

Cooperative Learning and Project
Maths: Attitudes, Key Skills and
Academics.
A Case Study.

Derek David Maher

Master in Education
(Cooperative Learning)

University of Dublin, Trinity College

Supervisor: Mr. Brendan Keenan

Submitted to the University of Dublin, Trinity
College, September 2016

Declaration

I hereby declare that this is entirely my own work and that it has not been submitted as an exercise for the award of a degree at this or any other University. I agree that the library may lend or copy this dissertation on request.

Signature: _____

Name: Mr. Derek David Maher

Date: September 30th, 2016

Summary

Project Maths is the newly reformed mathematics curriculum at post-primary level in Ireland. This reform was the product of Ireland's poor results in comparison with previous years and other neighbouring countries in the Programme for International Student Assessment (PISA), in conjunction with a decline in assessment results in state examinations. Project Maths intends to be the curriculum of the future; it strives to educate students for life and work in the 21st century. In addition to educating students for the 21st century, the National Council for Curriculum and Assessment (NCCA) published their framework for Key Skills at Leaving Certificate. This document illustrated the fundamental importance for students to be fluent in the key skills in order for successful living and participation in the 21st century.

Although Project Maths was developed and composed in conjunction with these key skills, the Project Maths Junior Certificate curriculum does not contain any key skills. This gap in the approaches to teaching and learning is left to the teacher to ensure that students are best prepared for life and society. In addition, while the development of Project Maths has focused heavily on overhauling the assessment strategies and the curricular content, it can be argued that there has been a lack of emphasis on the teaching and learning strategies for delivering this new curriculum. Project Maths has developed a plethora of resources to best support the changes in assessment and curriculum content overhaul. In addition, the Project Maths Development Team has published Teaching and Learning plans to best guide the teachers in this process. These plans aim to utilise “group-work” as one of the main strategies for delivering Project Maths, however one must question how to achieve this goal.

This research sought to examine the potential benefits of using Cooperative Learning as the main teaching and learning methods within a second year Project Maths Junior

Certificate classroom. Cooperative Learning can be described as structured team-work which, when constructed correctly, can enable students to benefit. In addition, the author believed that Cooperative Learning would also best encapsulate the NCCA's key curricular skills.

This case study was conducted over ten academic weeks with a group of mixed-gender second-year higher level students in an urban school. Students were arranged into three membered teams and received instruction on algebra, probability and sets from the Project Maths syllabus. Data was generated throughout three main outlets including a pre- and post-questionnaire, team processing sheets and finally an assessment examination. This triangulation of data enabled the author to develop an understanding of student attitudes towards Project Maths, the impact that Cooperative Learning has on learning and its ability to encompass the key skills.

After the implementation of Cooperative Learning, the findings revealed some interesting and useful outcomes. In addressing the three main research questions, it was discovered that students preferred to learn mathematics when challenged to work as a team. Secondly, there was a strong correlation between teaching through Cooperative Learning and educating students on the key curricular skills. Lastly, it was discovered that teaching through Cooperative Learning was approximately equivalent to teaching through more traditional methods. There were some statistical differences between these two methods of teaching. However the benefits of teaching students social skills and equipping them with the key skills to progress their learning are also highly beneficial for life in the 21st century.

Cooperative Learning was an effective methodology for delivering Project Maths and , in particular, had an impact on key skills, academic results and attitudes.

Acknowledgements

I would like to thank the following people for their assistance in helping me to complete this dissertation.

I want to extend my sincerest gratitude to my supervisor Mr. Brendan Keenan. Thank you for your guidance, patience and encouragement. Thank you for your watchful eye and for going beyond the call of duty to ensure that I completed this piece of work.

To my parents, Dave and Eileen, thank you for your constant support. Thank you for the use of your kitchen table and for always encouraging me to do my best. I would also like to thank my brother, Jason, for reminding me to take breaks and for listening to my complaints throughout the year..

To my extended family and friends, your reassurance and help throughout this process have been incredible.

To my Principal, Deputy Principal and Board of Management, your guidance, support and kindness have been invaluable.

To my proof readers, Bríd Flood, Luke Fitzsimons, Karen Gernon, Michelle McCabe, Teide O' Brien and Colette Phillips, thank you for your hours of correcting my mistakes and making this dissertation what it is.

To my maths students, thank you for participating in this research, without your co-operation this dissertation would not have been possible.

To the Masters of Education Cooperative Learning Class of 2016, thank you for all the good memories.

Table of Contents

Chapter One: Research Questions	1
1.1 Introduction	1
1.2 Developing Research Question One: Student Attitudes towards Mathematics	2
1.3 Developing Research Question Two: Cooperative Learning, Key Skills and Project Maths .	3
1.4 Developing Research Question Three: Cooperative Learning, Assessment and Project Maths	4
1.5 Structure of Dissertation	4
1.5.1 Overview of Chapter Two: Literature Review.....	4
1.5.2 Overview of Chapter Three: Methodology.....	5
1.5.3 Overview of Chapter Four: Findings	5
1.5.4 Overview of Chapter Five: Discussion	5
1.5.5 Overview of Chapter Six: Conclusion.....	6
1.6 Conclusion.....	6
Chapter Two: Literature Review	7
2.1 Introduction	7
2.2 The need for change: Ireland's review of Mathematics Education	8
2.3 Curriculum Reform: The need to change classroom practices	10
2.4 A New Curriculum: The Search for New Teaching and Learning Methodologies	11
2.5 Project Maths Teaching and Learning Plans.....	12
2.6 Cooperative Learning: Moving away from Traditional Methodologies in Project Maths .	13
2.6.1 Element One: Positive Interdependence	13
2.6.2 Element Two: Individual Accountability	14
2.6.3 Element Three: Face-to-Face Promotive Interaction.....	15
2.6.4 Basic Element Four: Use of Social Skills	15
2.6.5 Element Five: Group Processing	16
2.7 Theoretical Framework of Cooperative Learning	16
2.8 Cooperative Learning and Student Attitudes to Mathematics	17
2.9 Utilising the key skills within the Teaching and Learning of Project Maths	18
2.9.1 European Union's Key Competences for Lifelong Learning.....	19
2.9.2 Partnership for 21 st Century Learning Framework	19
2.9.3 The NCCA's Key Skills Framework.....	20
2.9.3.1 Information Processing	20

2.9.3.2 Critical and Creative Thinking	21
2.9.3.3 Communicating	21
2.9.3.4 Working with Others	21
2.9.3.5 Being Personally Effective	22
2.9.3.6 Key Skills and Junior Certificate Project Maths.....	22
2.10 Cooperative Learning and Mathematics: Current Research	22
2.11 Challenges of Implementing Cooperative Learning within Mathematics	23
2.12 Conclusion	24
Chapter Three: Methodology	26
3.1 Introduction to Methodology.....	26
3.1.2 Rationale for undertaking this Research	26
3.1.3 Methodology Aims	27
3.2 Methodology Rationale.....	29
3.2.1 Case Study as a Research Method	30
3.3 Data Collection in a Case Study	31
3.3.1 Data Collection within the School Context	32
3.3.2 Qualitative Research	33
3.3.2.1 Qualitative Research Method One: Questionnaire	34
3.3.2.2 Qualitative Research Method Two: Team Processing Information Sheet	35
3.3.3 Quantitative Research	36
3.3.3.1 Quantitative Research Method One: Post-Implementation Comparative Assessment	36
3.4 Data Triangulation, Reliability, Validity and Generalizability	37
3.5 Research Ethics	38
Chapter Four: Findings	40
4.1 Introduction	40
4.1.2 Graphical Representation of the Generation of Research Data	40
4.2 Qualitative Analysis I: Questionnaires	41
4.2.1 Assessing Participants Access and Prior Experience to Teamwork	42
4.2.2 Attitudes to teamwork:	46
4.2.3 Skills required for teamwork:	49
4.2.4 Opinions of Mathematics	50
4.2.5 Mathematical Statements	57
4.3 Qualitative Findings II: Team Processing Sheets.....	66
4.3.1 Findings from Team Pythagoras	67

4.3.2 Findings from Team Euler.....	68
4.3.3 Findings from Team Gauss	68
4.3.4 Findings from Team Newton	69
4.3.5 Findings from Team Turing.....	69
4.3.6 Findings from Team Leibniz.....	70
4.3.7 Findings from Team Riemann.....	71
4.3.8 Findings from Team Fibonacci	71
4.3.9 Findings from Team Einstein	72
4.4 Quantitative Analysis: Common Assessment Test.....	72
4.5 Conclusion.....	73
Chapter Five: Discussion	74
5.1 Introduction	74
5.2 Key findings from the Qualitative Data: Research Question 1	74
5.2.1 Addressing Research Question One: The issue of “mathophobia”	75
5.2.2 Addressing Research Question One: Students’ preferred method of Teaching and Learning	76
5.2.3 Addressing Research Question One: The benefits of Cooperative Learning	77
5.2.4 Conclusion.....	77
5.3 Key findings from the Qualitative Data: Research Question 2	78
5.3.1 Addressing Research Question Two: Coding the Team Processing Sheets	78
5.3.2 Addressing Research Question Two: Discussion on Cooperative Learning integrating the NCCA’s key skills.....	81
5.3.2.1 Assessing the occurrence of the key skills in the Cooperative Learning Classroom	81
5.3.3 Limitations to assessing the key skills within the Cooperative Learning classroom. ..	86
5.3.4 Conclusion.....	86
5.4 Key findings from the Quantitative Data: Research Question 3	87
5.4.1 The impact of Cooperative Learning on Junior Certificate Project Maths Algebra	87
5.4.2 The impact of Cooperative Learning on Junior Certificate Project Maths Probability	88
5.4.3 The impact of Cooperative Learning on Junior Certificate Project Maths Sets.....	89
5.5 Conclusion.....	90
Chapter Six: Conclusion.....	93
6.1 Introduction	93
6.2 Summary	93
6.3 Dissertation Contributions	95
6.4 Author’s Recommendations.....	96

6.5 Further Research	96
6.6 Limitations of this research	97
6.7 Conclusion	98
References	99
Appendices	112
Appendix A.....	112
Overview of Mathematics Education in Ireland	112
Appendix B	114
The overview of the reasons leading to mathematical reform in Ireland	114
Appendix C	117
Nine forms of Positive Interdependence.....	117
Appendix D.....	118
Four Levels of Cooperative Skills	118
Appendix E	119
Eight key competences as described by the European Union (2011).....	119
Appendix F	120
Recommended Problem Solving Techniques for Project Maths	120
Appendix G.....	121
Current International Research into Mathematics Education	121
Appendix H: Team Folder utilised throughout the implementation of Cooperative Learning	123
Appendix I: Pre-Questionnaire and Draft Documents	124
Pre-Questionnaire Draft One	124
Pre-Questionnaire Draft Two	127
Pre-Questionnaire Draft Three (Final Draft).....	131
Appendix J: Post Questionnaire	135
Post-Questionnaire Draft One (Final Draft)	135
Appendix K: Team Processing Sheet	139
Appendix L: Informed Consent and Guidelines for Parents.....	140
Appendix M: Informed Consent and Guidelines for Student Participants.....	142
Appendix N: Informed Consent and Guidelines for Principal in research school.	144
Appendix O: Student (Individual) Reflection Sheet	146
Appendix P: Figure 6.1 Experimental Class Results (C L)	148
Appendix Q: Frequency of the codes for key skills.	151

List of Tables and Illustrations

Number	Description of Diagram/Figure	Page
Diagram 4.1	Overview of the methods of data collection.	41
Figure 4.2	Responses to Question 1: Have you been asked to work as a team over the last year in secondary school?	42
Figure 4.3	Responses to Question 2 (i): How often are you expected to work as part of a team in school?	43
Figure 4.4	Responses to Question 2 (ii): How often are you asked to work in a team during maths class?	43
Figure 4.5	Responses to Question 2 (iii): What is the worst part of working as part of a team?	44
Figure 4.6	Responses to Question 3: Have you ever been taught the required skills to work as a team member?	45
Figure 4.7	Responses to Question 5: Do you enjoy working as part of a team?	46
Figure 4.8	Responses to Question 6: Which method of learning maths do you prefer?	46
Figure 4.9	Responses to Question 7: Is it important for you to help other class mates if they are having difficulties with maths?	47
Figure 4.10	Responses to Question 8: Are you part of a team outside of school (sports team / scouts / dance group)?	48
Figure 4.11	Responses to Question 9: What skills do you need to work as part of a team?	49

Figure 4.12	Responses to Question 12: Do you enjoy studying maths in secondary school?	51
Figure 4.13	Responses to Question 13: Maths is an important skill to have in life.	52
Figure 4.14	Responses to Question 17: If you get stuck on a maths problem at home who do you turn to for help?	53
Figure 4.15	Responses to Question 15: Is maths homework beneficial to you?	54
Figure 4.16	Responses to Question 16: Do you think that by correcting your classmates' homework that it will help you to improve on your maths skills?	55
Figure 4.17	Responses to Question 18: In your opinion, what's the best way of learning maths?	56
Figure 4.18	Responses to Question 19: Describe your maths ability.	57
Figure 4.19	Responses to Statement 1: I have a certain amount of maths ability and I can't do much to change it.	58
Figure 4.20	Responses to Statement 2: Asking questions helps me to learn maths.	59
Figure 4.21	Responses to Statement 3: Maths involves creativity and new ideas.	60
Figure 4.22	Responses to Statement 4: Maths helps to solve everyday problems and tasks.	61
Figure 4.23	Responses to Statement 5: It is easier to do maths by working together as a team.	62

Figure 4.24	Responses to Statement 6: I think that it is important to help people.	63
Figure 4.25	Responses to Statement 7: By helping my classmates with maths, it helps me to understand the topic better.	64
Figure 4.26	Responses to Statement 8: Working as a group in maths class will enable me to improve my grades.	65
Figure 4.27	Responses to Statement 9: Reflecting on group activities helps the group to improve and work better.	66
Figure 5.1	Collective Frequency of key skills in Team Processing Sheets.	80
Figure 6.1	Results from the Common Assessment (CL Class)	148
Figure 6.2	Results from the Common Assessment (Traditional Control Class 1)	149
Figure 6.3	Results from the Common Assessment (Traditional Control Class 2)	150
Figure 7.1	Coding Results from Team Pythagoras	151
Figure 7.2	Coding Results from Team Euler	151
Figure 7.3	Coding Results from Team Gauss	152
Figure 7.4	Coding Results from Team Newton	152

Figure 7.5	Coding Results from Team Turing	153
Figure 7.6	Coding Results from Team Leibniz	153
Figure 7.7	Coding Results from Team Riemann	154
Figure 7.8	Coding Results from Team Fibonacci	154
Figure 7.9	Coding Results from Team Einstein	155

List of Abbreviations

CL: Cooperative Learning

CPD: Continuous Professional Development

CPS: Collaborative Problem-Solving

DCYA: Department for Children and Youth Affairs

DES: Department of Education and Skills (Ireland)

EGFSN: Expert Group on Future Skills Needs

EU: European Union

IAEP: International Assessment of Educational Progress

IMTA: Irish Mathematics Teachers Association

NCCA: National Council for Curriculum and Assessment (Ireland)

NCTM: National Council for Teachers of Mathematics

NESC: National Economic and Social Council

NI: Negative Interdependence

OECD: Organisation for Economic Co-operation and Development

P21: Partnership for 21st Century Learning

PI: Positive Interdependence

PISA: Programme for International Student Assessment

PM: Project Maths

PMDT: Project Maths Development Team

REC: Research Ethics Committee

STEM: Science, Technology, Engineering and Mathematics

TIMMS: Third International Mathematics and Science Study

Note:

The OECD utilises the spelling of “competencies” whereas the European Union chooses the alternative spelling of “competences”. The author has decided to uniformly use the latter spelling.

Chapter One: Research Questions

1.1 Introduction

“The only thing that is constant is change” (Heraclitus, 535 – 475BC).

Society is constantly subjected to renewal and transformation. The inevitable advancement of civilisation is inescapable and governments are challenged to meet the new demands of the modern era. The birth of our contemporary society has led to the Irish Department of Education and Skills (DES) declaring that “the 21st century is a mathematics economy” (p. 8). Furthermore the DES (1999) stated that “society needs people who can think and communicate quantitatively and who can recognise situations where mathematics can be applied to solve problems” (p. 8). As a result of the advancement of society, and the new skills that students need to succeed in this rapidly changing environment, the DES and the NCCA introduced the new mathematics curriculum at post-primary level entitled “Project Maths” in 2008. This reformed curriculum contains the slogan “Teaching and Learning for the 21st Century”. Project Maths calls for a fresh approach to the curriculum content of mathematics in Ireland and to the assessment strategies employed, along with new methods of teaching and learning (Cosgrave, Perkins, Shiel, Fish & McGuinness, 2012).

Although Project Maths endeavours to deliver curriculum content through group-work activities, the traditional teaching of mathematics in Ireland has been focused on “teaching for the exam” and rote learning. Over 70% of mathematics teachers have claimed that their teaching methodologies are heavily influenced by sample and past examination papers, rather than novel approaches developed from Continuous Professional Development (CPD) courses or international research into mathematics education (Cosgrave et al., 2012). Additional research conducted in 2012 indicated that

Junior Certificate students worked in small groups or pairs less than 40% of the time in mathematics lessons (Jeffes et al., 2012; Cosgrave et al., 2012). Furthermore, Junior Certificate students reported spending over 90% of their mathematical instruction copying information and then practising questions using examples (Jeffes et al., 2012). These traditional methods of teaching mathematics could be a contributing factor for Ireland's poor international ranking in common comparison examinations (Jeffes et al., 2012).

This research dissertation intends to examine the role played by Cooperative Learning (CL) in implementing this “group-work” reference within Project Maths. Johnson (1991) defined CL as “the instructional use of small groups so that students work together to maximize their own and each other’s learning” (p. 3). It is envisaged that by participating in CL in Project Maths, this group-work based teaching and learning methodology will assist students in their understanding, achievement and attitude towards mathematics.

1.2 Developing Research Question One: Student Attitudes towards Mathematics

There has been a lot of negativity surrounding Project Maths in the media since its introduction in 2008. Article titles such as “*Project Maths linked to decline in third level performance*” (Humphreys, 2015), “*The Project Maths course divides teachers - but does it add up?*” (Bielenberg, 2012), and “*Project Maths is not the answer to the tough question*” (Gath, 2012) reflect the negative attitude of the media. This unfavourable view towards mathematics in Ireland has also been discussed by the DES (2010), which has stated that “a cultural change is needed which acknowledges the benefits of mathematics knowledge in all walks of life” (p. 9). Furthermore, students have also revealed a pessimistic attitude towards mathematics, one student stated that “If you’re

smart at maths, you go to the higher level, if you're alright at maths you go to the ordinary, if you are useless you go to foundation" (NCCA, 2010, p. 12). Hence, the first dissertation research question will address this negative attitude towards mathematics:

- a) Does teaching through Cooperative Learning improve students' attitudes towards Project Maths?

1.3 Developing Research Question Two: Cooperative Learning, Key Skills and Project Maths

Governments and institutions around the world are now prescribing the explicit teaching of key skills with the purpose of complementing the academic curriculum. The European Union (EU) has accredited the move towards globalisation as one of the main reasons for key competences to be embedded into the European education curricula. The EU (2007) stated that "each citizen will need a wide range of key competences to adapt flexibly to a rapidly changing and interconnected world" (p. 10). Following on from the EU directive, the NCCA formally published their key skills charter in 2009. Even though the NCCA (2008) has emphasised the importance of these skills as pre-requisites for life and learning in the 21st century, these key skills were not included in the new Junior Certificate Project Maths curriculum, despite their inclusion in the Leaving Certificate Project Maths curriculum. This dissertation will address the teaching methodology of CL as a method of integrating the key skills into the teaching and learning of Project Maths at Junior Certificate level. Hence, the second research question of this dissertation is:

- (b) What are the implications of using Cooperative Learning as a method of integrating the NCCA's key skills within the Project Maths curriculum?

