L.C. (1982) 'Educational outcomes of tutoring: a meta-analysis of findings', *American Educational Research Journal,* 19(2), 237-248.

Conlin, N., McGavock, K., Miller, D., Thurston, A. and Topping, K., (2011) 'Peer tutoring in reading in Scotland: thinking big', *Literacy,* 45(1), 3-9.

Conway, P. F., and Sloane, F. C. (2005) *International trends in post-primary mathematics education: perspectives on learning, teaching and assessment*, Dublin: NCCA.

Cooper, H. (2001) 'Homework for All – In Moderation', *Educational Leadership,* 58(7), 34-39.

Corey, S.M. (1953) *Action research to improve school practices*, New York: Teachers College Press.

Cosgrove, J., Perkins, R., Shiel, G., Fish, R. and McGuinness, L. (2012) *Teaching and Learning in Project Maths: Insights from Teachers who Participated in PISA 2012*, Dublin: Educational Research Centre.

Cosgrove, J., Shiel, G., Sofroniou, N., Zastrutzki, S. and Shortt, F. (2004) *Education for Life, The Achievements of 15-year-olds in Ireland in the Second Cycle of PISA, Summary Report*, Dublin: Educational Research Centre, St. Patrick's College.

Crotty, Y. (2012) 'Methodology: There is Method in My Madness', in Crotty, Y. ed*., How am I Bringing an Educationally Entrepreneurial Spirit into Higher Education?*, Dublin: Dublin City University, 124-160.

Dawes, J. (2008) 'Do data characteristics change according to the number of scale points used? An experiment using 5 point, 7 point and 10 point scales', *International Journal of Market Research,* 50(1).

Department of Communication and Media, Rensselaer (2014) *Research* [online], available: *http://www.cm.rpi.edu/pl/cm-research* [Accessed: 01 Jan 2015].

Department of Education and Skills (2012) *Irish Students' Performance in PISA 2012*[online], available:https://www.education.ie/en/Publications/Education-Reports/Programme-for-

International-Student-Assessment-PISA-2012-Explanatory-Memorandum.pdf [accessed 08 August 2014].

Department of Education and Skills, Qualifications, Curriculum and Assessment Policy Unit, (2011) *Initial Steps in the Implementation of the National Literacy and Numeracy Strategy* [online], available:https://www.education.ie/en/Circulars-and-Forms/Active-Circulars/cl0056_2011.pdf [accessed 4 August 2014].

Di Martino, P. and Zan,R. (2011) 'Attitude towards mathematics: a bridge between beliefs', *The International Journal on Mathematics Education,* 43(4), 471-482.

Dweck, C. and Molden, D. (2005) 'Self-theories: Their impact on competence, motivation and acquisition', in Elliot, A. and Dweek, C. eds., Handbook of Competence and Motivation, New York: Guilford, 122-140.

Eccles, J.S., and Wigfield A. (1992) 'The development of achievement-task values: A theoretical analysis', *Developmental Review,* 12, 265-310.

Eccles, J.S., Wigfield A., and Schiefele, U. (1998) 'Motivation to succeed', in Eisenberg, N. and Damon, W., eds., *Handbook of child psychology, 5th edition: Vol. 3, Social, emotional, and personality development,* New York: Wiley, 1017-1095.

Edsource (2009) *Why It Is Important to Learn Algebra. Parent/Student Guide*, Mountain View, California: EdSource.

Elliot, J. (1991) *Action Research for Educational Change*. Buckingham: Open University Press

Engineers Ireland (2010) *Report of the Task Force on Education of Mathematics and Science at Second Level* [online], available: http://webpages.dcu.ie/~bradysa/CASTEL_report_uploads/20100211-Mathematics_and_Science_at_Second_Level.pdf [accessed 12 August 2014].

Engineers Ireland (2012) *Irish Maths Teachers Association Survey 2012*, Dublin: Engineers Ireland.

Epstein, J.L., and McPartland, J.M. (1976) 'The concept and measurement of the quality of school life', *American Educational Research Journal ,* 13, 15-30.

Ernest, P. (2004) 'Images of mathematics, values and gender: a philosophical perspective', in Allen, B. and Johnston-Wilder, S., eds., *Mathematics Education: exploring the culture of learning.* London: Routledge, 11-25.