1.4 Developing Research Question Three: Cooperative Learning, Assessment and Project Maths

Handel & Herrington (2003) have stated that teachers' beliefs and opinions impact the reform of mathematics. Similarly, Cuban (1993) cautions that the intentions of the policy and curricula makers tend not to meet what is implemented by the classroom teachers. This worrying statement means that mathematics teachers must fully believe in the creditability of a new teaching approach prior to implementing it within the classroom. Therefore, the last research question will investigate the credibility and impact that CL has on the assessment grades of students:

- (c) Does teaching through Cooperative Learning improve 2nd-year students' assessment results in the Junior Certificate Project Maths classroom?

1.5 Structure of Dissertation

This dissertation will be structured into a further five chapters. An overview of the content of each of these chapters is outlined below:

1.5.1 Overview of Chapter Two: Literature Review

This chapter addresses the current literature on Project Maths and CL. An overview of the reasons for reform will provide the reader with the necessary knowledge to understand and appreciate the need for curriculum reform in Ireland. A review of CL and its underpinning theories and basic elements is presented. Furthermore, a detailed overview of the key curricular skills and their descriptors is provided. The importance of integrating the key curricular skills within the school curriculum will also be discussed from both a national and international perspective. Studies into Cooperative Learning and mathematics will also be reviewed in this chapter.

1.5.2 Overview of Chapter Three: Methodology

This methodology chapter contains the rationale for undertaking this research. This chapter comprises of an overview of the qualitative and quantitative research methods and an introduction to the research methods tools. The importance of data triangulation, along with data reliability, validity and generalizability will be addressed within this chapter. Lastly, the important issue of research ethics will be specified.

1.5.3 Overview of Chapter Four: Findings

This chapter presents the main findings of the research. A series of graphical representations are used to depict the main results of the qualitative data gathered from both the pre-questionnaire and post-questionnaire. Data collected from team processing sheets are represented by using quotes from the students' feedback sheets and finally, data from the quantitative research method are presented via tables of results. This chapter exclusively presents the data that has been generated from the implementation of CL within the classroom.

1.5.4 Overview of Chapter Five: Discussion

This chapter comprises of a discussion and analysis of the results that emerged from the research findings. This chapter is guided by the information revealed from the literature on Cooperative Learning and mathematics. The discussion intends to address the three research questions of this research. The impact that Cooperative Learning has on the academic attainment of students, the influence that Cooperative Learning has on student attitudes and finally the ability of Cooperative Learning to integrate the key skills will all be addressed within this chapter.

1.5.5 Overview of Chapter Six: Conclusion

This chapter comprises of a summary and conclusion of the previous five chapters. The contribution of this dissertation to maths education and, in particular, the impact that Cooperative Learning has as a method of delivering the new curriculum of Project Maths are included in this chapter. A list of recommendations and suggestions for further research are included.

1.6 Conclusion

This chapter outlines the review of mathematics in Ireland conducted over the past number of years. It introduces the new curriculum of Project Maths and elaborates on the limited information provided to teachers in order to deliver this new curriculum. The rationale for developing the three research questions is provided for the reader. A brief synopsis of the future chapters of this dissertation is also provided.

Chapter Two: Literature Review

2.1 Introduction

Ireland is currently in the early stages of the reformation of its post-primary mathematics curriculum; a programme which is referred to as Project Maths. This revised syllabus was first introduced in 2008 and was fully implemented over the following six years. Project Maths aimed to change the subject content, the teaching and learning methodologies and the assessment protocols of mathematics in Ireland. However, the focus of this reform emphasises the curriculum content and assessment style over teaching and learning methodologies. This resulted in mathematics teachers having to apply what they felt were the most appropriate methods of delivering this new curriculum. Additionally, the classroom teacher had to consider the inclusion of the government's key skills which are required to successfully prepare students for lifelong learning and future employment.

Based on this, the following research concentrated on the relationship between the CL method and Project Maths. Firstly, it addresses the impact of CL on student attitudes towards Project Maths. Secondly, it focuses on teaching the key skills through the use of CL. Finally, it explores whether the use of CL has an impact on assessment results in the Junior Certificate Project Maths classroom. A brief overview of the structure of mathematics education in Ireland is provided (Appendix A). A synopsis describing the impact that globalisation and comparative society have on the reformation of mathematics education in Ireland is also presented (Appendix B). Additionally, the literature of the newly reformed curriculum and the numerous government review documents which accompany it, are evaluated in this chapter. The literature relating to CL and its basic elements and theories are explored before examining the global shift

towards key skills in education. The following research questions will guide the structure of this literature review:

- a) Does teaching through Cooperative Learning improve students' attitudes towards Project Maths?
- b) What are the implications of using Cooperative Learning as a method of integrating the NCCA's key skills within the Project Maths curriculum?
- c) Does teaching through Cooperative Learning improve 2nd -year students' assessment results in the Junior Certificate Project Maths classroom?

2.2 The need for change: Ireland's review of Mathematics Education

The low volume of students taking higher level mathematics, combined with a gender imbalance of more male students studying higher level leaving certificate mathematics and worrying results from international assessments were responsible for the birth of Project Maths. Before the reform, a report published by the NCCA (2005) highlighted that mathematics teachers should be encouraged to adopt new ways of teaching in order to aid learners to develop a better sense of confidence in the subject. The report revealed that large amounts of tuition time were invested in the procedural and rote learning skills of students in preparation for predictable summative examinations (NCCA, 2006). Furthermore, the traditional approach of "drill and practice" methods combined with rote learning, procedural methods, the memorising of facts and a sole focus on cumulative examinations were also evident from inspection visits conducted by the Department of Education (Lyons, Lynch, Close, Sheehan & Boland, 2003). In the author's experience, these traditional methodologies are a possible factor for the unsatisfactory achievement in international testing and the high failure rates in state examinations.

Ireland participates in the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA). The test assesses the

skills and knowledge of fifteen-year old students in mathematics, reading and science. PISA began in 2000 and works in three year cycles examining one of the three main themes (Cosgrave et al., 2012). The PISA results from 2003 were worrying for Ireland and its international image (Conway & Sloane, 2005). These worrying results depicted that Irish Junior Certificate students scored on average less than several other OECD countries and other participating countries (NCCA, 2005). Ireland's students were ranked in 17th place out of the twenty-nine participating OECD countries and in 20th place when ranked out of the forty participating countries in mathematics (Shiel, Perkins, Close & Oldham, 2007). These results also highlighted that there are fewer high achievers in mathematics in Ireland in comparison to other OECD countries. 11% of Irish students achieved the highest mathematical proficiency levels of five and six in the PISA mathematical testing in comparison to the OECD average of 15% of students (Shiel et al., 2007).

The Educational Research Centre in Ireland has responded to these results and debates that there were limited questions that corresponded to the Irish Junior Certificate styled questions. Conway & Sloane (2005) claim that approximately 29% of the PISA mathematics test was not directly related to that of the Irish Junior Cycle syllabus for mathematics. However, it was still evident that Irish students had less ability to connect with real life applications and contextual questions that are the style of PISA and other international countries. The importance of the PISA examination can be viewed as being one of the major factors in curricular reform in Ireland. Grek (2009) has stated that although PISA results and rankings seems like they are separated from European education policy, there seems to be an unintentional secondary impact of this comparative data on European education as a result of globalisation. There have been several negative responses to the impact that PISA has played on the development of a new maths curriculum for Ireland. Grannell, Barry, Cronin, Holland & Hurley (2011),

from the University College Cork, have cautioned on the external influences that PISA testing has on the Irish mathematics education curriculum. They claim that Project Maths has been heavily impacted by the style of PISA testing and, as a result, there are several flaws within the design of this new curriculum (Grannell et al., 2011). Equally, Kirwan (2015) has expressed her concerns that the PISA results have been at the root cause of the development of mathematical reform in Ireland.

2.3 Curriculum Reform: The need to change classroom practices

The NCCA (2006) has concluded that it is the manner in which the subject is taught that has the biggest impact on the students' understanding of mathematics (NCCA, 2006). Similarly, Smyth, McCoy & Darmody (2004) pointed to the fundamental role that classroom culture has on the teaching and learning of students. The NCCA reported that teachers, especially those more senior, had developed their classroom resources over a long time period and that they had become comfortable in their teaching styles and approaches (NCCA, 2006). The narrow focus of these approaches was found to hinder learning potential. The NCCA stated that it was necessary for mathematics teachers to alter their teaching methodologies in order for positive change to occur within the classroom. This recommendation sought a transformation of the mathematics experience for all students, stating it was critical to the success of a reformed approach to mathematics in Ireland (NCCA, 2006). The NCCA indicated that this transition would be challenging and that teachers would ultimately need support to participate in the evolution of the teaching and learning of mathematics (NCCA, 2006).

It is interesting to note that as a solution to the difficulties of implementing Project Maths, the NCCA stated that education centres, the support services, the Irish Mathematics Teachers Association (IMTA) and others could assist teachers in adapting their resources to suit the needs of the new curriculum. However, it is worth highlighting

the use of the word *could* rather than *should* (NCCA, 2006). This language suggests that the responsibilities for this significant shift in teaching and learning methodologies lie not with the NCCA but with the individual teacher; the teacher must adapt his/her methods as they see fit without receiving comprehensive and uniform guidelines through adequate in-service training.

2.4 A New Curriculum: The Search for New Teaching and Learning Methodologies

Composed by the European Commission, the Eurydice Report has outlined that there is no one correct methodology for teaching mathematics (European Commission, 2011). This report recommends that teachers should engage with a variety of Continuous Professional Development (CPD) courses in order to enable them to select the best approach for improving the teaching and learning of mathematics. In Ireland, the NCCA favours both an enquiry-based approach and the constructivist method of learning (NCCA, 2006).

Grannell et al., (2011) have defined constructivism in mathematics education as the process of students, under the guidance of a teacher, independently investigating and ascertaining mathematical concepts and facts. Project Maths strives to educate pupils by utilising this constructivist approach (DES, 1999). The National Council of Teachers of Mathematics (NCTM) (2000) has emphasised the importance of moving away from rote learning towards the promotion of problem-solving and communication. Clements & Battista (1990) advanced the notion that the constructivist approach to learning involves students actively gaining knowledge from the social process around them. They stated that learning is a social process which allows children to grow into the intellectual lives of those around them. Clements & Battista (1990) concluded that “mathematical ideas and truths, both in use and in meaning, are cooperatively established by the members of

a culture. The constructivist classroom is seen as a culture in which students are involved not only in discovery and invention but also in a social discourse involving explanation, negotiation, sharing and evaluation” (p. 6). However, Wood, Cobb & Yackel (1995) have criticised the over-simplistic ideology of constructivism. They claim that merely placing students into groups and expecting them to communicate is not a constructive way of acquiring mathematical knowledge. Instead, they advocate the designing of tasks and learning activities that require students to pose questions, seek answers and establish goals for the successive building of knowledge.

2.5 Project Maths Teaching and Learning Plans

Project Maths makes use of the constructivist approach. The NCCA commissioned the formation of the Project Maths Development Team (PMDT), a group which composed and constructed extensive lesson schemes to assist mathematics teachers. These teaching and learning plans are well designed, articulated and structured. However, they refer heavily to the use of group-work in the learning of mathematics. Despite the investment in creating these lesson plans, there seemed to be limited supporting guidelines for teachers with reference to the teaching methodology of effective group-work.

The majority of the Project Maths teaching and learning plans refer to students working in pairs or groups. Nevertheless, there is a failure to understand the preparation required for beneficial and productive group-work. Traditional classroom learning groups involve students accepting that they have an obligation to work together in order to complete a structured task with little joint work. As a result, the students perceive that they are evaluated as individuals rather than as a group. This may result in a lack of participation in group activities by those students who are not sufficiently motivated to succeed as their lack of engagement is not seen to damage the outcome of their peers (Johnson & Johnson, 2008). The placement of students into a group setting does not necessarily

allow for productive group-work and Felder & Brent (2007) have noted that many opportunities to capitalise on the potential benefits of groups are missed by teachers.

2.6 Cooperative Learning: Moving away from Traditional Methodologies in Project Maths

CL presents an alternative to traditional classroom group-work. It has several definitions due to the large variety of learning settings. Johnson (1991) defined CL as the “instructional use of small groups so that students work together to maximize their own and each other’s learning” (p. 31). Similarly, Leikin & Zaslavsky (2004) described CL as students mutually working together in small groups whereby every student is accountable for the learning of the group as a whole. Johnson & Johnson (1999) have identified the five fundamental elements of CL:

1. Positive Interdependence
2. Individual Accountability
3. Face-to- Face Promotive Interaction
4. Use of Social Skills
5. Group Processing

2.6.1 Element One: Positive Interdependence

Johnson, Johnson & Smith (1998) have acknowledged three forms of social interdependence: positive, negative and a total absence of interdependence. These are linked to the student’s approach to learning. Positive interdependence (PI) is said to take the form of cooperation between students. In contrast, negative interdependence (NI) is formulated from competitive learning. Finally, the complete absence of interdependence is said to result in individualistic learning. CL is principally focused on positive interdependence. This occurs when students acknowledge that their own goals can only

be realised if those of the other students in the group are also met. Johnson, Johnson & Holubec (1998) state that “group members have to know that they sink or swim together’ in order for group-work to occur” (p. 4). Laal (2013) claimed that it is positive interdependence that defines the process of collaboration learning and that it is responsible for transforming group-work into teamwork. Positive interdependence can take nine unique forms which range from goals and rewards interdependence to resource and roles interdependence (Appendix C). Despite the fact that research strongly promotes the helpful nature of positive interdependence within the classroom, it is necessary to point out that some warnings have also been aired. Kohn (1994) has expressed concern about the use of positive reward interdependence, claiming that external rewards can affect and damage the intrinsic motivation of students to learn. Similarly, Graves (1991) warned that teachers can find it difficult to move away from routinely presenting students with rewards during CL activities.

2.6.2 Element Two: Individual Accountability

Within the CL paradigm each student must be accountable, in addition to working in cooperation with each other. Laal, Geranpaye & Daemi (2013) describe individual accountability as “a structural element in collaboration which is pivotal to prevent and lower the likelihood of free riders or social loafing” (p. 286). Furthermore, Joyce (1999) determined that the issue of “free-riding” is the most important and most difficult element of CL. Ballantine & McCourt Larres (2007) have defined free-riding as the “problem of the non-performing group member who reaps the benefits of the accomplishment of the remaining group members with little or no cost to him/herself” (p. 130). Joyce (1999) stresses that the issue of grading assessments in CL is regularly interrupted by “free-riding”; he infers that it occurs not only between the lower-ability students, but also amongst those who possess a higher level of capability. Mello (1993)

offers the solution of peer learning logs which enable each student team to address the actions of their teammates throughout the CL lesson. Additionally, the application of team penalties has been suggested to discourage poor individual performance of team members and to encourage all team members to work both autonomously and cooperatively.

2.6.3 Element Three: Face-to-Face Promotive Interaction

Johnson & Johnson (1999) have highlighted the important role that face-to-face promotive interaction plays in the CL model. Siegel (2005) describes this element as “equal participation and discussion between all group members” (p. 344). The motivational and cognitive components of such social interactions have been outlined by Johnson, Johnson & Holubec (1994). The fundamental factors of providing feedback, achieving mutual goals, assisting each other and exchanging resources are vital to the CL lesson. Furthermore, Johnson & Johnson (1999) have suggested that teachers should ensure that there are a selectively small number of students participating in each team in order for the group to reach their maximum potential; it is recommended that no more than two to four students are placed in each team. This fosters more meaningful interaction throughout CL.

2.6.4 Basic Element Four: Use of Social Skills

Oakley, Felder, Brent & Elhadj (2004) stated that “students are not born with the project management, time management, conflict resolution and communication skills required for high performance teamwork” (p. 9). As a result, students must be taught the required skills for successful work and team management. Goodwin (1999) has stated that students cannot be expected to work cooperatively if they have never been taught the social pre-requisites required for teamwork. Thus, “pre-skilling” is of fundamental

importance in ensuring that students are capable of building on their positive interdependence and team spirit. Johnson, Johnson & Holubec (1994) have acknowledged four levels of cooperative skills. These skills of forming, functioning, formulating and fermenting are all vital for the success of CL (Appendix D). Goodwin (1999) advised that teachers should observe, monitor and evaluate the level of mastery that their students have with social skills prior to selecting which social skills to teach.

2.6.5 Element Five: Group Processing

Sharan (1990) has defined group processing as “reflecting on a group session to describe which members’ actions were helpful and unhelpful, which enable students to make decisions about what actions to continue or change” (p. 32). This element of CL can assist students to build on their successes. Yager, Johnson & Johnson (1986) outlined two models for group processing: the counselling method and the feedback method. The counselling method poses that self-evaluation leads to increased efficiency for the student team. In contrast, the feedback model makes use of constructive and accurate comments on the working procedures of the team. Although the requirement for reflecting on and evaluating teamwork is essential to the structure of CL, Bertucci, Johnson, Johnson & Conte (2012) have acknowledged that some difficulties exist. Their research found that the students’ academic achievement improved in relation to their experience with the group processing model. As a result, teachers must ensure that they extend the period of time in which they engage their students in reflection to best achieve quality group processing and to recognise an improvement in academic results.

2.7 Theoretical Framework of Cooperative Learning

CL is derived from three theories of learning: Social Interdependence Theory, Cognitive Development Theory and Behaviour Learning Theory (Galván, Rubin, & Morgan,

2009). The combination of this trinomial of educational theories makes for a powerful learning tool for educators. Social interdependence provides CL with the key aspect of accountability: this is only deemed to exist when the student's outcomes are not solely affected by his/her own actions but also by the actions of other students (Johnson & Johnson, 2009). Behavioural Learning Theory deals with the assumption that students will work harder on learning tasks which result in rewards rather than those which do not involve accolades or those which yield sanctions (Johnson, Johnson & Smith, 1998). Cognitive Development Theory is based on the models of Piaget and Vygotsky; it asserts that knowledge is constructed from the cooperative social events of learning. This results in cognitive disequilibrium which, as a result, stimulates cognitive development and allows for learning to occur (Doolittle, 1995). Despite this positive view towards cognitive disequilibrium resulting in cognitive development which is reinforced by the works of Jean Piaget and Lev Vygotsky (Johnson, Johnson & Smith, 1998), it can perhaps be argued that this peer imbalance may also lead to a complete shut down in the student's cognition, thus hindering the ability to learn. Students' are socially developing and strives to belong among their peers, it can be articulated that cognitive disequilibrium if not managed correctly can result in tension to form between team members and hence lead to unproductivity measures in the team setting.

2.8 Cooperative Learning and Student Attitudes to Mathematics

Student opinions are vital to their success and understanding of mathematics. It is thought that if students enjoy engaging with mathematics they may continue to study it at third level. The NCCA (2005) has claimed that there is a correlation between students' attitudes and their levels of achievement. This viewpoint is reiterated in the OECD's (2004) research. This found that in all OECD countries an interest and enjoyment in learning mathematics was closely related to academic performance. The

issue of “mathophobia”, the fear of mathematics, can also impact the student’s performance. The NCCA’s report (2005) ascertained that “mathophobia” is not exclusively related to students but, also, to adults. The Economic and Social Research Institute (ESRI) established that students who had negative feelings towards mathematics often had negative relationships with their teachers. Moreover, they were more likely to be bullied by their peers as those who are weak at mathematics are often allocated to lower performing classes (Smyth, McCoy & Darmody, 2004).

CL presents the opportunity for the student to develop a positive attitude towards mathematics. Akdemir & Arslan (2012) have highlighted that cooperation between team members, in combination with peer support, encouragement and feedback, leads to an increase in student achievement. The use of CL can be seen as a means for preparing students to work together in teams - a skill which is highly sought after by employers. Additionally, CL enables students to flourish in both their academic and social lives, allowing them to develop a positive sense of cooperation and to take pride in their work (Pewewardy, 2002, as cited in Tarmizi & Bayat, 2012).

2.9 Utilising the key skills within the Teaching and Learning of Project Maths

The new curriculum was introduced in order to enable students to work and live successfully in the 21st century; this entails teaching students to work and participate in modern society and requires more than just an emphasis on academics. Project Maths was introduced in parallel with the government’s strategy to embed key skills in curriculum subjects. The Expert Group on Future Skills Needs’ (EGFSN) National Strategy for Skills has highlighted the generic skills that are required for all employment positions. These skills include literacy and numeracy, alongside people-related skills and conceptual thinking skills (NESC, 2008). Project Maths aims to ensure that its curricular

content is accessible to learners. However, it is evident that the classroom teacher must make use of methodologies which not only allow for the covering of the curriculum, but also promote the people-related skills and conceptual thinking skills that best prepare students for employment in the knowledge-based economy.

2.9.1 European Union's Key Competences for Lifelong Learning

In 2006, The “Key Competences for Lifelong Learning” were produced by recommendation of the European Parliament and Council due to the growing impact of globalisation on European countries (European Council, 2006). The council stated that European citizens are Europe's best asset and, as such, their education is imperative to the needs of the knowledge-based economy. The Union outlined eight key competences (Appendix E) which include a high standard of mathematical aptitude (European Council, 2006). These components are described as being significantly important in a student's compulsory education as they ensure that students are supplied with the skills necessary to work and actively contribute to 21st century society.

2.9.2 Partnership for 21st Century Learning Framework

In addition to the European Union's key competences, The Partnership for 21st Century Learning (P21), based in Washington DC, has outlined the Framework for 21st Century Learning. This document highlights the essential abilities and knowledge that students must possess in order to successfully live, work and thrive in this century (Partnership for 21st Century Learning, 2015). This learning method is based on an array of different factors which include, but are not limited to, the scholarship and innovation skills of critical thinking, communication, collaboration and creativity. The Partnership for 21st Century Learning outlines that these learning skills must be taught in conjunction with an essential proficiency in mathematics. In order for this model to be achieved, the

Partnership has affirmed that a detailed and elaborate support structure must be adhered to. These systems include professional development for teachers, appropriate access to learning environments and the correct implementation of curriculum via skilled instruction (P21, 2015).

2.9.3 The NCCA's Key Skills Framework

In 2008, as a response to the established need to educate students to live, work and survive in the 21st century, the introductory interim draft report of the “Key Skills at Senior Cycle” was published by the NCCA. The NCCA has developed five key skills which aim to encompass all curriculum subjects at senior cycle level. These include:

1. Information Processing
2. Critical and Creative Thinking
3. Communicating
4. Working with others
5. Being Personally Effective

The following sections will look at these skills in relation to Project Maths.

2.9.3.1 Information Processing

Project Maths requires students to process and evaluate large amounts of information in order to construct solutions to mathematical problems. Students are challenged to interpret questions and to articulate solutions based on the information provided. This key skill also requires that students present information in a structured and logical manner. Students are tasked with reflecting on their learning and evaluating which aspects are efficient and which demand improvement (NCCA, 2008).

2.9.3.2 Critical and Creative Thinking

This key skill refers to the mathematical process of problem-solving. Students are regularly asked to interpret challenging mathematical problems in Project Maths. This key skill also seeks to encourage students to be creative in their methods to provide solutions. Project Maths urges students to utilise different problem-solving strategies in order to increase their ability to answer mathematics questions in a more creative manner (Appendix F).

2.9.3.3 Communicating

The NCCA (2008) has encouraged the adoption of the key skill of communication in order to develop the student's ability to listen to the viewpoints of others and also to elicit opinions based on fact. Additionally, students are tasked with the problem of selecting appropriate mediums and techniques in order to present their solutions to a variety of audiences. The NCCA has recognised that students must be prepared to defend their arguments. This defence has the potential to create cognitive disequilibrium in students which can lead to the acquirement of knowledge (Johnson, Johnson & Smith, 1998).

2.9.3.4 Working with Others

The NCCA (2013) stated that “mathematics learners are encouraged to work together in groups to generate ideas, problem solve and evaluate methods” (p.9). This information lacks specificity and has failed to provide mathematics teachers with the adequate means to successfully enable students to work together. Similarly, the NCCA (2009) key skills Framework for Leaving Certificate has merely called for students to “co-operate with other members of the group” (p. 11). Once again there are no clear guidelines provided for teachers to achieve this outcome. Teachers must ensure that they are selecting

teaching strategies which include students working in groups but the onus is on them to choose the correct method for employing this strategy.

2.9.3.5 Being Personally Effective

The NCCA has stated that students need to become confident and develop a sense of assertion. Furthermore, it is necessary for students to “take stock of current achievements and, with the help of others, to engage in an honest appraisal of their strengths and weaknesses” (NCCA, 2008, p. 12). CL tasks students with working both autonomously and as part of a team setting.

2.9.3.6 Key Skills and Junior Certificate Project Maths

The integration of the NCCA’s key skills was completed in parallel with the curriculum design of Project Maths. Despite the importance of the key skills to the curriculum on an international and European Level, the NCCA decided not to include the key skills in the Junior Certificate Project Maths curriculum. However, the NCCA’s key skills have featured predominantly in the Project Maths syllabus for Leaving Certificate and their importance is greatly emphasised (DES, 2013). This dissertation intends to examine if CL can be utilised as a method for exposing students to the required key skills at Junior Certificate level.

2.10 Cooperative Learning and Mathematics: Current Research

Much research indicates the efficacy of CL within education. Studies conducted since 1995, via a meta-analysis of sixty-five published articles on the topic have reported favourably on its impact. These results verified the benefits of CL as a teaching style when compared to traditional instructional methods (Kyndt, Raes, Lismont, Timmers, Cascallar & Dochy, 2013). This research concluded that students do in fact learn more

when they are challenged to work as part of a group rather than working in isolation. It also advised that CL be utilised in non-linguistic courses such as mathematics due to the problem-solving nature of these subjects. Hossain & Tarmizi (2013) reported positively on the effects of student learning in mathematics as a result of the implementation of CL. They concluded that CL had significant positive effects on students' attitudes and achievements in mathematics. This study cautioned that in order for CL to be successful students must be intrinsically linked together. The importance of developing positive interdependence between team members and, also, task interdependence, is vital to constructing effective CL. The progression of the group dynamic enables students to foster a positive environment for learning, resulting in a greater achievement rate than that of competitive learning. Hossain & Tarmizi (2013) noted that there was also a significant increase to be seen in the students' mathematical problem-solving techniques when CL methods were applied. Furthermore, Gillies & Boyle (2010) have elaborated on the importance of peer interactions within the educational paradigm. They argue that students gain both academically and socially as a result of working together to complete a shared task.

2.11 Challenges of Implementing Cooperative Learning within Mathematics

Whilst in theory the implementation of CL seems like a simple task, Gillies & Boyle (2010) have identified potential difficulties that may arise. They acknowledge the reluctance of established teachers to expand on their teaching methodologies within the classroom. This same issue is echoed throughout the Irish government research into mathematics education. Although the benefits of CL seem very encouraging, the designing, managing and constructing of CL can be difficult. Teachers must be taught the skills necessary for a comprehensive understanding of the model. Cohen (1994)

advises that when students are tasked with working cooperatively on procedural exercises, there is little peer interaction and in order to maximise learning, students should be challenged to work cooperatively on problem-solving. This process enables students to listen to and dissect the viewpoints of others whilst celebrating successes and receiving bonuses. Johnson & Johnson (1990) stated that one of the most pressing issues in CL is for teachers to develop a sense of dual responsibility with their students. This skill requires the student to understand that they are not only responsible for their own learning but also for the learning of their team-mates. This is the concept of positive interdependence and is one of the elements which is essential to CL (Johnson & Johnson, 1990). Teachers must also instruct their students in the required interactional group skills which are vital to the workings of an efficient team (Blatchford, Kutnick, Baines & Galton, 2003). Furthermore, the classroom environment must be developed to ensure that it is suitable for group interaction and learning. Hertz-Lazarowitz (1992) highlights the complexity of this educational methodology but reassures that once the initial preparation and training is complete, students will gain the maximum from this process.

2.12 Conclusion

It is evident that the objectives of the Irish government are to ensure that our education system is building a society for the future. The government intends to provide its forthcoming leaders with the skills which are required for working together effectively in addition to having a strong academic foundation. Although Project Maths strives for reform in all three aspects of the curriculum, it is evident that the selection of teaching and learning methodologies was not satisfactorily dealt with. Nevertheless, Project Maths has called for a shift from traditional learning to a more collaborative form of learning within the classroom. This literature review has established the suitability of CL

as a feasible option for the implementation of the government's key skills within the reformed mathematical curriculum. The validity of the academic and social benefits of CL and the potential positive effects that CL can have in the teaching of Project Maths has been established throughout this chapter. This is supported by the recent research into maths education and curriculum reform in Ireland which favours moving towards CL (Appendix G). The NCCA's plan to encompass CL as a pillar within the reformed curriculum highlights the support that the government has for this teaching and learning methodology. It is clear that students living in this knowledge-based economy are required to have, not only the manual skills but also the much sought after skills of problem-solving, interpersonal communication, self-management and the ability to process information (OECD, 2013).

Chapter Three: Methodology

3.1 Introduction to Methodology

This chapter outlines the research methodology selection for this dissertation in order to answer the three research questions:

- a) Does teaching through Cooperative Learning improve students' attitudes towards Project Maths?
- b) What are the implications of using Cooperative Learning as a method of integrating the NCCA's key skills within the Project Maths curriculum?
- c) Does teaching through Cooperative Learning improve 2nd-year students' assessment results in the Junior Certificate Project Maths classroom?

Initially, the chapter will elaborate and expand on the available research methods that are utilised in education research. Next, an overview of the selected methodology will be discussed, including the reasons for this approach. The composition and design of this research intervention from its origin will be discussed along with the developments and difficulties of this research project. Data collection and the varying data categories will be addressed and an explanation into their selection will be provided. The research instruments and their design will be elaborated on and a rationale for their acceptance will be established. The strengths and weaknesses of this research model and its instruments will be deliberated. Finally, issues in relation to reliability, validity, generalizability and ethics of this research intervention will be discussed.

3.1.2 Rationale for undertaking this Research

The rationale for undertaking this research into the use of CL in a post-primary school emerged from several sources. Predominantly, one factor for this research arose from the

researcher's professional teaching experience. The researcher constantly received negative attitudes and negative feedback from students in relation to the new Project Maths curriculum. The discontent with Project Maths within the schools was also echoed by several third level institutions and media outlets (Grannell et al., 2011; Kirkland, 2012). In order to correct these negative viewpoints that students are developing towards mathematics, it is envisaged that the teaching of Project Maths through CL methods may yield an improvement in students' attitudes and achievement. The European Commission's Eurydice Report (2011) has correlated the same themes across the European Union countries, as the themes reported by Conway & Sloane (2006). The Eurydice report concluded that there is no singular definitive correct method for teaching mathematics and rationalise that many research articles concluded that different methodologies work in different mathematical contexts. It seems that the conclusion is that "professional development for teachers in a range of different methods, and allowing them to make decisions about what can be applied, when and why, is the best approach for improving teaching" (European Commission, 2011, p. 52). This professional autonomy allows teachers to act as researchers into their own practices and to design, implement and review different learning styles in the classroom setting. Hence, this research aims to test the effectiveness of CL in the teaching of Project Maths.

3.1.3 Methodology Aims

Initially, this methodology aims to establish a base line of students' attitudes, opinions and academic achievement in relation to the Project Maths curriculum. Students will then be introduced to CL strategies in the teaching of the Project Maths curriculum. This methodology aims to design and implement an altered teaching approach to certain curricular learning outcomes of Strand One: Probability and Statistics, Strand Three:

Number and Strand Four: Algebra of the Junior Certificate Project Maths Curriculum (NCCA, 2013).

The resources that will be utilised for this research will stem from the published teaching and learning plans of Project Maths, along with other published material from the Project Maths website (www.projectmaths.com) and the Project Maths Development Team (PMDT). Where there are no published or approved prepared Project Maths resources, the researcher will formulate suitable resources. Where it is necessary, these Project Maths resources will be adapted to suit the strategies and approaches that promote cooperation between students.

Vitality, this methodology aims to equip the students with the required social skills to work cooperatively together. Johnson & Johnson (1990) caution that people do not instinctively have the skills required to work together cooperatively. They argue that in order for the real potential benefits of CL to occur, students must firstly be taught how to work together. Johnson & Johnson (1991) state that in order for students to develop positive interdependence four conditions must be established and built upon. These vital conditions include students developing a rapport and a sense of trust with the team members, clear and concise communication, building acceptance and support systems between each other and finally, to resolve conflicts constructively.

Throughout this implementation there will be a strong focus on developing the students' individual and interpersonal skills. Students will be tasked to examine specific social skills (via T-charts) and to discuss the components of these social skills. Students will establish a strong sense of rapport between their team members. The concept of the student team, rather than the individual student, will be fostered throughout this process. Students will engage with the concept of a team folder (Appendix H) and will complete

a series of worksheets to assist and enable each team to foster their sense of pride and teamwork.

3.2 Methodology Rationale

There are several different methods that educational research can take. Cohen, Manion & Morrison (2013) defined research methods as “that range of approaches used in education research to gather data which are used as a basis for inference and interpretation, for explanation and prediction” (p. 66). The range of approaches can include action research, case studies, meta-analysis and quasi-experiments. Each of these different methods offers a different style and structure to the research paradigm. In the selection of a research method for this dissertation, there are several conditions that must be considered. Due to the limited time available for secondary school teachers it is vital that the research works within a structured time frame (ten academic weeks) to construct a suitable learning intervention. Furthermore, a second consideration of practical and beneficial research that operates in parallel to the Project Maths curriculum and the school’s department subject plans is required. Although action research has been gathering momentum over the past two decades (Nolen & Vander Putten, 2007) there are also several criticisms of this style of research methodology. The typical cyclic approach to action research is a major limiting factor in research methods within a short period of implementation (Cohen, Manion & Morrison, 2013). The issue of the teacher as a researcher who becomes over-involved with the research process leads to questions in relation to the scientific basis of action research (Rose, Spinks & Canhoto, 2014). Finally, due to the ever changing approaches of the threefold process of action research, ethical issues in relation to informed consent can arise (Zeni, 1998; Rose, Spinks & Canhoto, 2014). In order to alleviate these potential ethical difficulties and to work

within the time constraints of the research process, it was concluded that a case study approach to research methods was most suitable.

3.2.1 Case Study as a Research Method

Yin (2013) describes a case study in its two separate words; the word “case” refers to the examination of a point of interest or phenomenon within a real life context; the second term “study” denotes the construction of the data collection and its tributaries of triangulation, rigor and limitations. In this research study, the “case” will refer to the impact of CL as a teaching and learning strategy in the second year post-primary Project Maths classroom. The term “study” will refer to the selected data collection tools and sources, which will be further discussed within this chapter.

In the selection of a case study approach, it is imperative that a clear overview of the rationale of this particular research method be established. Yin (2011) offers four considerations where it is appropriate to utilise a case study approach to research. The first consideration includes when a study aims to provide solutions to research questions that seek to find the “how” and “why” of a situation. As outlined in chapter one, the research question aims to seek the answers to these styled questions. These include:

- (a) Does teaching through Cooperative Learning improve students’ attitudes towards Project Maths?
- (b) What are the implications of using Cooperative Learning as a method of integrating the NCCA’s key skills within the Project Maths curriculum?

Secondly, Yin (2011) cautions that the researcher does not manipulate the behaviour of the participants within the research period. The relationship between the researcher and the participants was established in the process of ethical approval, which was granted by Trinity College Dublin. This rigorous ethical approval process consisted of discussing

the research design with the participants' parents/guardians and receiving written consent. The participants, all second year students in the research school, received a talk on the research aims of the research programme prior to agreeing to participate.

Thirdly, the research study aims to investigate certain contextual conditions that are deemed to be of importance to the research process. In this research study, these contextualised conditions refer to the potential positive impact that CL could have on the teaching and learning of Project Maths.

Lastly, Yin (2011) considers that the research parameters are not yet defined between the case and the context. As Project Maths is only a recent addition to the reform curriculum of mathematics in Ireland, there is little or no known research available in relation to the impact that CL might have on the teaching and learning of Project Maths. The third and final research question aims to address the possible strengths and weaknesses of using such a teaching strategy within the context of this newly reformed curriculum:

(c) Does teaching through Cooperative Learning improve 2nd-year students' assessment results in the Junior Certificate Project Maths classroom?

3.3 Data Collection in a Case Study

Another vital part of the research methodology is in the selection of suitable data collection methods. One of the trademark features of a case study approach to research is to include multiple data sources (Patton, 1990; Yin, 2011). This utilisation of multiple sources enables a case study to increase data credibility. Baxter & Jack (2008) referred to each of these multiple data sources as a different piece to the research puzzle. They claim that upon the integration and organisation of these puzzle pieces, this can assist in contributing to the researcher's understanding of the studied phenomenon. The evidence from these puzzle pieces can be sourced from several methods of data collection

including questionnaires, semi-structured interviews, observational and documentary data (Cohen, Manion & Morrison, 2013).

Yin (2011) stated that there are six common sources of evidence for case studies from which data can be sourced, including:

- direct observations,
- interviews,
- student records,
- documents,
- participant observation
- physical artefacts.

Although there are several sources that evidence for a case study can draw from, Hurrell (2004) has cautioned about the risk of collection of overwhelming amount of data that needs to be analysed within the brief time period of the research. Cohen, Manion & Morrison (2013) describe the limitations of data collection as a series of “orienting decisions” that the researcher must consider prior to implementation. These “orienting decisions” are defined as the parameters of the research process which are vital in the planning of a manageable data collection period. In particular, the factor of the available time in which research can be carried out must be strictly organised. However, Cohen, Manion & Morrison (2013) also highlighted the benefits of having such limited time to conduct the study, as this will enable the researcher to be focused on the implementation.

3.3.1 Data Collection within the School Context

The researcher has been a teacher in the research school on a full time basis for the past three years, teaching mathematics at all levels of the second level education curriculum. Within this research study, data was collected over a period of ten school weeks. Data

was collected in a large co-educational post-primary urban school situated in Leinster. The class selected for this research was a second year higher level Project Maths class. Students were placed in a mixed ability class for their first year in this school (2014/2015) and were separated into higher level groups in December 2015. The research participants for this study consisted of twenty-seven second year students from a variety of different social and economic backgrounds. Student participants ranged in age from 13 – 15 years of age and consisted of sixteen male students (60%) and eleven female students (40%). This class was composed of twenty one (78%) students who remained in the research class since their first year in this school and six students (22%) who were transferred to this class.

This research inquiry used a mixed-methodology approach to data collection methods. Creswell (2009) highlights the benefits of the utilisation of mixed methods as it encompasses the benefits of both qualitative and quantitative research methods. Similarly Johnson & Onwuegbuzie (2004) stated that by utilising a mixed-methods approach to data collection, this minimises the weaknesses of both qualitative and quantitative methods. In order to increase scientific rigour and to improve triangulation of data evidence, a mixed methodology approach was utilised for this research study.

3.3.2 Qualitative Research

Denzin & Lincoln (1994) stated that qualitative research “is many things to many people” (p. 8). This ambiguous definition is due to several factors and conditions that add to the complexity of the research paradigm. However, Van Maanen (1979) defined qualitative research as “an umbrella term covering an array of interruptive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning and not the frequency, of certain more or less naturally occurring phenomena in the social world” (p. 520). Hence, qualitative research focuses on the meaning and

enables research to take a non-numerical approach and allows researchers to understand the meaning people have developed and constructed from their own perspectives (Merriam & Tisdell, 2015). In terms of this research study, two qualitative data collection instruments were used.

3.3.2.1 Qualitative Research Method One: Questionnaire

Student participants were given a pre-questionnaire to complete (Appendix I) that was structured into five sections:

- Prior experience to teamwork
- Attitudes to teamwork
- The social skills required for team cooperation
- Current opinions of mathematics
- A series of rateable mathematics statements.

A questionnaire was selected as one of the data collection instruments to gather articulated opinions by the students on their learning experiences to date. Cohen, Manion & Morrison (2013) argue that questionnaires have the ability to gather data at some particular point in the research process with the intention of describing the current situation. This instrument enabled a standard in the teaching and learning processes to be identified prior to the implementation of CL. This pre-questionnaire (Appendix I) enabled the researcher to gain an understanding of the students' attitudes and opinions to mathematics and teamwork. Although, there was several positive aspects of utilising questionnaires, including cost, time and ease of implementation, Cohen, Manion & Morrison (2013) highlighted that the researcher should be cautious in the design of the research questionnaire. This is to ensure that the questionnaire meets the comprehension skills of those being questioned. In order to avoid any difficulties in students'

understanding, the questionnaire was piloted to a different group of students ($n = 5$) to rectify any difficulties in comprehension prior to data collection from the research participants. After the ten week implementation of CL strategies, a post-questionnaire was delivered (Appendix J). This was to assist in the analysis of the data and to comment on changes in students' perceptions, attitudes and opinions of teamwork and CL in Project Maths.