Fantuzzo, J. and Ginsburg-Block, M. (1998) 'Reciprocal Peer Tutoring: Developing and Testing Effective Peer Collaborations for Elementary School Students', in Ehly, S. and Topping, K. eds., *Peer Assisted Learning,* Mahwah, NJ: Lawerence Erlbaum Associates, 121-144.

Ferrance, E. (2000) *Action Research*, Providence, Rhode Island: Brown University.

FitzSimons, G., Jungwirth, H., Maas, J. and Schloglmann, W. (1996) 'Adults and Mathematics (Adult Numeracy)', in Bishop, A.J., Clements, K., Keitel, C. and Laborde, C. eds., *International Handbook of Mathematics Education,* Dordecht: Kluwer, 755-784.

Further Mathematics Support Programme (2015) *Gender and participation in mathematics and further mathematics A-levels: a literature review for the Further Mathematics Support Programme* [online], available: http://www.furthermaths.org.uk/docs/Gender%20Literature%20Review%20FINAL%20Oct.pdf [accessed 12 June 2015].

Golafshani, N. (2003) 'Understanding Reliability and Validity in Qualitative Research', *The Qualitative Report,* 8(4), 597-607.

Good, T., Mulryan, C., and McCaslin, M. (1992) 'Grouping for instruction in mathematics: A call for programmatic research on small-group processes', in Grouws, D. ed., *Handbook of research on mathematics teaching and learning,* New York: Macmillan, 165-196.

Goodlad, S. (1996) *Students As Tutors and Mentors*, London: Kogan Page Ltd.

Grouws, D.A. and Cebulla, K.J. (2000) *Improving student achievement in mathematics, Educational Practices Series 4*, Switzerland: PCL, Lausanne.

Guest, G., Namey, E.E. and Mitchell, M.L. (2013) 'Qualitative Research: Defining and Designing', in Guest, G., Namey, E.E. and Mitchell, M.L. *Collecting Qualitative Data: A Field Manual for Applied Research,* Thousand Oaks, California: Sage Publications, 1-40.

Haladyna T. and Thomas, G. (1979) 'The attitudes of elementary school children toward school and subject matters', *Journal of Experimental Education,* 48, 18-23.

Hammersley, M. and Traianou, A. (2012) *Ethics and Educational Research, British Educational Research Association on-line resource* [online], available:*https://www.bera.ac.uk/wp-content/uploads/2014/03/Ethics-and-Educational-Research.pdf?noredirect=1* [accessed 04 August 2015].

Harter, S. (1981) 'A new self-report scale of intrinsic versus extrinsic orientation in the classroom: Motivational and informational components.', *Developmental Psychology,*17(3), 300-312.

Heffner, C.L. (2015) *Research Methods. AllPsych* [online], available: *http://allpsych.com/researchmethods/* [accessed 31 July 2015].

Heller, R., Calderon, S., and Medrich, E. (2002) *Academic achievement in the middle grades: what does research tell us? A review of the literature*. Atlanta, Georgia: Southern Regional Education Board.

Hembree, R. (1990) ‘The nature, effects and relief of mathematics anxiety’, *Journal for Research in Mathematics Education,* 21, 33-46.

Hidi, S and Harackiewicz, J.M. (2000) ‘Motivating the Academically Unmotivated: A Critical Issue for the 21st Century’, *Review of Educational Research*, 70 (2) 151-179.

Hidi, S. (1990) ‘Interest and its contribution as a mental resource for learning’, *Review of Educational Research*, 60, 549-571.

Hidi, S. (2006) ‘Interest: A unique motivational variable’, *Educational Research Review*, 1, 69–82.

Humphreys, J. (2015) ‘Teachers’ qualifications don’t match subjects taught – survey’, *The Irish Times* [online], 15 June, available: http://www.irishtimes.com/news/education/call-to-pay-maths-graduates-bonus-to-go-into-teaching-1.2062310[accessed 29 June 2015].

Hidi, S. and Berndorff, D. (1998) 'Situational interest and learning', in Hoffmann, L., Krapp, A., Renninger, K., and Baumert, J. eds. *Interest and Learning; Proceedings of the Seeon Conference on interest and gender,* Kiel, Germany: IPN, 74-90.

Hidi, S. and Renninger, K.A. (2006) 'The Four-Phase Model of Interest Development', *Educational Psychologist,* 41(2), 111-127.

Hillman, J. (2014) *Mathematics after 16: the state of play, challenges and ways ahead,* London: Nuffield Foundation.