3.3.2.2 Qualitative Research Method Two: Team Processing Information Sheet

The second form of qualitative data that was collected was post-task team processing information sheets (Appendix K). As discussed in the literature review, group processing is one of the five basic elements of CL. Yager, Johnson & Johnson (1986) claimed that student team members must engage in group processing. Here they discussed the group's functioning dynamics and the group's effectiveness and reflected on the helpful actions of each member. The feedback model as described by Johnson & Johnson (1979) was employed in the data collection instrument as it provided students with information that helped each team member to improve his/her performance. This model also assists in the positive reinforcement aspects of feedback and affirms students' participation in a cooperative manner.

The outline and design of this qualitative tool was based on group processing templates as outlined by Johnson & Johnson (2008). Students were tasked with providing two accounts of positive feedback to their team members and also to reflect on what ways the team could improve prior to the next learning task. Students were challenged to debate all aspects of their learning task and to ensure that all members were satisfied with their responses prior to each team signing off on its team's reflection.

Johnson & Johnson (2008) examined the limitations to the group processing element of CL. These obstacles include student processing being very vague and under-developed. This can be due to the age of the participants and their level of attention throughout this higher order process. However, Johnson & Johnson (2008) stated that teachers should use specific statements in reflection which would require detailed answers from the student. In addition, the issue of the limitation of time in the saturated school curriculum is raised by Johnson & Johnson (2008).

3.3.3 Quantitative Research

Aliaga & Gunderson (2000) defined quantitative research as “explaining phenomena by collecting numerical data that are analysed using mathematically based methods” (p. 2). Quantitative research studies are based on the foundations of scientific rigour and use the skills of mathematics to produce and measure outcomes. Kuhn (1961) highlights that in utilisation of quantitative data the “numbers register the departure from theory with an authority and fitness that no qualitative technique can duplicate” (p. 180). While there is a strong sense of evidence in using quantitative data, there are also limitations to this direct method of gathering evidence. Muijs (2010) suggests that there are certain limitations to answering direct research questions through direct numerical data. Muijs (2010) also states that this direct answering of the research question can be very limiting into the depth of educational research and states that very few phenomena in educational research have occurred due to the naturally occurring quantitative data.

3.3.3.1 Quantitative Research Method One: Post-Implementation Comparative Assessment

The third source of data collection was formulated from a quantitative approach to data collection using primary data. After the period of implementation, students underwent an assessment based on three sections of the Project Maths Junior Certificate syllabus that

they had been taught by CL. These three sections encompassed Algebra, Probability and Sets. Statistical analysis was applied to these results between this research class and two other second year Project Maths classes who had not been taught using CL methods. These additional two control classes were composed of equal ability, similar to that of the experimental class.

3.4 Data Triangulation, Reliability, Validity and Generalizability

According to Yin (2013) the onus must be on the case study researcher to guarantee validity in the research paradigm. This process of guarantee is grounded by data triangulation, through analytic generalization and by reliability in the case study methodology. This validity is obtained by the researcher ensuring a rigorous and quality process of gathering evidence that is sourced from a multiple of bases. Similarly, Baxter & Jack (2008) stated that in order to promote and comply with the main principles of the case study research process, that data collection must be triangulated to promote credibility and truth. They state that by fortifying the resource data sources, this enables the research phenomena to be explored from multiple perspectives. Data collection for this methodology was collected from three sources, using different data collection instruments in order to ensure that triangulation was present.

To ensure generalizability, caution was exercised in the process of analytic generalisations to ensure that the examining of carefully structured claims was presented in a thorough and well-rounded manner (Cohen, Manion & Morrison, 2013). It must be noted, that although this case study research was successful with this class, in this school, it may not be a successful methodology in every school with every student (Gillham, 2000).

3.5 Research Ethics

Cohen, Manion & Morrison (2013) have outlined the sensitivity process of ethics when conducting research within an education environment. They insist that the researcher must ensure that by participating in this research study the students' dignity as human beings is constantly maintained. Similarly, the Department of Children and Youth Affairs (DCYA, 2012) Ireland has stated that researcher has "an obligation to address the issue of who ought to receive the benefits of research and bear its burdens" (p. 1). These governmental ethical guidelines for research projects involving children state six main principles that must be considered in all studies. These include; minimising risk of harm (DCYA, 2012);

- informed consent and assent
- confidentiality and anonymity
- child protection principles
- legal obligations and policies
- A child centred approach that is inclusive of all students.

This research was also constructed in conjunction with the guidelines that are provided by Research Ethics Committee (REC) within Trinity College's School of Education (<https://www.tcd.ie/Education/ethics/>).

As a result of the importance of ethics, the researcher identified potential issues in relation to ethics prior to research implementation. Ethical approval was sought from Trinity College Dublin's REC. Ethical approval was granted on 9th of December 2015. The supporting documents for informed parental consent and guidelines (Appendix L); student participant informed consent and guidelines (Appendix M); school principal guidelines and consent (Appendix N) were established. Written informed consent was

received from all parties prior to implementation. The ethics guidelines of Trinity College Dublin's REC and the state guideline for ethical research involving children were strictly adhered to during the research study.

Chapter Four: Findings

4.1 Introduction

This chapter presents the key findings that emerged from the data collected during the period of research. The author is mainly concerned with assessing the potential impact that CL can have in the Junior Certificate Project Maths classroom. This research study strives to address the possible change in attitudes towards mathematics, a positive adjustment in student academic achievement and also the implications of utilising CL in conjunction with the NCCA's key skills within the Project Maths curriculum.

The findings from this chapter will address the three main research questions of this dissertation:

- a) How does teaching through Cooperative Learning improve students' attitudes towards Project Maths?
- b) What are the implications of using Cooperative Learning as a method of integrating the NCCA's key skills within the Project Maths curriculum?
- c) Does teaching through Cooperative Learning improve 2nd -year students' assessment results in the Junior Certificate Project Maths classroom?

4.1.2 Graphical Representation of the Generation of Research Data

As previously described in Chapter 3 Section 3.3.1, the author has decided to utilise a mixed methods approach to data collection in this study. Hence, this chapter addresses the data findings from both the qualitative and quantitative perspectives. Diagram 4.2.1 provides the reader with an overview of the methods used for generating research data in this mixed methods study. The qualitative approach consisted of two separate research methods, the use of pre- and post- questionnaires and also team processing information

sheets. The quantitative approach consisted of post-implementation comparative assessment results.

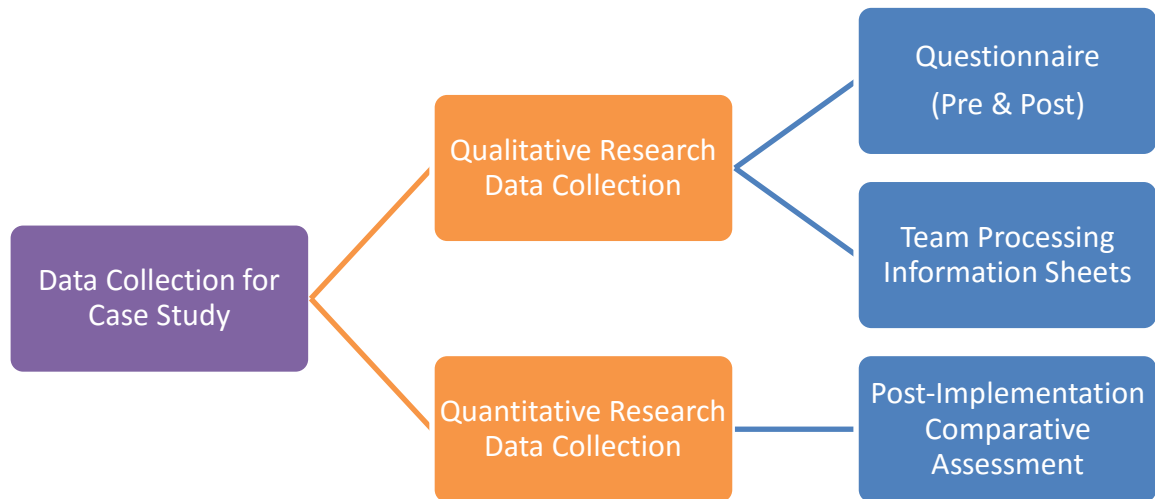


Diagram 4.1 Overview of the methods of data collection

4.2 Qualitative Analysis I: Questionnaires

Throughout this research period, student participants completed a pre- and post-questionnaire (Appendices C and D) during the research period of January to April 2016. The sample size was $n = 27$. The questionnaire was categorically structured into five main areas:

- Prior experience of teamwork
- Attitudes to teamwork
- Skills required for teamwork
- Opinions of mathematics
- A series of mathematics statements.

4.2.1 Assessing Participants Access and Prior Experience to Teamwork

This section established the prior knowledge of students' experiences of teamwork within the education system. The frequency of expectation and access to teamwork was established and in particular students' prior access to teamwork in mathematics was revealed. An overview of whether students received any instructional teachings on the necessary skills required to successfully work as part of a team was also developed. Finally, students were asked for their opinion on whether they think that teamwork is an important skill to learn while attending secondary school.

Question 1: Have you been asked to work as a team over the last year in secondary school?

n	Yes	No
27	24	3

Figure 4.2

Initially twenty-four students (89%) stated that they were expected to participate in teamwork as part of their studies in this school over the past year. Three students (11%) declared that they were not tasked with working as part of a team throughout the last academic year. Two of these students were transferred to this newly formed higher level class from a different base class.

Question 2 (i): How often are you expected to work as part of a team in school?

	n	Daily	Weekly	Monthly	Never
PRE-IMPLEMENTATION Q2 (i) How often are you expected to work as part of a team in school?	27	4	15	5	3
POST-IMPLEMENTATION Q2 (i) How often are you expected to work as part of a team in school?	27	10	13	1	3

Figure 4.3

There was a six student increase in the frequency of occasions that students were expected to work as part of a team daily during class time over the implementation period. This increase in the frequency of teamwork was in relation to the entire range of curriculum subjects studied at school rather than just exclusively referring to teamwork in mathematics.

Question 2 (ii): How often are you asked to work in a team during maths class?

	n	Daily	Weekly	Monthly	Never	Unanswered
PRE-IMPLEMENTATION Q2 (ii) How often are you asked to work in a team during maths class?	27	3	12	7	3	2
POST-IMPLEMENTATION Q2 (ii) How often are you asked to work in a team during maths class?	27	13	12	1	0	1

Figure 4.4

The use of daily teamwork rose from three students (11%) to thirteen students (49%), whereas there was no difference in frequency of the weekly groupwork pre and post implementation. There was a decrease in students in the monthly use of teamwork from seven students to just one student. All of the students stated that they participated in teamwork in the post-questionnaire, with the exception of one student who did not answer this question.

Question 2 (iii): What is the worst part of working as part of a team?

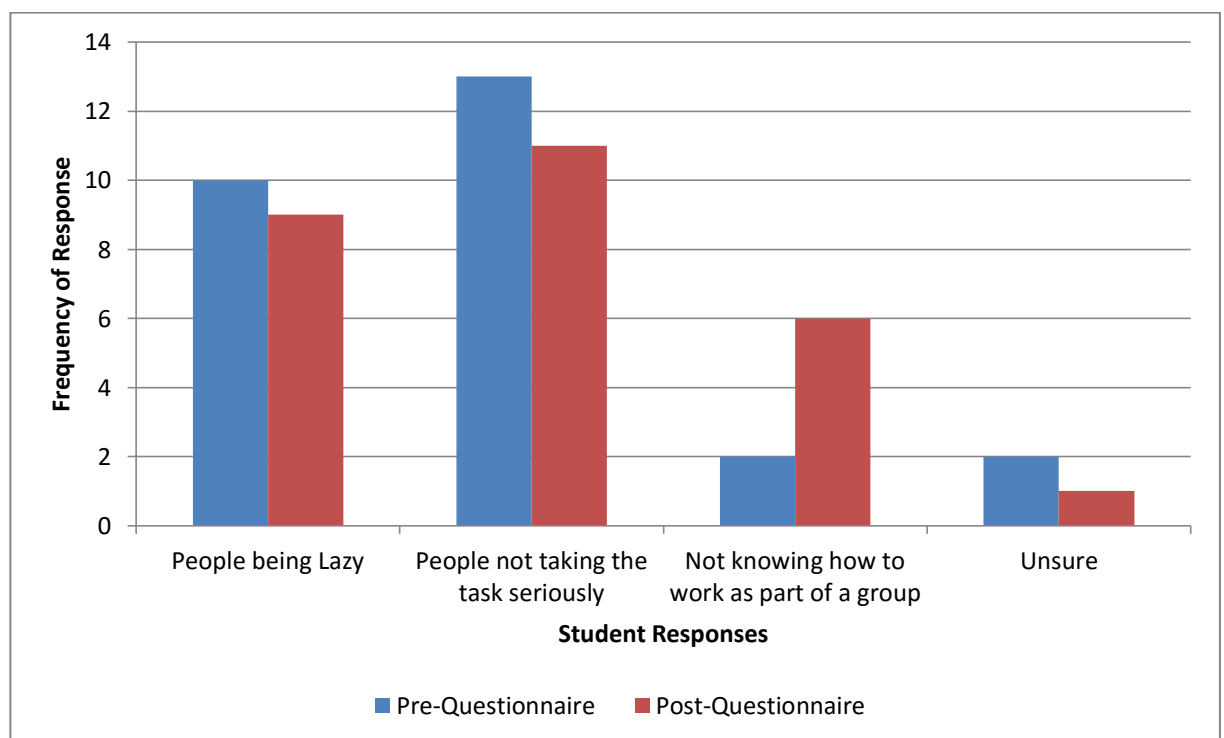


Figure 4.5

Figure 4.5 provides a comparison of the students' perspective on the challenges of teamwork within the classroom setting. Students were provided with three main options regarding the worst element of participating in teamwork. "People being lazy" and "People not taking the task seriously" both referred to the concept of "free-riding" in CL as previously outlined in the literature review (Slavin, Hurley & Chamberlain, 2003). Overall, there was a two student decrease (7%) in "people not taking the task seriously" option between the pre- and post- implementation questionnaires.

Question 3: Have you ever been taught the required skills to work as a team member?

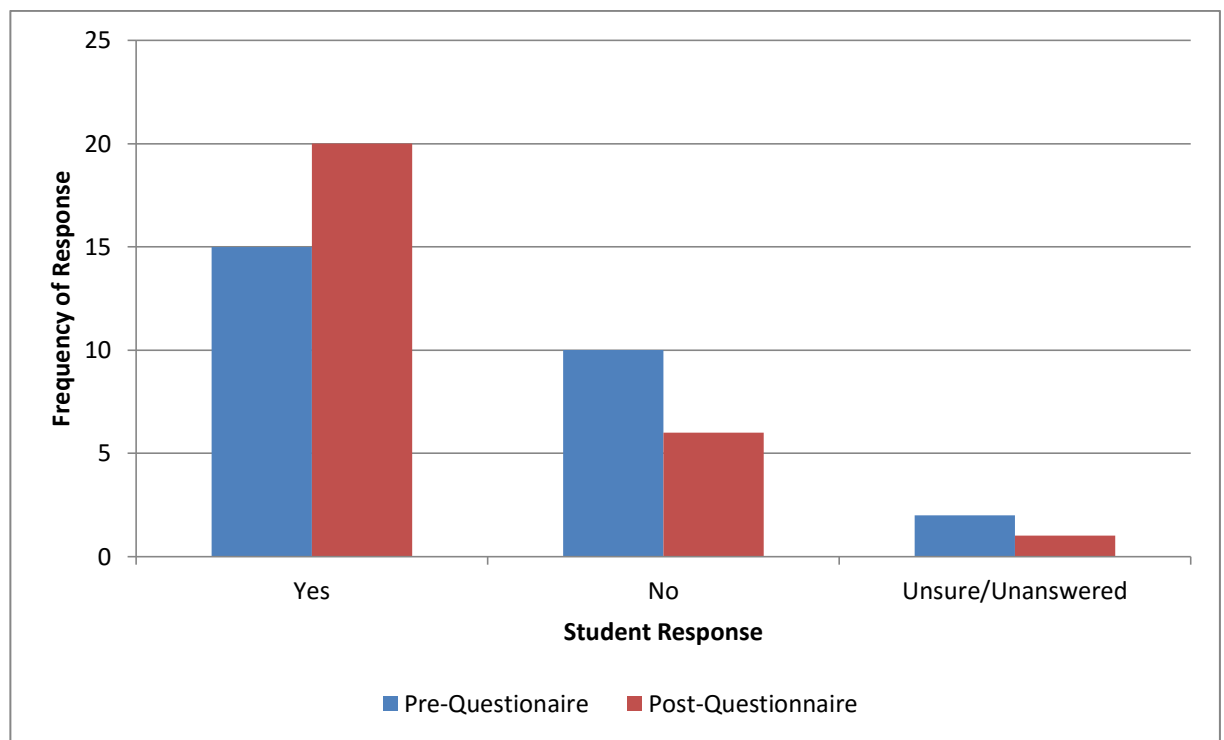


Figure 4.6

Initially, ten students (37%) stated that they were not taught the skills needed to work as part of a team. After this implementation period, twenty students (74%) stated that they were taught the required skills to work as part of a team within the classroom setting.

Question 4: Do you think that teamwork is an important skill to learn in secondary school?

In the pre-questionnaire, all students declared that teamwork was an important skill to learn while they were attending secondary school. The post-questionnaire revealed a similar response, twenty-five students (93%) agreed that teamwork was a vitally important skill to learn while in school, whereas two students (7%) disagreed and claimed that teamwork was not an important skill to learn while in school.

4.2.2 Attitudes to teamwork:

The second section of the student questionnaire revealed the participants' attitudes to teamwork. In particular, these questions intended to identify the students' preferred methodology of learning mathematics in school. The findings from question five to eight are recorded below.

Question 5: Do you enjoy working as part of a team?

Pre-Questionnaire		Post-Questionnaire	
<u>Yes:</u>	<u>No:</u>	<u>Yes:</u>	<u>No:</u>
97%	3%	85%	15%

Figure 4.7

Initially twenty-five (97%) of the student participants claimed that they enjoyed working as part of a team. This response referred to teamwork in the non-specific and non-curricular context. It included teamwork in terms of sporting and non-sporting activities and also in relation to school activities. After the implementation period, there was a decrease of three students (11%) in students' preference of working as a part of a team in favour of students working independently.

Question 6: Which method of learning maths do you prefer?

Pre-Questionnaire		Post-Questionnaire	
<u>Myself:</u>	<u>Team:</u>	<u>Myself:</u>	<u>Team:</u>
37%	63%	41%	59%

Figure 4.8

From figure 4.8, ten students (37%) initially stated that they preferred to learn mathematics independent of others. The remaining seventeen students (63%) stated that they preferred to learn mathematics as part of a group. After the implementation phase, eleven students (41%) stated that they preferred learning mathematics autonomously whereas sixteen students (59%) stated that they preferred to learn cooperatively. There was a one student (4%) decrease in preference of learning Project Maths by engaging in teamwork as a result of CL. However, overall the majority of students (59%) indicated that they preferred to learn mathematics as part of a team rather than in isolation.

Question 7: Is it important for you to help other class mates if they are having difficulties with maths?