Hislop, J. and Lane, J. (2015) *Research Report Poster Presentation Number: RR-PO-08-13, Evaluation of a Peer tutoring Scheme to empower Students in their transitions through the Student Journey*, Edinburgh: Queen Margaret University.

Hodgen, J., Pepper, D., Sturman, L., and Ruddock, G. (2010) *Is the UK an outlier? An international comparison of upper secondary mathematics education,* London: Nuffield Foundation.

Hoffmann, L., and Haussler, P. (1998) ‘An intervention project promoting girls’ and boys’ interest in physics’, in Hoffmann, L., Krapp, A., Renninger, K., and Baumert, J. Baumert eds. *Interest and learning: Proceedings of the Seeon Conference on interest and gender*, Kiel, Germany: IPN, 301-316.

Hoyles, C. Wolf, A., Molyneux-Hodgson, S. & Kent, P. (2002). Mathematical skills in the workplace. London: The Science, Technology and Mathematics Council.

Humphreys, J. (2015) ‘Call to pay math’s graduates bonus to go into teaching’, *The Irish Times* [online], 11 January, available: http://www.irishtimes.com/news/education/teachers-qualifications-don-t-match-subjects-taught-survey-1.2249193_ [accessed 11 September 2015].

Jamieson, S. (2004) 'Likert scales: how to (ab)use them', *Medical Education,* 38(12), 1217-1218.

Jeffes, J., Jones, E., Cunningham, R., Dawson, A., Cooper, L., Straw, S., L. Sturman and M. O’ Kane (2012) *Research into the impact of Project Maths on student achievement, learning and motivation: First interim report*. Slough: NFER.

Jeffes, J., Jones, E., Wilson, M., Lamont, E., Straw, S., Wheater, R. and Dawson, A. (2013*) Research into the impact of Project Maths on student achievement, learning and motivation: final report*, Slough, Berkshire: National Foundation for Educational Research.

Johnson, B., Christensen, L., and Christensen, L. B. (2011) *Educational research: quantitative, qualitative, and mixed approaches,* 3rd ed., Los Angeles: Sage Publications.

Joppe, M. (2015) *The Research Process,*[online], available: https://www.uoguelph.ca/hftm/research-process [Accessed: 01 Jan 2015].

Kagan, S. and Kagan, M. (2009) *Cooperative Learning*, San Clemente, California: Kagan Publishing.

Kaput, J. J. (1989) 'Information technologies and affect in mathematical experience', in McLeod, D.B. and Adams, V. M., eds., Affect and mathematical problem solving, New York: Springer-Verlag, 89-103.

Kearney, C. (2011) *Efforts to Increase Students' Interest in Pursuing Science, Technology, Engineering and Mathematics Studies and Careers: National Measures taken by 21 of European Schoolnet's Member Countries - 2011 Report,* Brussels: European Schoolnet (EUN Partnership AISBL).

Kemmis, S. and McTaggart, R. (2005) 'Participatory Action Research: Communicative Action and the Public Sphere', in Denzin, N.K., and Lincoln, Y.S., eds., The SAGE Handbook of Qualitative Research, 3rd ed., London: SAGE Publications.

Kestin, I. (2015) Statistics in medicine, *Anaesthesia & Intensive Care Medicine,* 16, 200-207.

Kirk, R. E. (1999) Statistics: An introduction, London: Harcourt Brace.

Kolb, D.A. (1984) *Experiential learning: Experience as the source of learning and development,* Englewood Cliffs, NJ: Prentice-Hall.

Koshy, V. (2005) 'What is action research?', in Koshy, V., ed., Action Research for Improving Practice: A Practical Guide, London: Sage Publications, 1-22.

Koshy, E., Koshy, V. and Waterman, H.(2011) *Action Research in Healthcare*, London: Sage Publications.

Lavy, V. (2011) *What makes an effective teacher? Quasi-experimental evidence, Cambridge, Mass, National Bureau of Economic Research* [online], available: http://econpapers.repec.org/paper/nbrnberwo/16885.htm [accessed 01 Jan 2015].

Lepper, M. R. and Malone, T. W. (1987) 'Intrinsic motivation and instructional effectiveness in computer-based education' in Snow, R.E. and Farr, M. J., eds., *Aptitudes, learning and instruction; Vol 3. Conative and affective process analyses* Hillsdale, New Jersey: Erlbaum, 255-286.

Lepper, M. R., and Henderlong, J. (2000) 'Turning "play" into "work" and "work" into "play": 25 years of research on intrinsic versus extrinsic motivation and performance', in Sansone, C. and Harackiewicz, J.M. eds., *Intrinsic and extrinsic motivation: The search for optimal motivation,* New York: Academic Press, 251-307.

Luftig, J. T., and Jordan, V. S. (1998) *Design of experiments in quality engineering*, New York: McGraw-Hill.

Lyons, M., Lynch, K., Close, S., Sheeran, E., and Boland, P. (2003) Inside Classrooms: a Study of Teaching and Learning. Dublin: Institute of Public Administration

Mac an Bhaird, C. (2014) ‘The Necessity of Maths Support Centres in Higher Level Education', in Carey, L., Guerin, H., Huntley-Moore, S., Magennis, S. and McMullin, B., eds., *Proceedings of AISHE, AISHE-C Encouraging Student Engagement,* Maynooth: AISHE.

Martino, P. and Zan, R. (2011) 'Attitude towards mathematics: a bridge between beliefs and emotions', *ZDM,* 43(4), 471–482.

Mathematics in Education and Industry (MEI) (2015) *Changing the structure of AS/A levels in Mathematics and Further Mathematics* [online], available: http://www.mei.org.uk/files/pdf/models_2015_3.pdf [accessed 01 September 2015].

Maughan, S. and Cooper, L. (2010). 'Policy and developments in mathematics assessment in England', paper presented at *The 36th International Association for Educational Assessment Conference 'Assessment for Future Generations'*, Bangkok, 23 August 2010.

May, S., Cowles, S. and Lamy, M. (2012) *Pisa 2012 New Zealand Summary Report,* Wellington, New Zealand: Comparative Education Research Unit.

McDonagh S. and Quinlan T. (2012) *A discussion document submitted to the National Competitiveness Council,* Available at:*http://www.competitiveness.ie/media/NCC04072012-Maths-Publication-Updated.pdf* [accessed 11 June 2014].

McLeod, D. B. (1994) Research on Affect and Mathematics Learning in the JRME: 1970 to the Present. *Journal for Research in Mathematics Education,* 25, 637.

Mee, P (2013) *Inquiry into compulsory vs. elective subjects in secondary schools – should subjects like science be compulsory?*
[online], available: http://www.myd.govt.nz/documents/youth-parliament-/education-and-science-committee-background-paper.pdf [accessed 01 May 2014].

Merriman, B., Shiel, G., Perkins, R. and Cosgrove, J. (2014) *Project Maths and PISA: Comparing the coverage of PISA mathematics items by the Project Maths and pre-Project Maths curricula*, Dublin: Dublin City University.

Metzler, J. and Woessmann, L. (2010) *The impact of teacher subject knowledge on student achievement evidence from within-teacher within-student variation*, Munich: CESifo.

Miller, J. and Scott, J. (2012) *Uses of Multiple Measures for Performance-Based Compensation*, Washington, D.C.: Center for Educator Compensation Reform.

Ministry of Education, (2007) *The New Zealand Curriculum: for English-medium teaching and learning in years 1-13,* Wellington, New Zealand: Learning Media Limited.

Ministry of Education, New Zealand Government (2015) *Education Counts, Subject Enrolment* [online], available: *http://www.educationcounts.govt.nz/statistics/schooling/student-numbers/subject-enrolment* [accessed 20 July 2015].

Mislevy, R. J., Steinberg, L. S., Almond, R. G., Haertel, G. D., & Penuel, W. (2003). Improving educational assessment. In B. Means & G. D. Haertel (Eds.), Evaluating educational technology: Effective research designs for improving learning (pp. 149-180). New York: Teachers College Press

Mitchell, M. (1993) 'Situational Interest: Its Multifaceted Structure in the Secondary School Mathematics Classroom', Journal of Educational Psychology, 85 (3), 424 –436.

Morgan, D.L. (1997) 'Planning and Research Design for Focus Groups', in Morgan, D.L. *Focus Groups as Qualitative Research, 2nd ed.,* Thousand Oaks, California: Sage Publications, 31-45.

Morris, J. and Patterson, R. (2013) *World Class Education? Why New Zealand must strengthen its Teaching Profession The New Zealand Initiative,* Wellington, New Zealand: The New Zealand Initiative.