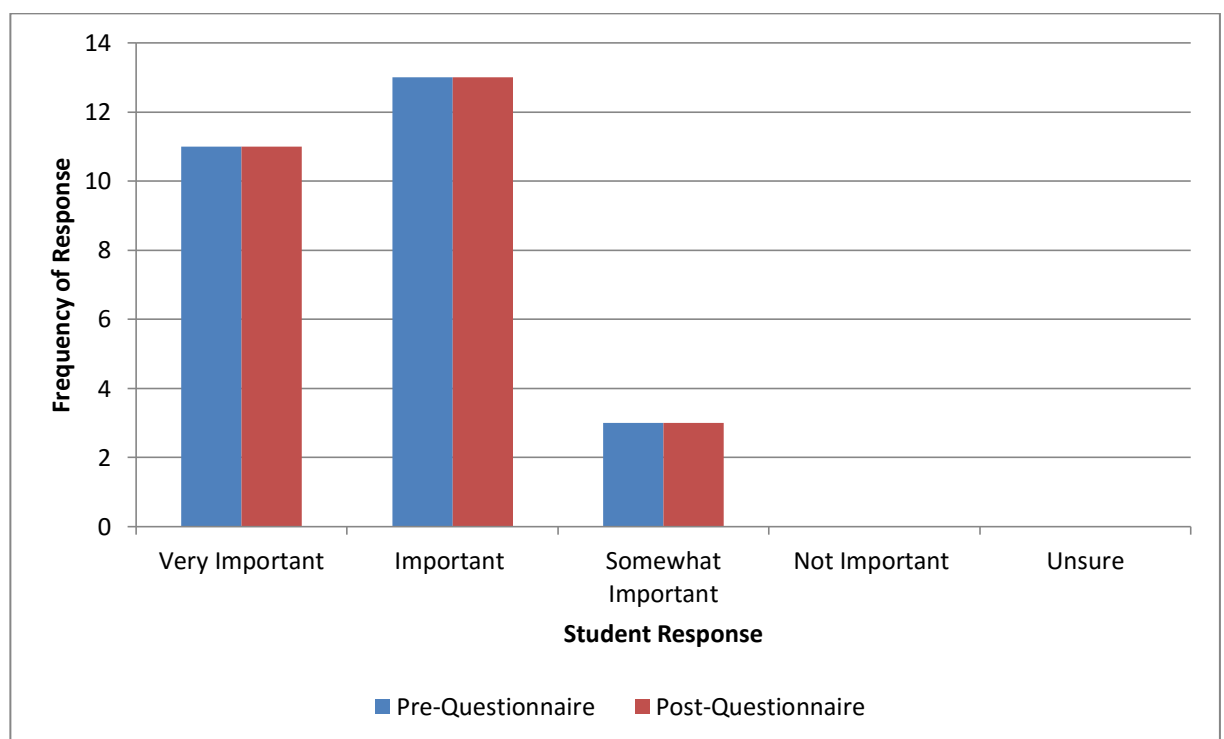


Figure 4.9

Students revealed that the vast majority of them found it important to assist their peers in mathematics class when they are having some form of difficulty. Eleven students (40%) of participants stated that it was “very important” for them to assist their peers, whereas

a further thirteen students (48%) highlighted that it was “important” for them to assist their peers. The remaining three students (11%) stated that it was “somewhat important” to assist their peers. There was no deviation in data between the pre-questionnaire and the post-questionnaire. Students’ attitudes towards assisting their classmates have not altered since the implementation of CL.

Question 8: Are you part of a team outside of school (sports team / scouts / dance group)?

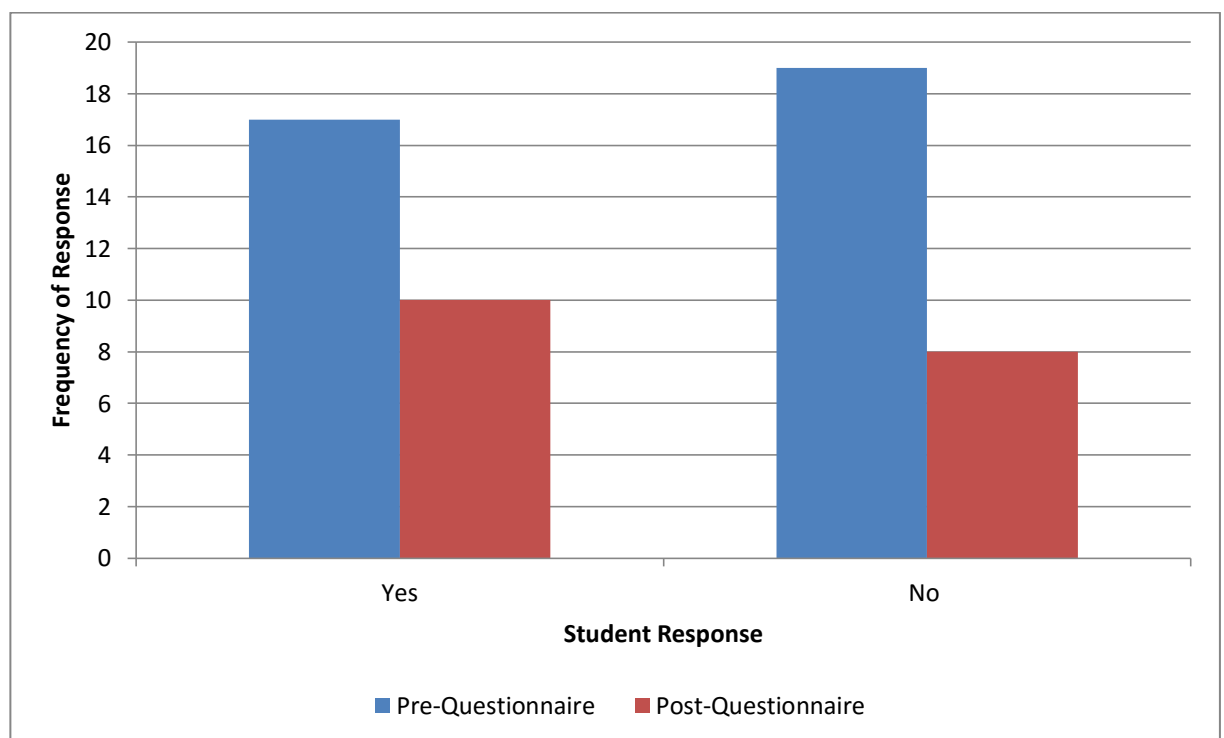


Figure 4.10

This question established if students were previously exposed to the teamwork skills that were required to work together cooperatively from participating in team activities outside of the school environment. It was revealed that seventeen students (63%) had participated as part of a team outside of the classroom and school setting. Ten students (37%) did not claim to participate in a team setting. After the implementation phase,

nineteen students (70%) claimed that they were part of an outside team. This is a marginal increase of two students (7%).

4.2.3 Skills required for teamwork:

As outlined in the literature review of this dissertation, there can be an underlying presumption that students inherently have the required skills to work cooperatively as part of a team. CL aims to structure teamwork within the foundations of educating students on the basic skills required to maximise learning within cooperative groups. The basic elements of positive interdependence and social skills are at the heart of educating students on the necessary skills to structure group learning. This section established a baseline of the students' experiences in learning the fundamental skills that are required for learning as part of a group.

Question 9: What skills do you need to work as part of a team?

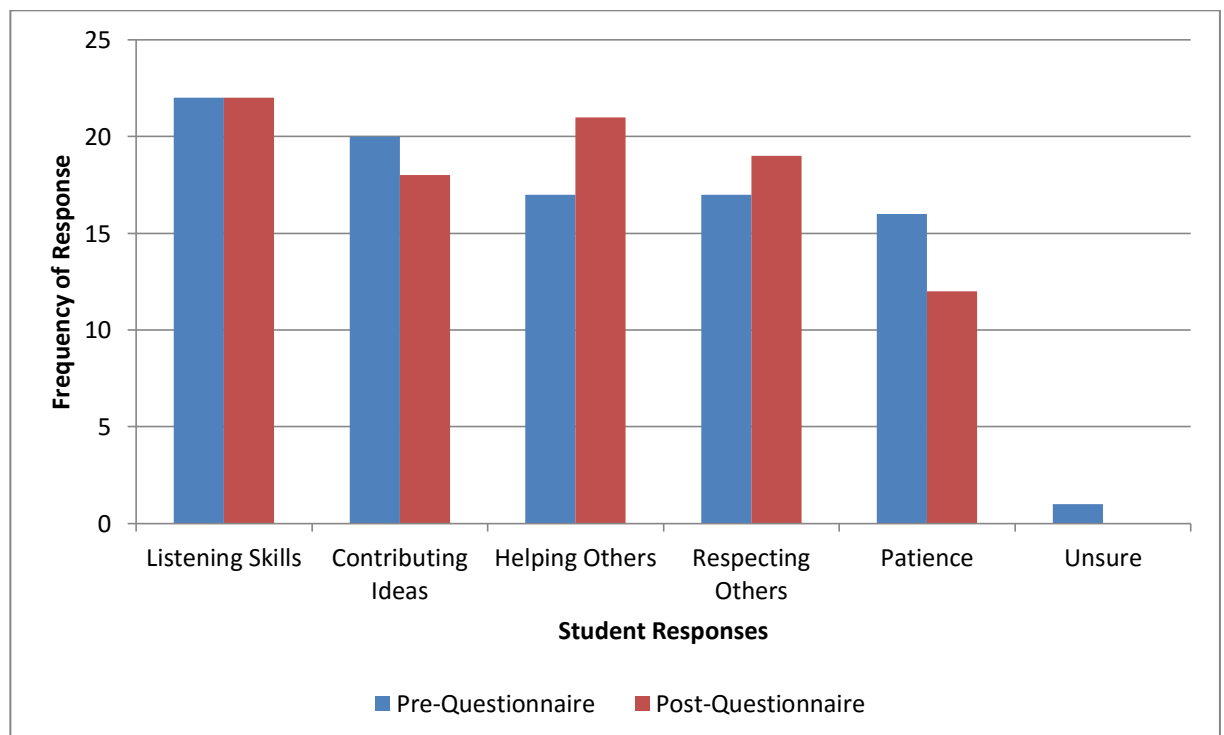


Figure 4.11

In figure 4.11, students were invited to select the necessary skills required for teamwork. Students were provided with the opportunity of selecting multiple skills. In the pre-questionnaire, a total of ninety-three responses were recorded. Students indicated that “listening skills” was the most predominant factor that must be included in teamwork. Students also selected “contributing ideas”, “helping others” and “respecting others” as highly valuable skills that are required for teamwork. In the post-implementation questionnaire, students identified a total of ninety-two responses and there was no significant alteration to the priority skills that were established in the pre-questionnaire. In the post-questionnaire, it was noted that there was an increase in selecting the skills of “helping of others” and “respecting others”. It was also noted that there was a decrease in the skill of patience by four responses.

Question 10: Have you ever been taught how to listen as part of a group?

Initially twenty students (74%) in the pre-questionnaire responded that they had been formally taught how to listen as part of a group, whereas seven students (26%) stated that they received no formal instruction on how to listen as part of a group. From the post-questionnaire, there was a slight increase of one student (4%) who had received training on listening skills as a result of the implementation in CL. The post-questionnaire highlighted that twenty-one students (78%) reported that they received some formal training in listening skills and six students (22%) had not received training on this skill.

4.2.4 Opinions of Mathematics

This section revealed insights into the students’ opinions of mathematics and to what extent the students rated mathematics as an important skill. This section also explored

the negative influences that arose from environmental and parental viewpoints towards mathematics.

Question 12: Do you enjoy studying maths in secondary school?

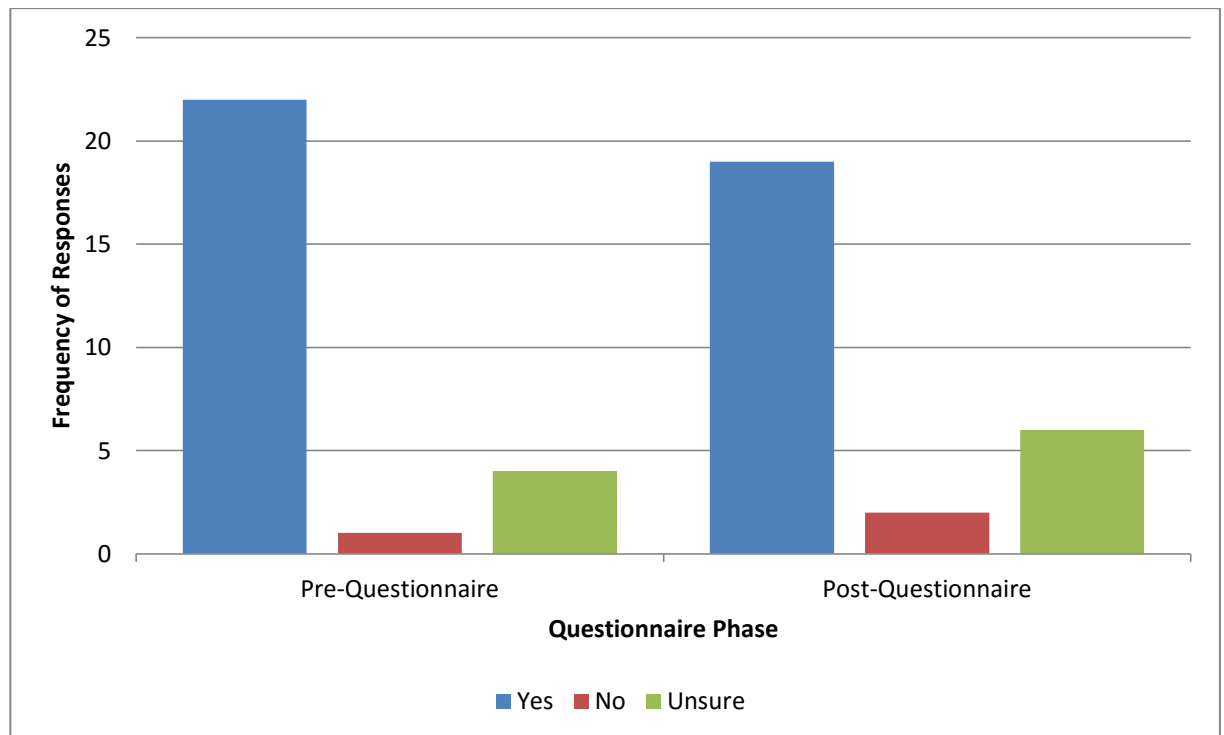


Figure 4.12

The pre-questionnaire revealed that twenty-two students (81%) reported that they enjoyed studying mathematics. However, one student (4%) claimed that he/she did not enjoy studying mathematics and four students (15%) were undecided. The post-questionnaire noted a decrease of three students in the enjoyment of studying mathematics after the implementation of CL. In the post-questionnaire, nineteen students (70%) declared that they enjoyed studying mathematics. There was also an increase in those who stated that they did not enjoy studying mathematics from one student (4%) to two students (8%).

Question 13: Maths is an important skill to have in life

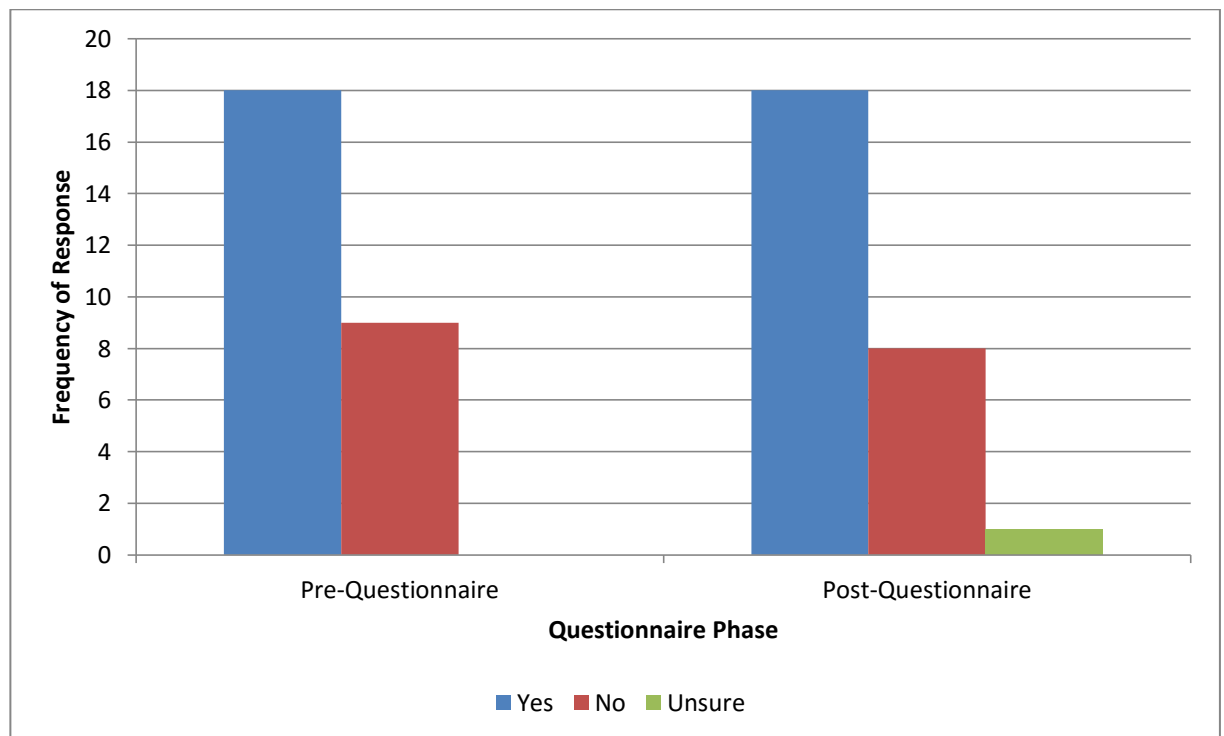


Figure 4.13

From figure 4.13, it is evident from these findings that these students understood the importance of an education in mathematics. Eighteen students (67%), at the pre- and post- questionnaire stage of CL implementation recognised that mathematics is a fundamental skill to have for life. There was a one student decrease in the amount of students who stated that mathematics was not an importance skill as a result of the implementation phase.

Question 14: Do your parents/guardians have a fear of mathematics?

Interestingly, no student stated that his/her parent/guardian had a difficulty with mathematics at both the pre and post stages of this process. Four students (15%), at the pre-questionnaire stage, stated that they were unsure if their parents had any noticeable difficulties with mathematics.

Question 17: If you get stuck on a maths problem at home who do you turn to for help?

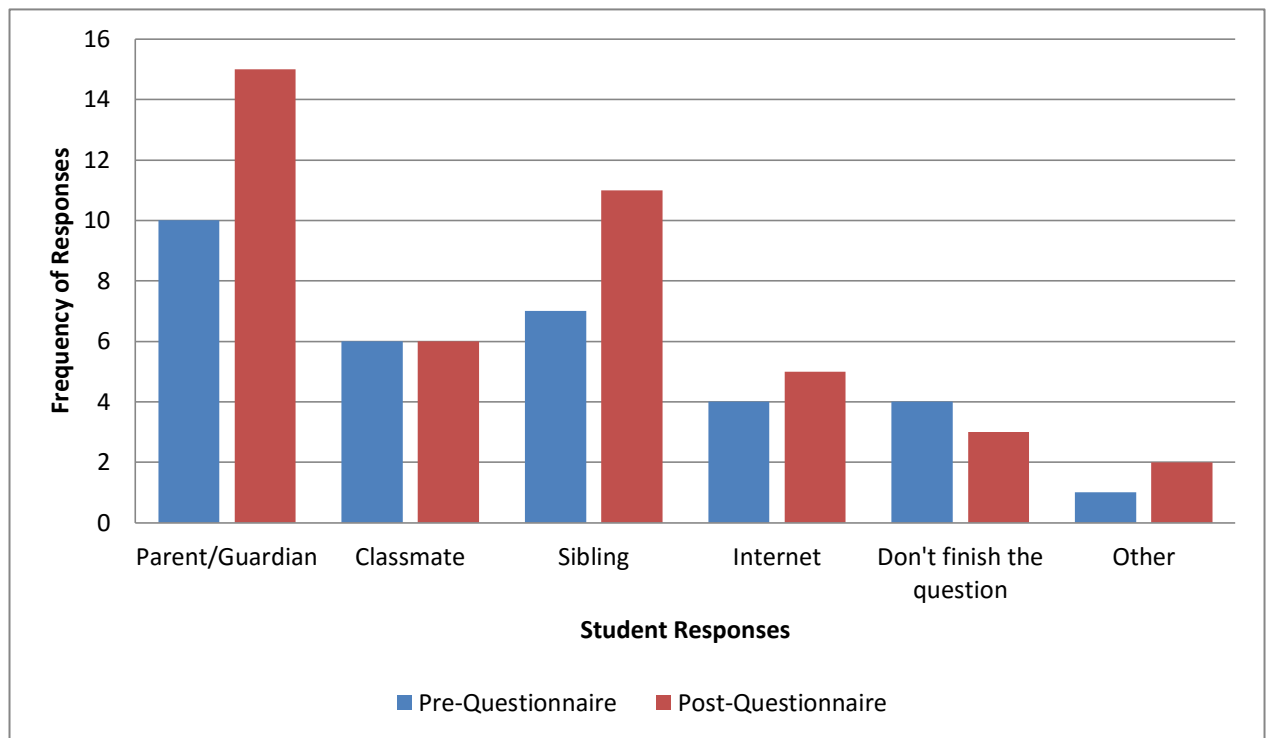


Figure 4.14

From the pre-questionnaire, ten students (37%) claimed that they sought additional help from their parent/guardian when solving difficult Project Maths questions. Fifteen students (56%) claimed the same type of support in the post-questionnaire. There was no deviation in the amount of students seeking support from their CL classmates after the period of implementation. There was also an increase of four students, between the pre- and post-questionnaire, seeking support from their siblings, the internet and other sources.