Morris, J. and Patterson, R. (2014) *Teaching Stars Transforming the Education Profession The New Zealand Initiative* [online], available: http://nzinitiative.org.nz/site/nzinitiative/files/Teaching_stars_web.pdf [accessed 23 Jun 2015].

Murnane, R.J., Willett, J.B. and Levy, F. (1995) 'The Growing Importance of Cognitive Skills in Wage Determination', *Review of Economics and Statistics,* 77, 251-266.

NCCA National Council for Curriculum and Assessment (2012) *Responding to current debate on Project Maths,* [online] available: *http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Project_Maths/Information/Project_Maths_response_to_current_debate.pdf* pdf [accessed 04 August 2014].

National Centre for Excellence in the Teaching of Mathematics (2008) *Mathematics Matters: Final Report* [online], available:*http://www.gram.edu/sacs/qep/chapter%204/4_10NCETMMathMatters.pdf* [accessed 23 July 2015].

National Council for Curriculum and Assessment (2006) 'NCCA Review of Mathematics in Post-Primary Education Response of the Royal Irish Academy Committee for Mathematical Sciences', *Irish Math. Soc. Bulletin,* (57), 11-20.

National Council for Curriculum and Assessment (2006) *Review of Mathematics in Post-Primary Education-Report on the Consultation* [online], available: *http://www.ncca.ie/uploadedfiles/mathsreview/Maths_Consult_Report.pdf* [accessed 11 June 2014].

National Council for Curriculum Assessment (2006) 'NCCA Review of Mathematics in Post-Primary Education Response of the Royal Irish Academy Committee for Mathematical Sciences', *Irish Math. Soc. Bulletin,* 57, 11-20.

National Education Association (NEA) Education Policy and Practice Department (2008) *Class Size Reduction: A proven reform strategy*, Washington D.C.: National Education Association.

National Educational Psychological Services (2015) *Effective Interventions for Struggling Readers in Irish schools* [online], available: http://www.education.ie/en/Schools-Colleges/Services/National-Educational-Psychological-Service-NEPS-/neps_resource_interventions_struggling_readers.pdf [accessed 01 Jan 2015].

NCE-MSTL National Centre for Excellence in Mathematics and Science Teaching and Learning (2014) *Project to up skill out-of-field post primary teachers of Mathematics: Professional Diploma in Mathematics for Teaching (Level 8)/Dioplóma Gairmiúil Mhatamaitic don Mhúinteoireacht*, 5(1), Limerick: University of Limerick.

Nelson, D. (2013) 'Action Research: An Appropriate Research Paradigm for Practitioners', *Language in India,* 13(10), 183-196.

New Zealand Qualifications Authority (2015) *Factsheet#4: Credits and the NCEA,* [online], available: http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/the-facts/factsheet-4/ [accessed 08 August 2015].

Nguyen, M. (2013) *Peer tutoring as a Strategy to Promote Academic Success* [online], available: https://childandfamilypolicy.duke.edu/pdfs/schoolresearch/2012_PolicyBriefs/Nguyen_Policy_Brief.pdf [accessed 24 August 2014].

Ni Riordain, M., and Hannigan, A. (2009) *Out of Field Teaching in Post primary Mathematics Education; An Analysis of the Irish Context*, Limerick: NCE-MSTL.

Notebook (2015) *Neils Toolbox Bibliography Creator* [online], available: *http://www.neilstoolbox.com/bibliography-creator/reference-journal.htm* [accessed 12 September 2015].

Nuffield Foundation (2013) *Towards universal participation in post-16 mathematics: lessons from high-performing countries Country profile: New Zealand*, London: Nuffield Foundation.

Nugent, M. (2008) 'A Rough Guide to Reading Partners- A cross age, peer tutoring approach', Learn, Journal of the Irish Learning Support Association, 30, 76-82.

O'Donoghue, J., Gill, O. and O'Meara, N. (2011) *Improving mathematics teaching at second level through the design of a model of teacher knowledge and an intervention aimed at developing teachers' knowledge*, Limerick: University of Limerick.

Ofsted (2008) *Mathematics: Understanding the score – Messages from the inspection service*, London: Crown.

O'Leary, Z. (2004) *The Essential Guide to Doing Research*. London: Sage.

Organisation for Economic Co-Operation and Development (2009) *PISA 2009 Ranking by Mean Score for Reading, Mathematics and Science* [online], available: *http://www.moe.gov.sg/media/press/files/2010/annex-pisa-2010.pdf* [accessed 01 August 2014].