Question 15: Is maths homework beneficial to you?

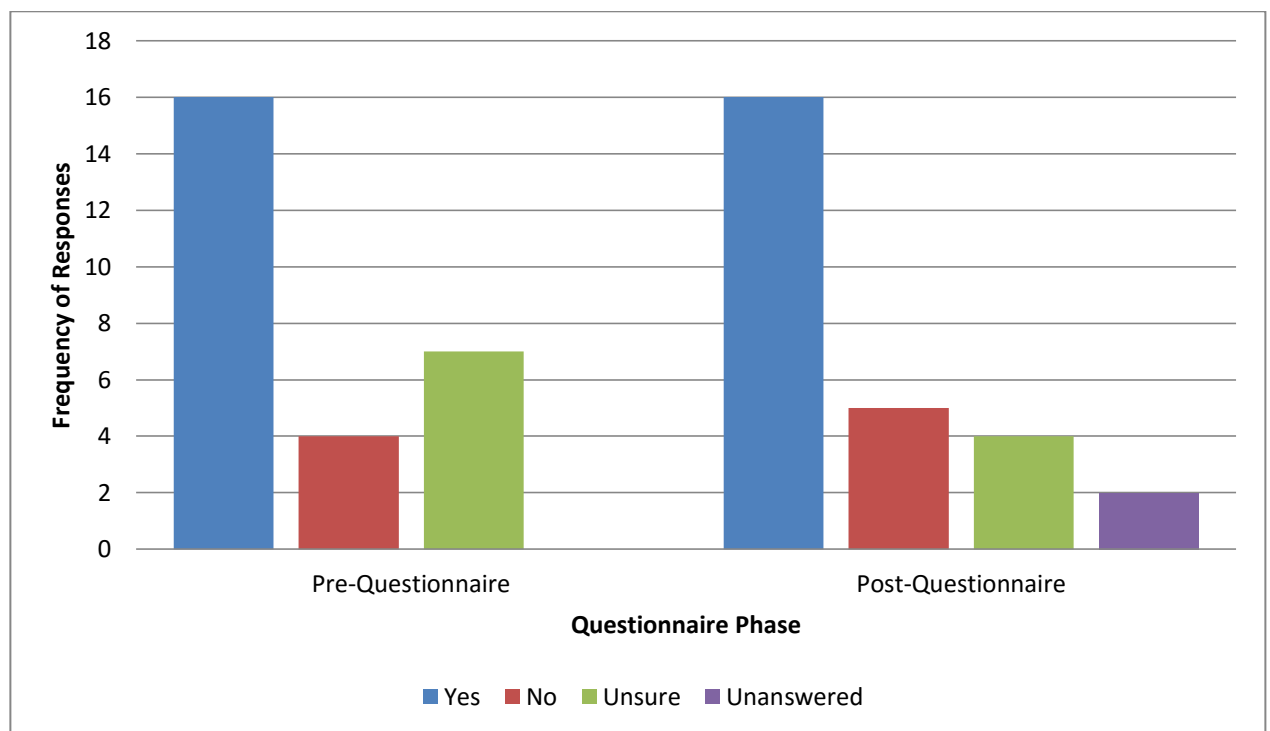


Figure 4.15

Sixteen pre-questionnaire students (60%) stated that they found mathematics homework beneficial to their learning process. Four students (16%) stated that they did not agree that maths homework was beneficial to their learning and seven students (25%) were unsure about this statement. There was no significant difference between the pre-questionnaire and the post-questionnaire results for this question.

Question 16: Do you think that by correcting your classmates' homework that it will help you to improve on your maths skills?

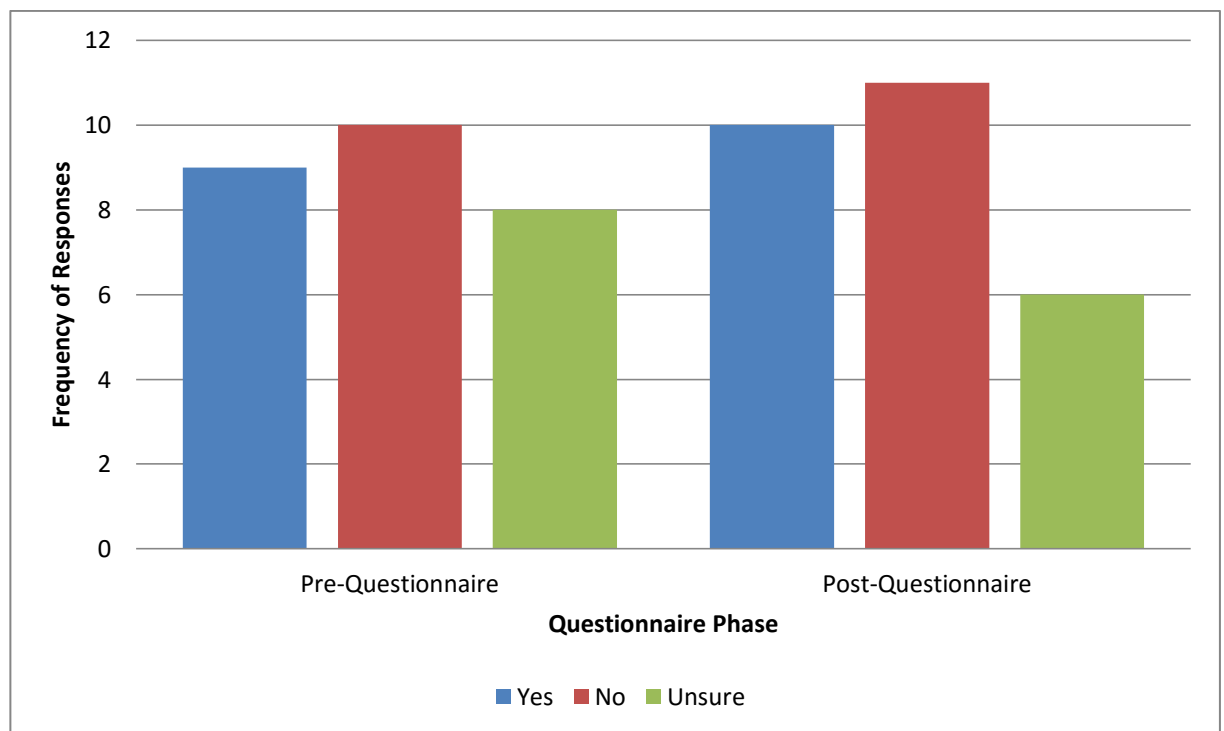


Figure 4.16

From the pre-questionnaire, nine students (33%) stated that they thought that by participating in the process of correcting their teammate's homework that this would assist them in their own learning of mathematics. On the other hand, ten students (37%) disagreed with this process of peer-correction within the classroom. The remaining eight students (30%) were unsure about their stance on this question. From the post-questionnaire, there was a slight increase in those who believed that participating in the correction of their peers' homework would assist them in learning maths. After the implementation, ten students (37%) agreed that this was a beneficial process.

Question 18: In your opinion, what's the best way of learning maths?

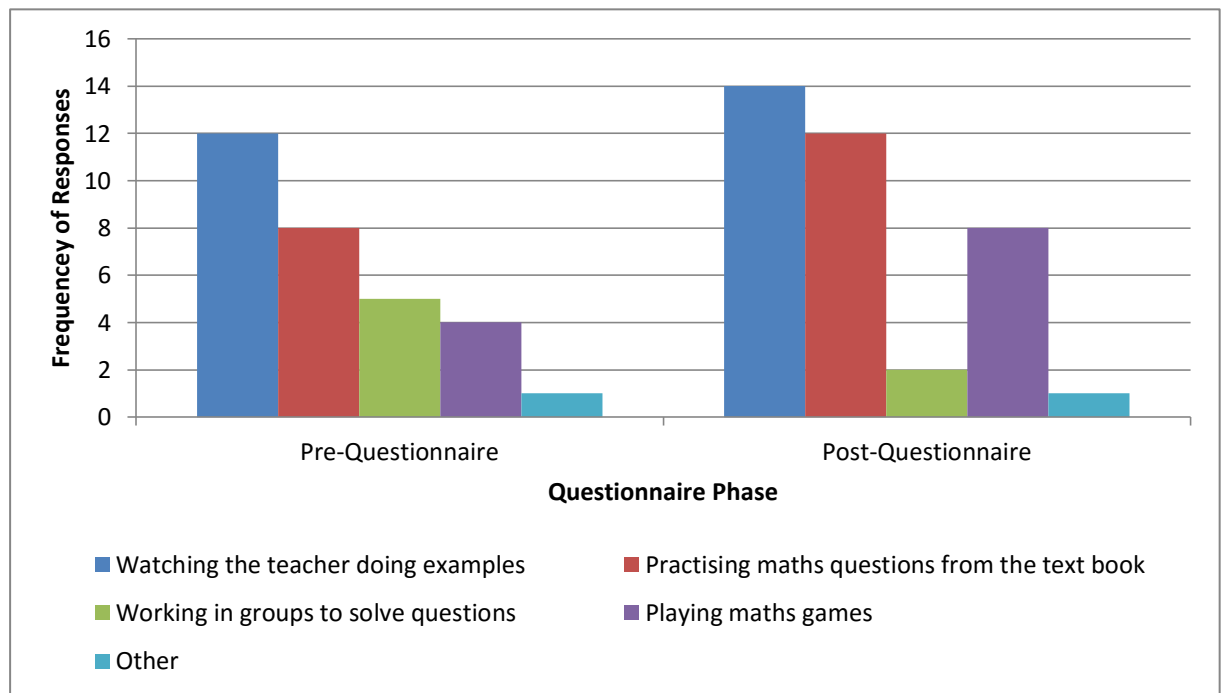


Figure 4.17

Illustrated in figure 4.17 are the responses provided by students on which pedagogical approach they preferred to learn mathematics. From the pre-questionnaire, it was evident that students favoured the traditional methodology of the teacher led instruction. Working in groups was in the median of this generated data. After the implementation of CL as the predominant methodology, there was a decrease in this pedagogical model. However, from the post-questionnaire there was a two student increase in to the amount of students who preferred watching the teacher completing examples on the whiteboard. There was also an increase in the amount of students who stated that they enjoyed learning mathematics through participation in maths games.

Question 19: Describe your maths ability

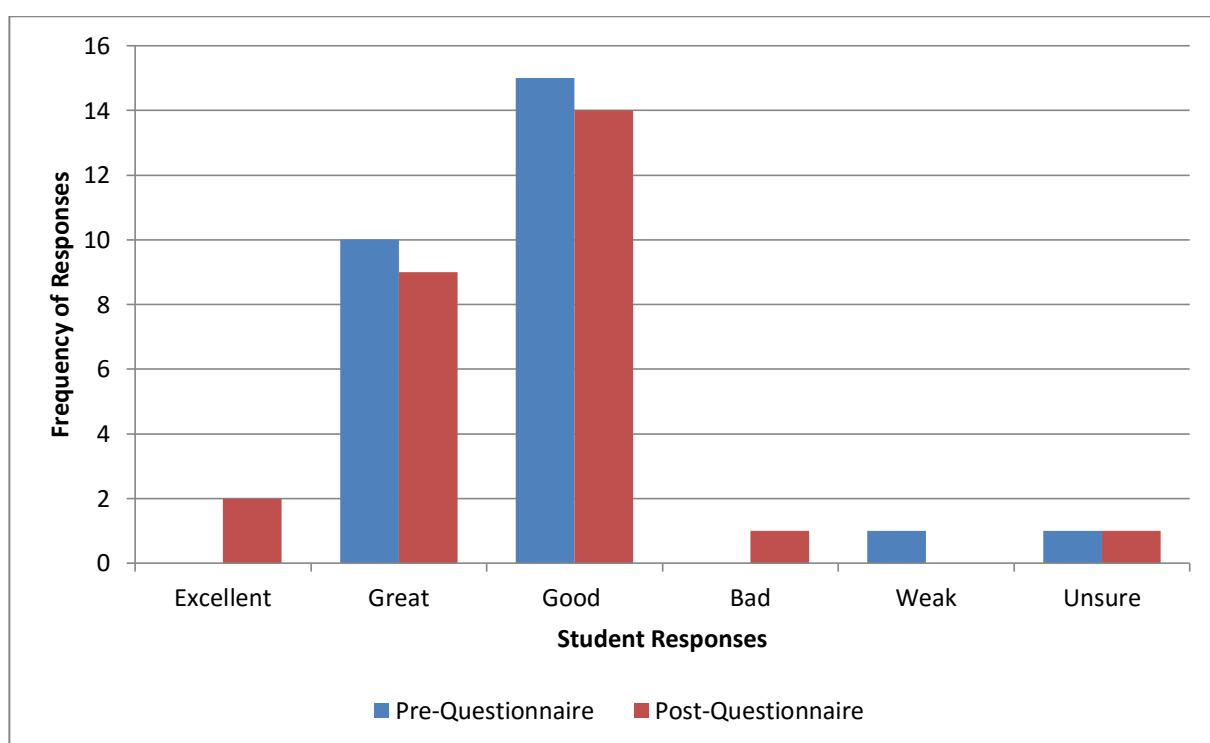


Figure 4.18

From the pre-questionnaire, the majority of students identified that they had “great” or “good” mathematical ability. From the post-questionnaire, there was an increase of two students who identified that their mathematical ability was excellent after the implementation of CL. However, the post-questionnaire highlighted a slight two student decrease in those students who classed themselves as “great” and “good” throughout the research period. There was also one student who claimed to be bad at mathematics in the post-questionnaire.

4.2.5 Mathematical Statements

The concluding section of the questionnaire required students to assess themselves on a series of mathematical statements related to a series of aspects of the CL paradigm. Students were provided with a Likert scale of five distinct answers consisting of strongly agree, agree, unsure, disagree and strongly disagree. The bar charts in this section

illustrate the comparison in the data between the pre-questionnaire and the post-questionnaire.

Statement 1: I have a certain amount of maths ability and I can't do much to change it

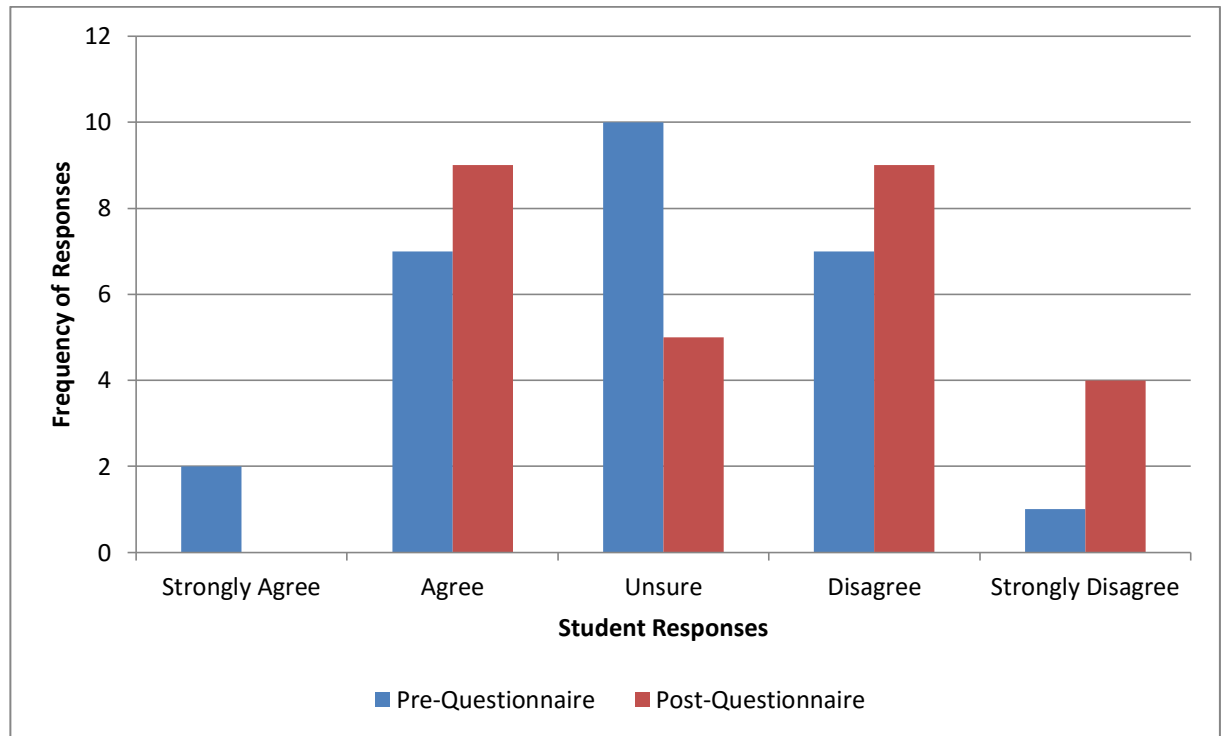


Figure 4.19

The post-questionnaire revealed that no student strongly agreed with this statement after the implementation of CL. There was a five student decrease in those who were unsure in their opinion between the pre-questionnaire and the post-questionnaire. There was also a three student increase in those who felt that they strongly disagreed with this statement and hence they acknowledged that they can change their mathematical ability.

Statement 2: Asking questions helps me to learn maths.

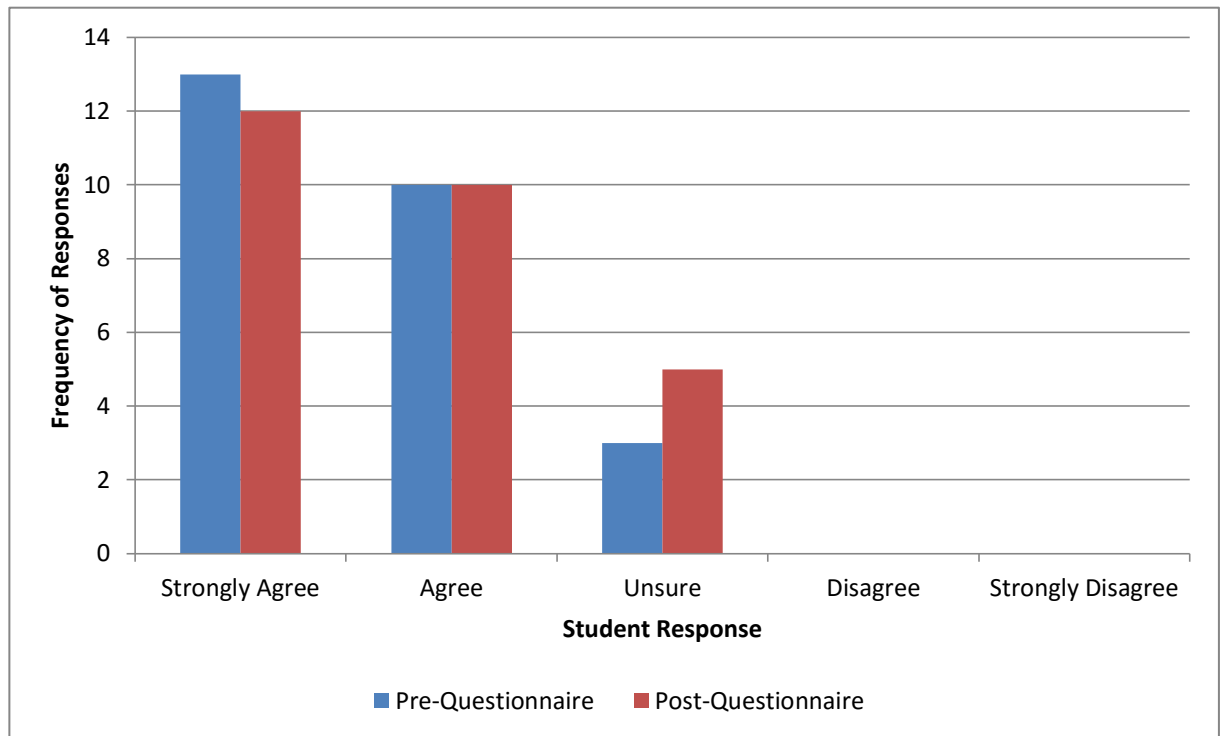


Figure 4.20

From the pre- and post-questionnaire, the majority of students “strongly agreed” with the statement that asking questions in the classroom assisted them in their learning. The post-questionnaire revealed that there was a two student increase in the amount of students who were ‘unsure’ after being taught by CL strategies.

Statement 3: Maths involves creativity and new ideas

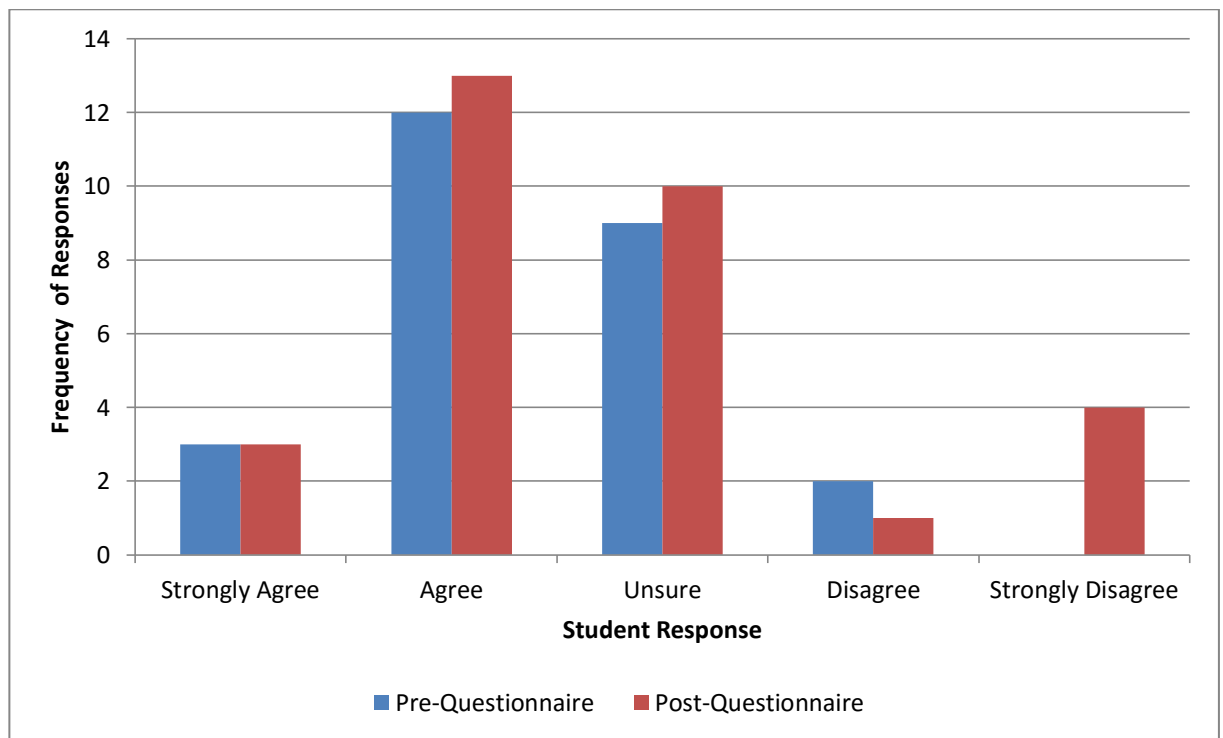


Figure 4.21

After the implementation stage of CL, there was a minor increase in students' opinions in relation to the statement that mathematics can be creative and innovation. However, some students were still unsure in relation to whether maths can be seen as a creative subject. There was 15% increase of those students who "strongly disagreed" with this statement as a result of the implementation phase.

Statement 4: Maths helps to solve everyday problems and tasks

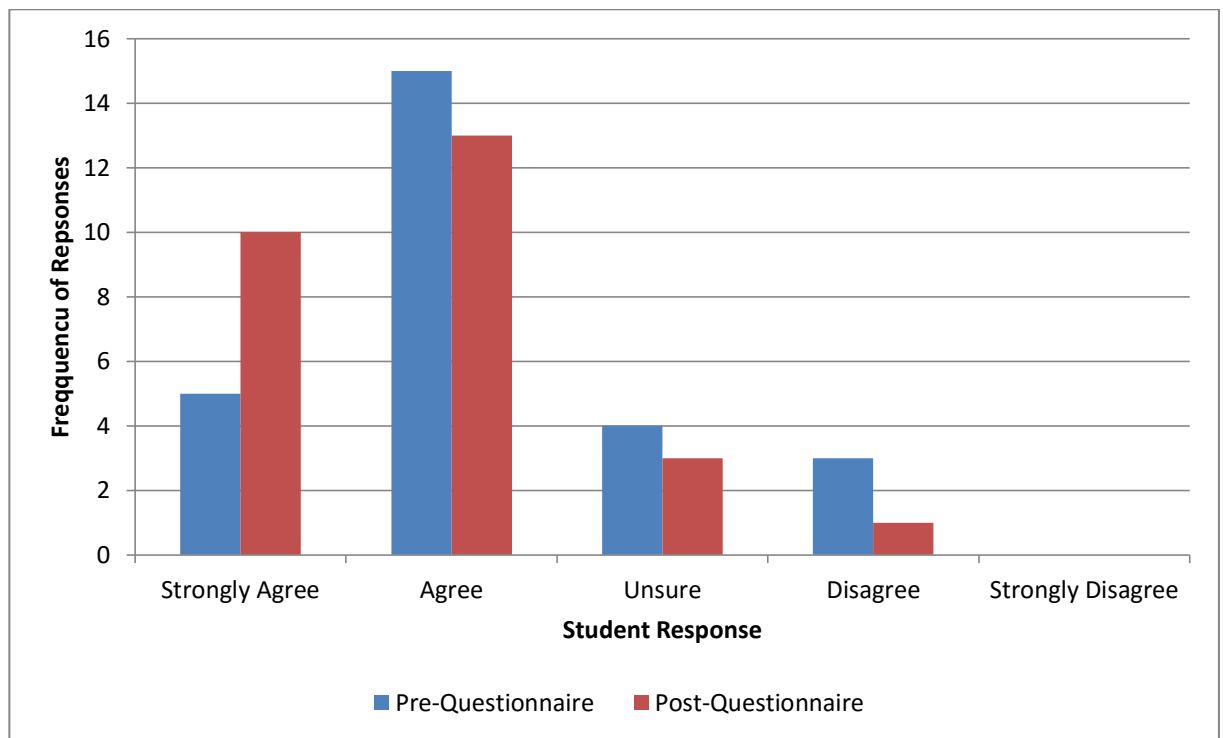


Figure 4.22

After the implementation of CL within the Project Maths classroom there was an increase of five students (50%) of students who “strongly agreed” that maths helps to solve everyday problems and tasks. There was also a small decrease of two students who “disagreed” with this statement.

Statement 5: It is easier to do maths by working together as a team:

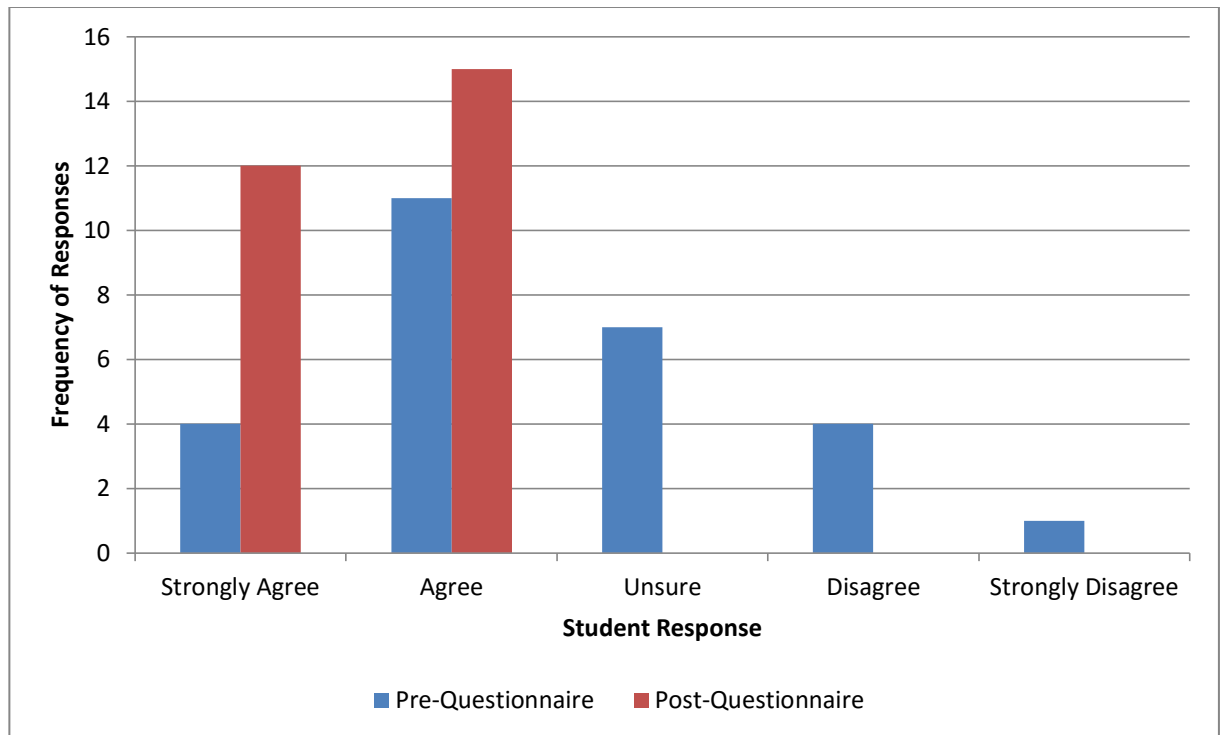


Figure 4.23

There was a shift in data between the pre-questionnaire and the post-questionnaire. The concluding data is positively skewed to the right. Students' opinions have shifted towards the "strongly agree" and "agree" categories. All students have claimed that they either strongly agreed or agreed with the statement that it is easier to do maths by working together as a team.

Statement 6: I think that it is important to help people:

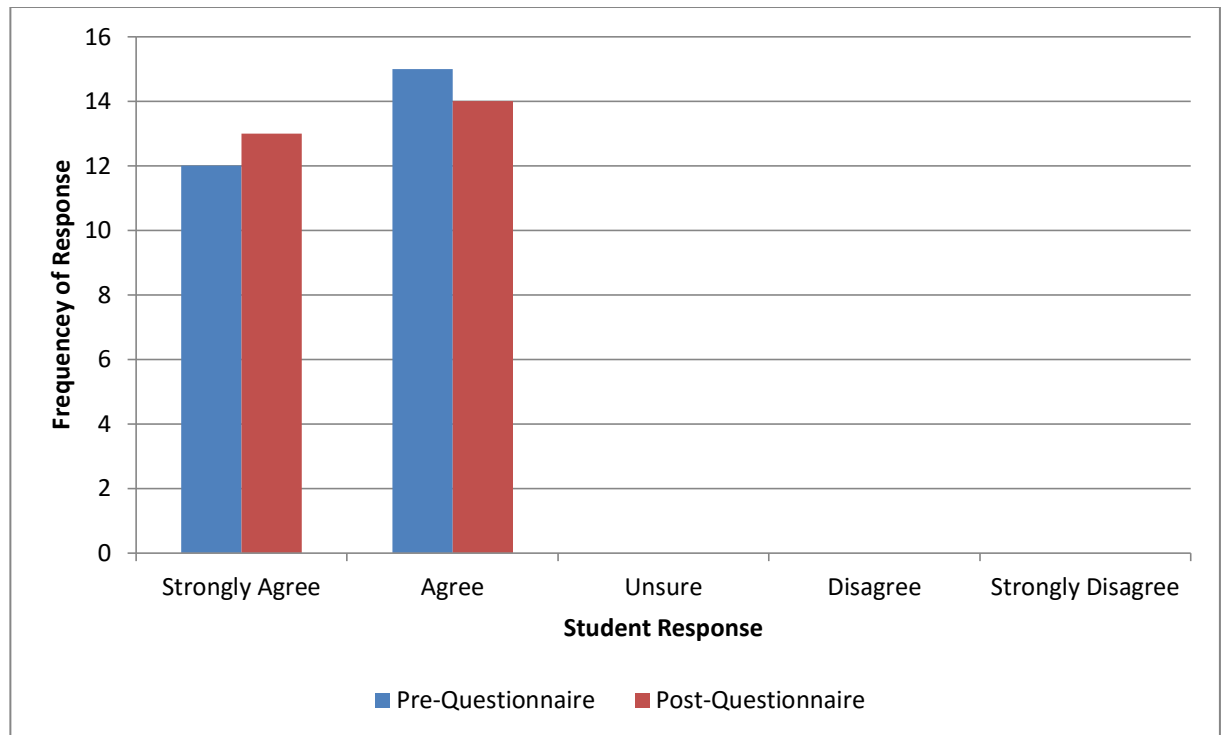


Figure 4.24

As previously mentioned in question seven above, this class seems to have a high regard for assisting their peers. After the period of CL, there was a slight increase of one student (4%) strongly agreeing that helping people is important. No student was unsure in relation to this statement and furthermore, no student disagreed or strongly disagreed with this statement.

Statement 7: Do you think that each member of the group should have a particular job to do?

There was no change in the data over the period of implementation. Initially seven students (26%) had responded that they “strongly agreed” that each member of the group should have a specific role within the team. There was a marginal decrease in those who “agreed” with this statement. In the pre-questionnaire, fourteen students (52%) “agreed” and this was reduced to twelve students after the implementation period of CL.

Statement 8: By helping my classmates with maths, it helps me to understand the topic better.

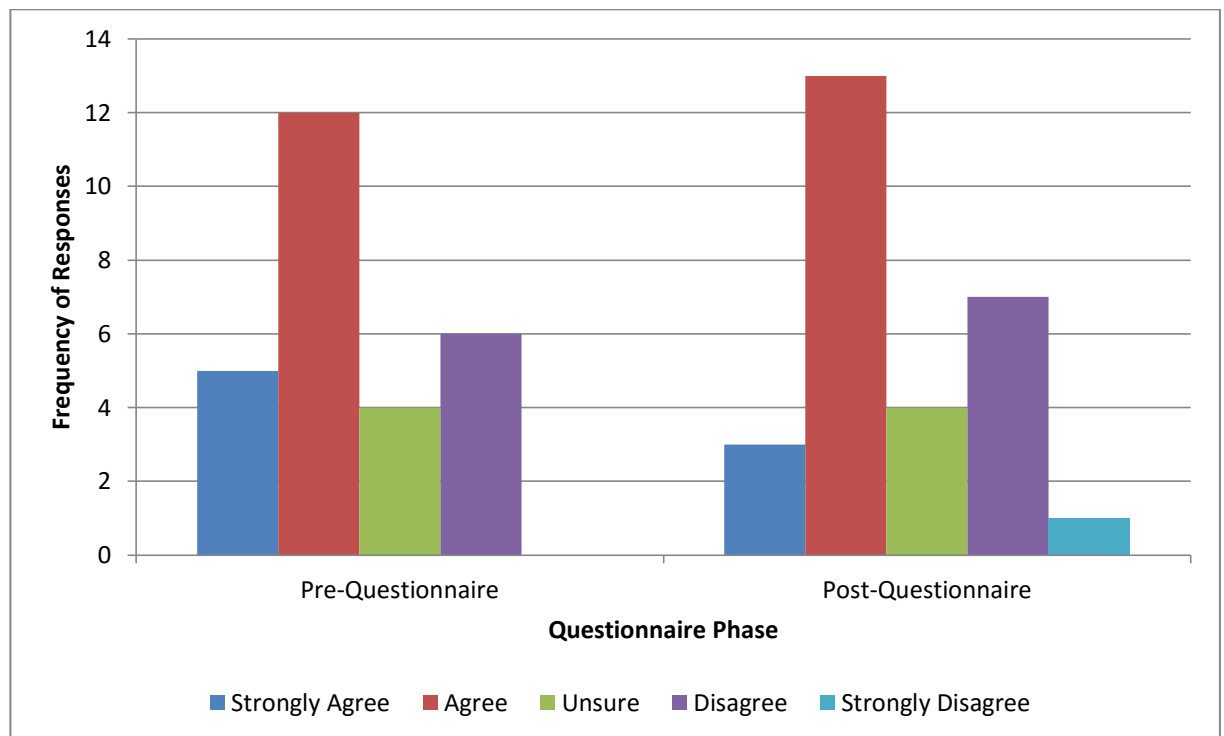


Figure 4.25

After the implementation period there was a decrease in those who thought that working together would assist them in understanding the topic better. There was also an increase by one student who “disagreed” with this statement.

Statement 9: Working as a group in maths class will enable me to improve my grades.

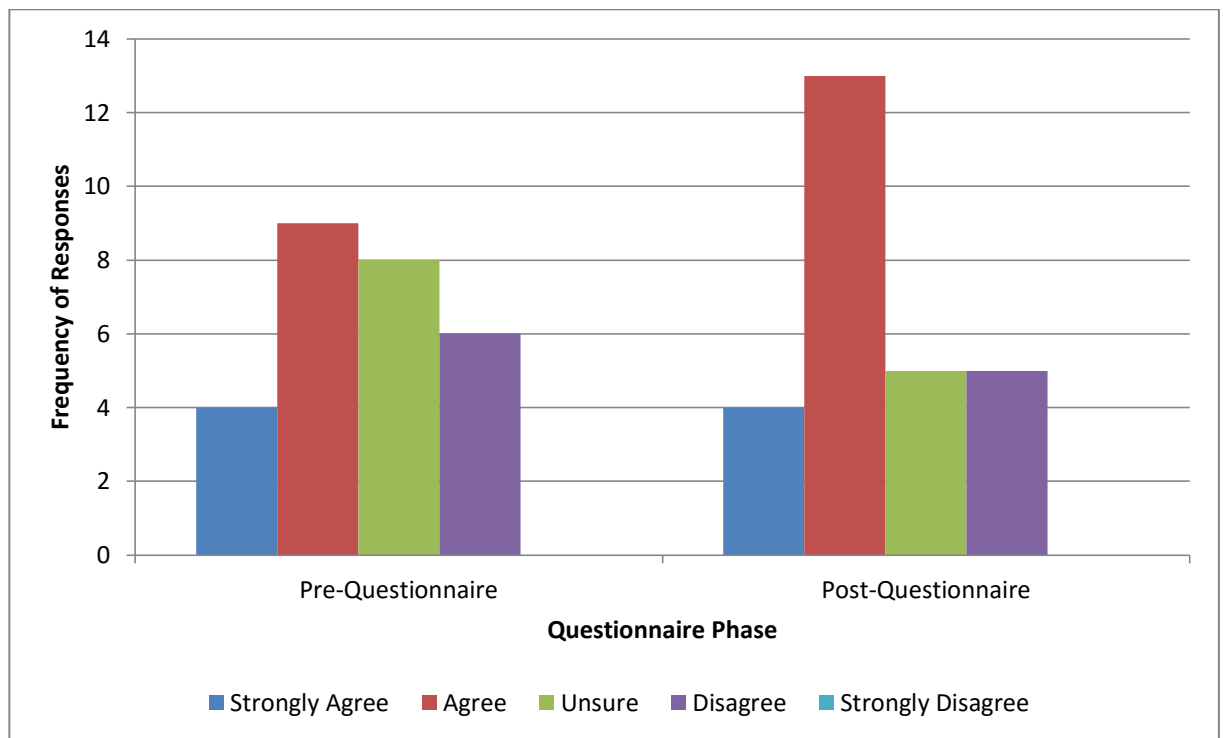


Figure 4.26

There was a slight decrease of one student who “disagreed” with this statement. There was a four student increase in those students who “agreed” that by working cooperatively as part of a group in mathematics, this can enable an improvement in grades.