Organisation for Economic Co-Operation and Development (2010) 'Shanghai and Hong Kong: Two Distinct Examples of Education Reform in China', in Organisation for Economic Co-Operation and Development ed., *Strong Performers and Successful Reformers in Education: Lessons from PISA for the United States,* Paris: OECD Publishing, 83-115.

Organisation for Economic Co-Operation and Development (2013) *PISA 2012 assessment and analytical framework mathematics, reading, science, problem solving and financial literacy*, Paris: OECD Publishing.

Organisation for Economic Co-Operation and Development (2014) *PISA 2012 Results in Focus - What 15-year-olds know and what they can do with what they know*, Beaconsfield, Quebec: OECD Publishing.

Organisation for Economic Co-Operation and Development, National Center on Education and the Economy (U.S.), Programme for International Student Assessment, OECD Directorate for Education, & OECD Library (2011) *Strong performers and successful reformers in education: lessons from PISA for the United States*, Paris: OECD Publishing.

Pallant, J. (2013) *SPSS Survival Manual*, 5th ed., Berkshire, England: Open University Press.

Paterson, E., Vernon, B., and Stringer, E. (2010) *Count me in: improving numeracy in England: a guide for charities and funders*, London: New Philanthropy Capital.

Perkins, R., Shiel, G., Merriman, B., Cosgrove, J., and Moran, G. (2013) *Learning for life: the achievements of 15-year-olds in Ireland on mathematics, reading literacy and science in PISA 2012*, Dublin: Educational Research Centre.

Person, N.K. and Graesser, A.G. (1999) 'Evolution of discourse during cross-age tutoring' in O'Donnell, A.M. and King, A. eds., *Cognitive Perspectives on Peer Learning,* Mahwah, New Jersey: Lawrence Erlbaum, 69-86.

Piaget, J. (1971) *Biology and knowledge; an essay on the relations between organic regulations and cognitive processes*, Chicago: University of Chicago Press.

Prendergast, M. and O'Meara, N. (2015) 'Investigating the Time Allocated to Teaching Mathematics in Irish Second Level Schools', in Rogerson, A., eds., *The Mathematics Education for the Future Project,* Catania, Sicily, *16-20 Sept*, Münster: WTM-Verlag, 339-348.

Prenzel, M. (1988) 'Task persistence and interest', in Schiefele, U. Content and interest as motivated factors in learning, paper presented *The annual meeting of the American Educational Research Association*, New Orleans.

Professional Development Services for Teachers (2011) *Fractions Teacher's Manual. A Guide to Teaching and Learning Fractions in Irish Primary Schools* [online], available at:*http://www.pdst.ie/sites/default/files/PDST%20Guide%20to%20Teaching%20Fractions%20in%20Irish%20Primary%20Schools%281%29.pdf* [accessed 9 June 2015].

Programme for International Student Assessment, Organisation for Economic Co-Operation and Development (2014) *Education at a glance 2014: Highlights. OECD Publishing* [online],

available:
http://www.oecdilibrary.org/docserver/download/9810131ec008.pdf?expires=1440715927&id=id&accname=guest&checksum=F382BAB550D09A3E225C4DDEF1F4E5BF [accessed 23 August 2015].

Programme for International Student Assessment, Organisation for Economic Co-Operation and Development (2004) *Learning for tomorrow's world: first results from PISA 2003,* Paris: OECD Publishing.

Project Maths Development Team (2015) *Working together to improve teaching & learning*, [online], available: *http://www.projectmaths.ie/* [Accessed: 27 August 2015].

Project Maths Development Team (2015) *Learning and teaching for the 21st century* [online], available: *http://www.projectmaths.ie/* [accessed 27 August 2015].

Project Maths Development Team (2015) *Learning and teaching for the 21st century- Teacher Area* [online], available: *http://www.projectmaths.ie/for-teachers/* [accessed 30 August 2015].

Reason, P. and Bradbury, H. (2008) *The SAGE Handbook of Action Research: Participative Inquiry and Practice*, 2nd ed., London: SAGE.

Renninger, A., Hidi, S. and Krapp, A. (1992) *The role of interest in learning and development*, Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Renninger, K.A. (1987) 'Do individual interests make a difference?' in *Essays by the Spencer Fellows IV,* Cambridge, Massachusetts: National Academy of Education, 228-253.

Renninger, K.A. (1990) ‘Children’s play interests, representation and activity’ in Fivush, R. and Hudson, J., eds., *Knowing and remembering in young children*, *Emory Cognition Series (Vol. 3),* Cambridge, Massachusetts: Cambridge University Press, 127-165.

Renninger, K.A. (1998) ‘The roles of individual interest(s) and gender in learning: An overview of research on preschool and elementary school-aged children/students’ in Hoffmann, L., Krapp, A., Renninger, K. and Baumert, J., eds., *Interest and learning: Proceedings of the Seeon Conference on interest and gender*, Kiel, Germany: IPN, 165-175.

Richards, C.J. and Renandya, W.A. (2002) *Methodology in Language Teaching: An Anthology of Current Practice*, Cambridge: Cambridge University Press.

Rockstroh, A. H. (2013) *Teacher Characteristics on Student Achievement: An Examination of High Schools in Ohio*, Kentucky: Martin School of Public Policy and Administration.

Rose, H. and Julian R. Betts, J. R. (2001) *Math Matters: The Links Between High School Curriculum, College Graduation, and Earnings*, California: The Public Policy Institute of California.

Rubin, L. and Hebert, C. (1998) ‘Model for Active Learning: Collaborative Peer Teaching’, *College Teaching,* 46, 26-30.

Rylands, L.J. and Coady, C. (2009) 'Performance of students with weak mathematics in first-year mathematics and science', *International Journal of Mathematical Education in Science and Technology,* 40(6), 741-753.

Sammons, P., Sylva, K., Melhuish, E., Siraj-Blatchford, I., Taggart, B., Toth, K., Draghici, D. and Smees, R. (2011) *Influences on students' attainment and progress in Key Stage 3: academic outcomes in English, maths and science in year 9,* London: UK Government, Department for Education.

Sanders, W.L., Wright, P.S. and Horn, S.P. (1997) 'Teacher and Classroom Context Effects on Student Achievement: Implications for Teacher Evaluation', *Journal of Personnel Evaluation in Education,* 11(1), 57-67.

Schafer, A.T. and Gray, M. W. (1981) ‘Sex and Mathematics’ *Science,* 211, 231-231.

Schreyer Institute for Teaching Excellence (2007) *Jigsaw Strategy*, Pennsylvania: Schreyer Institute for Teaching Excellence.

Schreyer Institute for Teaching Excellence (2007) *Peer Tutoring*, Pennsylvania: Schreyer Institute for Teaching Excellence.

Seale, C (2012) *Research Society and Culture*, 3rd ed., London: Sage Publications.

Sheridan, B. (2013) 'How Much Do Our Incoming First Year Students Know?: Diagnostic Testing in Mathematics at Third Level', *Irish Journal of Academic Practice,* 2(1), 1-19.

Smith, A. (2004*) Making Mathematics Count: the Report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education*, London: The Stationary Office.

Smith, C. (2014) *Gender and participation in mathematics and further mathematics A-levels: a literature review for the Further Mathematics Support Programme*, London: Institute of Education, University of London.

Smyth, E. and McCoy, S. (2011) Improving Second-Level Education: Using Evidence for Policy Development, Renewal Series, Paper 5, Dublin: The Economic and Social Research Institute.

Special Education Support Service (2015) *Metacognition for the classroom and beyond: Differentiation and support for learners* [online]*,* available: *http://www.sess.ie/sites/all/modules/wysiwyg/tinymce/jscripts/tiny_mce/plugins/filemanager/files/Projects/Equality_of_Challenge/SESS_Metacognition_Resource_V1.pdf* [accessed 01 July 2015].

SSAT (The Schools Network) Ltd. (2013) *Curriculum Radar 2013: Proposed reforms to key stage 4 and 5 qualifications*, London: SSAT (The Schools Network) Ltd.

SSB Code 130301: *Use number to solve problems* (2015), New Zealand, New Zealand Qualifications Authority.

Stewart, D.W. and Shamdasami, P.N. (2015) *Focus Groups: Theory and Practice*, 3rd ed., Newbury Park, California: Sage Publications Inc.

Stodolsky, S.S., Salk, S., & Glaessner, B. (1991) *Student views about learning math and social studies*, American Educational Research Journal 28: 89 - 116

Strand, E.P. (2004) *Using an ”unknown mystery” as a case for teaching students Information/Communication Technologies (ICT)*, Halden, Norway: School of Computer Sciences, Østfold College.

Tapia, M., and Marsh, G. E. II. (2004) '*An Instrument to Measure Mathematics Attitudes'*, Academic Exchange Quarterly, 8(2), 16-21.

Teijlingen, E. R. V. and Hundley, V. (2001) *The importance of pilot studies*, Surrey: University of Surrey.

Tella, A. (2013) 'The effect of Peer Tutoring and explicit instructional strategies on primary School pupils learning outcomes in Mathematics', *Bulgarian Journal of Science and Educational Policy (BJESP),* 7(1), 5-25.

The Department of Education and Skills (2011) *Literacy and numeracy for learning and life: the national strategy to improve literacy and numeracy among children and young people, 2011-2020*, Dublin: Department of Education and Skills.

The Learning and Teaching Support Network (2003) *Diagnostic Testing for Mathematics*, Dublin: LTSN Maths TEAM.

The Research Base (2015) *Country Reports - China – Shanghai* [online], available: *http://www.et-foundation.co.uk/wp-content/uploads/2014/12/China-Shanghai.pdf* [accessed 23 August 2015].

Topping, K. J. (2005) 'Trends in Peer Learning', *Educational Psychology,* 25(6), 631-645.

Topping, K., Miller, D., Murray, P. and Conlin, N. (2011) 'Original Articles Implementation Integrity in Peer tutoring of Mathematics', *Educational Psychology: An International Journal of Experimental Educational Psychology,* 31(5), 575-593.

Townsend, M. and Wilton, K. (2003) ‘Evaluating change in attitude towards mathematics using the 'then-now' procedure in a cooperative learning programme’, *British Journal of Educational Psychology,* 73, 473-487.

Travers, J.P. (1970) *Fundamentals of Educational Psychology* Scrantom, Pennsylvania: International Textbook Company.

Tucker, M. S., ED. (2014). *Chinese Lessons: Shanghai's Rise to the Top of the PISA League Tables*. Washington, D.C.: National Center on Education and the Economy.

UK Government, Department for Education (2013) *Mathematics GCSE subject content and assessment objectives* [online], available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/254441/GCSE_mathematics_subject_content_and_assessment_objectives.pdf [accessed 14 June 2014].

UK Government, Department for Education (2015) *Get Into Teaching* [online], available: https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding [accessed 31 August 2015].

UK Government, Department for Education (2015) *Getting into Teaching Bursaries and Funding* [online], available: https://getintoteaching.education.gov.uk/bursaries-and-funding [accessed 31 August 2015].

UK Government, Education Funding Agency (2015) *Information on maths and English condition of funding for academic years 2014 to 2015 and 2015 to 2016* [online], available: https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding [accessed 1 September 2015].

UNESCO United Nations Educational, Scientific and Cultural Organization (2012) *Challenges in basic Mathematics Education*, Paris: UNESCO United Nations Educational, Scientific and Cultural Organization.

Von Glasersfeld, E. (1995) *Radical constructivism: A way of knowing and learning,* Washington, D.C.: Falmer.

Wang, Y. (1999) *The changing educational framework for the teaching of mathematics in China*, Suzhou, China: Suzhou Railway Teachers' College.

Watt, J. H., and Berg, S. V. D. B. (2002) *Research methods for communication science*, Boston: Allyn and Bacon.

Watt, J.H., and Berg, S. V. D. B. (2002) 'Chapter 14: Controlled Environments: Experimental Research', *Research Methods for Communication Science,* Boston: Allyn and Bacon, 205-226.

Wellcome Trust (2012) *Department for Education: Reforming Key Stage 4 qualifications* [online], available:*http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/wtp041064.pdf* [accessed 23 June 2014].

Wood, D. (1998) *How Children Think and Learn,* Oxford: Blackwell Publishers Ltd.

Yeager, D. S., and G. M. Walton (2011) 'Social-Psychological Interventions In Education: They're Not Magic', *Review of Educational Research,* 81(2), 267-301.

Yin, R.K. (2003) 'Mixed Methods Research: Are the Methods Genuinely Integrated or Merely Parallel?', *Research in the Schools,* 13(1), 41-47.

Zeidner M. (1991) 'Statistics and mathematics anxiety in social science students: some interesting parallels', *The British Journal of Educational Psychology,* 61, 319-328.

Appendices

The Appendices are on a CD which is attached to the back inside cover of this thesis.