Statement 10: Reflecting on group activities helps the group to improve and work better

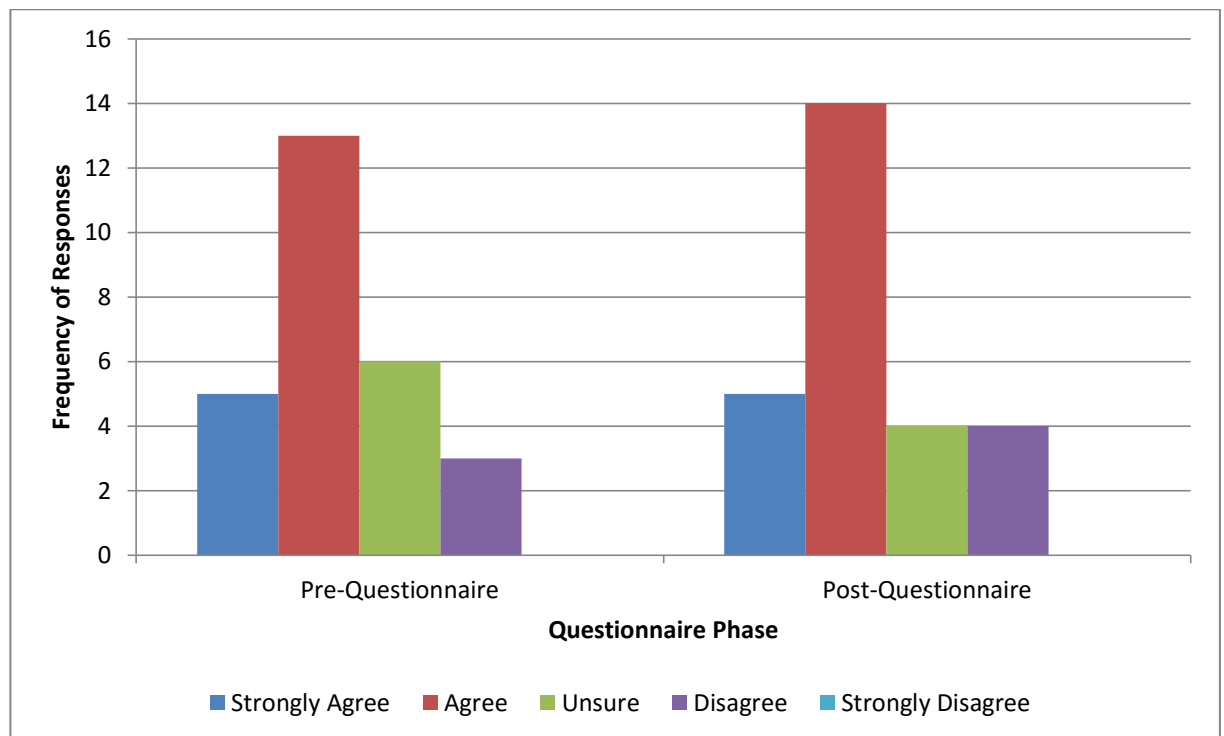


Figure 4.27

This final statement referred to students' attitudes on reflecting on their experiences as part of the learning process and also as part of the group processing element of CL. After the implementation process, there was a slight increase by one student who "agreed" with this statement.

4.3 Qualitative Findings II: Team Processing Sheets

The second form of data collection was completed in the form of a qualitative team processing sheet (Appendix K). Group processing is one of the five basic elements of the CL model. Johnson & Johnson (1999) stated that group processing refers to "group members discussing how well they are achieving their goals and maintaining effective working relationships" (p. 71). For this dissertation, students recorded their group processing in writing at four separate intervals throughout the implementation process.

The group processing sheets recorded two helpful actions of each team member in the task. The team processing sheets also identified areas for improvement for team members when working cooperatively as a team. Johnson & Johnson (1990) have cautioned that in order for group-work to succeed, students must be equipped with the correct social skills to work cooperatively to achieve team goals. These social skills can be related to the curricular key skills of learning as described by the NCCA. These include communicating, being personally effective, working with others, critical and creative thinking and information processing (NCCA, 2008). This acknowledgement of the helpful actions of each member can be linked to the CL social skills.

In addition to these team processing sheets (Appendix K), each team member also completed an individual processing sheet at the end of the implementation process, reflecting on their own processing after working within the team unit (Appendix O). In order to preserve the anonymity of all participants, the student-selected team names were provided with names of mathematicians. This ethical protection is necessary as direct quotes and recorded responses from these team members are described below.

4.3.1 Findings from Team Pythagoras

Team Pythagoras identified several aspects of the key skills charter including communication, managing information and also working together. From their team processing sheets, students have declared the following from their experience:

27/01/2016 *“Finish early / everyone knew their jobs. Good system”*

29/01/2016 *“It helped us improve on segments we may have found confusing”*

05/02/2016 *“We consulted each other before we wrote our answer”*

05/02/2016 *“If one of us forgot a definition, the other person was there to help”*

In addition, individual members from this team have recorded the following individual responses:

“If I can’t understand something, instead of disrupting the whole class I can just ask a group member”

“Doing group-work helped me in general as well as in maths, because it taught me how to communicate better with others”

“I think learning in groups is more beneficial than working alone”

4.3.2 Findings from Team Euler

Team Euler initially demonstrated some difficulties in grasping the concepts sought by the group processing process. They identified non-specific helpful actions of their team members. From observation, it seemed that this team had the most difficulty in developing their positive interdependence amongst their team members. It was evident that one team member seemed to be very domineering, the other team members did not respond well to this. One team member stated:

“I think that working as a group did not help as all the people in my group were grumpy and uncooperative”

On the other hand, other team members recognised the importance of positive interdependence and the fundamental importance of social skills required for productive teamwork. This member stated that:

“I learnt you get more things done with more people and that communication and listening are important when working together”

4.3.3 Findings from Team Gauss

This team demonstrated a highly positive approach to the CL strategies that were demonstrated throughout this implementation process. These student responses included:

“I think group-work was a really nice experience and I would like to do it in the future”

“I thought it (Cooperative Learning) made maths more enjoyable and we all helped each other out if we were stuck”

“Being able to help each other, teamwork makes maths more enjoyable and things get done quicker”

4.3.4 Findings from Team Newton

Team Newton members have highlighted the strong importance working as part of a group can have in terms of addressing misconceptions that may arise in Project Maths. One student stated:

“Working as a team covers up the things you don’t know, as your team probably knows it and can teach you. It is quicker and it is more fun to work as part of a team”

This same student addresses the importance of working together and states that the worst element of CL is when *“team members letting the team down”*.

Another student commented on her experience of CL over the period of implementation stating:

“It is more fun to work in groups. It helps with learning to work as a team. Contributing ideas is useful in work and makes it easier because everyone has difference ideas”.

4.3.5 Findings from Team Turing

Team Turing has identified the importance of the key skills of communication, working with others and being personally effective. From reviewing this team’s team processing

sheets, the theme of “encouraging” and “cheering” has been considered as a helpful action from several of the team mates. Students have stated the following from their group processing sheets:

29/01/2016 *“We can work out quicker”*

05/02/2016 *“We solved more questions and help each other”*

In addition to these comments, students have individually stated that:

“Everybody learns more. Listen when someone else is talking. Try to help everybody. Co-operation.”

Similarly, a student has responded that he prefers working together *“because if you don’t know the answer, you can ask your friends/team on how to solve the question”*.

4.3.6 Findings from Team Leibniz

The process of working together is not always a straightforward or linear model but one that contains many twists and turns. One student from this group stated *“Learning how to work together with different people to achieve something”* was the best part of this implementation process. This acknowledgement of “learning” the required skills is at the heart of the CL paradigm. This student articulated that *“teamwork could be both fun, great and beneficial but also hard and frustrating if you’re the only one doing work”*.

Another student stated that *“I think the maths classes are more enjoyable when we do group- work. Working as a team is good because if you don’t know something your team can help you”*

.

4.3.7 Findings from Team Riemann

Team Riemann reflections linked to the key skills of communication, working with others and being personally effective. One student stated *“I really enjoyed teamwork. It was a great way to learn and I would love to do it again in maths and other subjects”*. This group processed their newly acquired skills and one student proclaimed that *“I learnt how to communicate better. I learned new skills in maths. I learned that doing things together get the task done quicker”*.

Furthermore, another student discussed the concept of being personally effective and time management with the Project Maths timeline stating *“When working together, if you were stuck on a question you could ask your teammate. But if you were on your own it would take a long time for the teachers to go to each individual person”*.

The following additional quotes are from the team processing sheets:

27/01/2016 *“Worked well together”*

29/01/2016 *“Got questions done quicker”*

05/02/2016 *“We bossed it!” [This is a slang term for excelling at an activity]*

4.3.8 Findings from Team Fibonacci

This team’s processing referred to the key skills of working with others, communicating and critical and creative thinking. One student stated that the worst element of CL was *“arguing on an answer for the question”*. However on the other hand, another student stated that *“group partners are able to teach me how to do something I didn’t know”*. When asked about which teaching methodology he preferred, one student stated *“Would do it again (Cooperative Learning), any day for any class”*.

The following are additional quotes are from the team processing sheets:

27/01/2016 *“Worked out how to do the questions”*

29/01/2016 *“That it is better to work together than alone”*

4.3.9 Findings from Team Einstein

Team Einstein recorded the key skills of working with others, being personally effective and information processing within their group processing. Overall this group has demonstrated a positive view in relation to the implementation of CL. One student stated that he simply enjoyed being *“given tasks to complete”*. Furthermore, another student summed up the atmosphere within the classroom *“the laughter and excitement of the class, like the spirit. Good communication and listening. Fun problems and board work.”* When asked for his overall comment, this male student claimed *“teamwork is pretty decent”*.

Additional quotes from the team processing sheets include:

27/01/2016 *“We motivated each other”*

29/01/2016 *“Lots of cooperation”*

05/02/2016 *“Good teamwork”*

4.4 Quantitative Analysis: Common Assessment Test

Quantitative data was collected from a post-implementation of CL comparative assessment examination. This assessment was comprised four questions of which three represented the three areas of the curriculum which were covered during the implementation period. As it was a common scheme of work, all students in the experimental and control classes had received instruction in these topics. The fourth

question was from the students' common Christmas examination and acted as a revision question only. The experimental class was taught by CL methods and the control classes received traditional teaching methods. Figure 6.1 represents the experimental (CL) class results where $n=27$ (Appendix P). However, due to ethical constraints two parents have stated that their child's results must not be included in this dissertation. Additionally, one student was absent on the day of this examination hence reducing the participant number to 24. Figure 6.2 reflects the results obtained from the first control class (where $n = 24$) and similarly figure 6.3 reflect the results obtained from the second control class (where $n = 24$) (Appendix P).

4.5 Conclusion

This chapter illustrated the findings generated from the three main data collection tools. These three methods triangulated the data to increase validity, reliability and confidence in the results. The findings from both qualitative and quantitative methodologies were presented in this chapter. Qualitative data was presented by using a range of bar charts and tables that acted as a method of visually presenting the data generated from the pre-questionnaire and the post-questionnaire. The quantitative data from the experimental class was displayed in figure 6.1 and the data from the control classes was illustrated in figures 6.2 and 6.3 respectively (Appendix P). This chapter has provided the reader with the facts of the findings and a comprehensive discussion and analysis of these findings will be addressed in Chapter Five.

Chapter Five: Discussion

5.1 Introduction

This chapter will discuss the research findings that have emerged from the collection and organisation of data from the implementation of CL in the Junior Certificate Project Maths classroom. Data findings from the mixed methods approach, of qualitative and quantitative sources, as presented in Chapter Four, will be discussed and compared to that of the main aspects of the literature. This chapter will be guided by the three research questions of this dissertation.

5.2 Key findings from the Qualitative Data: Research Question 1

Does teaching through Cooperative Learning improve students' attitudes towards Project Maths?

As discussed in the literature review, there has been a lot of negativity and apprehension associated with the introduction of Project Maths in Ireland. This negativity has been widely circulated by media reports (Humphreys, 2015; Gath, 2012; Bielenberg, 2012). The impact of these published news articles has caused the NCCA to coin the term of “mathophobia” (NCCA, 2005). This term refers to the fear of mathematics that is present within society, which has developed from a personal apprehension towards the study of numbers and has been reinforced by media outlets. This off-putting and harmful attitude towards mathematics has impacted society as a result (NCCA, 2008).

This mathematical fear has frequently formed the basis of conversations between teachers and parents at information meetings, school open nights and parent-teacher meetings. From the author's experiences, these conversations tend to reveal cynical and pessimistic attitudes towards Project Maths from parents. Unfortunately, these negative

attitudes have filtered into mathematics classrooms throughout Ireland. From the author's experience, students have frequently expressed their discontent with Project Maths and its content, level of difficulty and teaching methodologies.

5.2.1 Addressing Research Question One: The issue of “mathophobia”

Students were posed the question “Do your parents/guardians have a fear of mathematics?” The corresponding answers were not in line with the suggested answers of the NCCA's “mathophobia” claims (NCCA, 2005). No students from this class responded that their parents/guardians had a fear of mathematics at either the pre-questionnaire or the post-questionnaire stage of research. However, 16% of students were “unsure” about how to answer this statement. There was no evidence that the parents/guardians of these students were victims of the dreaded “mathophobia”. In fact, figure 4.14 illustrated that students mostly reverted to their parents/guardians when having difficulties with mathematics at home. Similarly, students were asked to rate their own mathematical ability, only one student at both the pre-questionnaire and post-questionnaire stages reported that they were “weak” or “bad” at mathematics. The vast majority of students recorded that they had “excellent”, “great” or “good” mathematical ability. These findings highlighted that the majority of these students did not have a fear of mathematics. The use of CL with this sample of students has resulted in a 7.5% increase in students who responded that they were “excellent” at mathematics. This shift in attitude can be seen as in line with that of the NCCA's (2005) research, which has indicated that utilising an “appropriate course” with an “appropriate pedagogy” is a possible way forward to assist weaker students (p. 19). The fear of mathematics might also be at its lowest when students are placed within the Higher Level strand of Project Maths.

5.2.2 Addressing Research Question One: Students' preferred method of Teaching and Learning

As expected, the findings reported an increase in students working as part of a team throughout this implementation of CL. In particular, there was a dramatic increase of students responding that they were required to work as part of a team in mathematics. When students were asked prior to the implementation, if they enjoyed participating as part of a group, 97% of students responded that they did. However, the post-questionnaire revealed that there was a slight decrease in this response, only 85% of students agreed that they enjoyed working as part of a team. This 12% decrease could be as a result of the difficulties of working together to build positive interdependence as part of a team in CL. Johnson & Johnson (1990) have stated that it takes time for students to fully adapt to teamwork and to acquire the skills to successfully and productively work together.

Figure 4.8 emphasised students' preference to learning mathematics. Initially, 37% of students stated that they enjoyed studying and learning mathematics in isolation prior to the implementation of CL. This figure increased slightly to 41% after the implementation of CL. This relatively small increase is equivalent to one student and as a result, the majority of students in both the pre- (63%) and post- (59%) questionnaires stated that they preferred to learn mathematics as part of a team. This result can be linked to that of Bruner's (1986) statement that "learning is a social process in which children grow into the intellectual life of those around them" (p. 122). This use of CL provided students with the opportunity to be socially engaged with their peers in a mathematical environment in order to advance their learning of mathematics.

5.2.3 Addressing Research Question One: The benefits of Cooperative Learning

The response to statement 24: “It is easier to do maths by working together as a team”, showed a substantial shift in data. Initially, 60% of students had reported that they either “strongly agreed” or “agreed” with this statement. After CL was implemented, this grew to 96% of students who “strongly agreed” or “agreed” with this statement. Kyndt et al., (2013) have discussed the change in attitude that occurs when students learn cooperatively. Their meta-analysis research of sixty-five studies of CL concluded that students learn more when they are challenged to work as part of a group rather than learning alone. Their studies did not solely relate to CL in Mathematics, but they also noted that CL is most effective in non-linguistics subjects such as mathematics and science. These results are also comparable to that of the research of Hossain & Tarmizi (2013), who concluded that CL plays a major role in improving the attitudes of students due to the creating, fostering and maintaining of a positive group dynamic environment which promotes learning. The use of peer interaction during the journey to achieve a shared goal in CL has also enabled students to be engaged academically and socially in their learning (Gilles & Boyle, 2010). These peer to peer interactions improved students’ attitudes towards Project Maths.

5.2.4 Conclusion

This research question intended to see if there was a positive impact when utilising the teaching methodology of CL on the attitudes of students towards Project Maths. In concluding, it is fair to say that the concept of “mathophobia” did not exist within this research class. It can be concluded that this sample of students did not report having a fear of mathematics, nor did their parents. The majority of students preferred learning mathematics when challenged to work together. This intervention of CL enabled

students to work in collaboration with their peers in a team setting which fostered their positive attitudes towards Project Maths.

5.3 Key findings from the Qualitative Data: Research Question 2

What are the implications of using Cooperative Learning as a method of integrating the NCCA's key skills within the Project Maths curriculum?

This second research question intended to investigate if CL could be used as a teaching methodology to integrate the key curricular skills as described by the NCCA. In order to address this research question, the analysis tool of coding was applied. Each key skill was awarded a code and an analysis was conducted from the CL Team Processing Sheets.

5.3.1 Addressing Research Question Two: Coding the Team Processing Sheets

Student teams recorded their team's "Helpful Actions" throughout the completion of their Team Processing Sheets during CL lessons (Appendix K). The CL element of group processing was applied throughout this intervention. Each team described and reflected on their own and their group's accomplishments and efficiency when working together. These "Helpful Actions" responses were transferred into the coding process of analysing elements of students' responses and highlighted the frequency of the key curricular skills. Saldana (2009) stated that a code is "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a proportion of language-based or visual data" (p. 3). In order to best recognise and record the occurrence of the key skills emerging from this collected data, five codes were established as followed:

1. Team Communication
2. Personal Effectiveness
3. Working Cooperatively
4. Creative and Critical Thinking
5. Managing Information

These five codes are reflective of an amalgamation of the NCCA's key skills for Leaving Certificate (NCCA, 2008) and also of the new Junior Cycle key skills (NCCA, 2014). Coding was manually applied to all twenty-seven team processing sheets. To maximise confidentiality, each student team was assigned a unique team name and the presence of the codes was recorded in figures 7.1 – 7.9 (Appendix Q) with their corresponding frequency of occurrence. A collective summary of the frequency of all key skill codes is reported below in figure 5.1.

	Team Communication	Personal Effectiveness	Working Cooperatively	Creative and Critical Thinking	Managing Information
Team Pythagoras	3		2	1	7
Team Euler	9		5		1
Team Gauss	5	1	1		11
Team Newton					
Team Turing	8	1	4		3
Team Leibniz	2	2			8
Team Riemann	4	6		4	2
Team Fibonacci	4	1	4	4	5
Team Einstein	5		5	3	2
Total	40	11	21	12	39

Figure 5.1: Collective Frequency of key skills in Team Processing Sheets

5.3.2 Addressing Research Question Two: Discussion on Cooperative Learning integrating the NCCA's key skills

Although there are no direct empirical studies relating to the NCCA's key skills and the Project Maths curriculum, it is apparent that the occurrence of these coded themes is reflective of the ethos of curricula key skills. Students reported one hundred and twenty-three occasions where the key skills were incorporated and implemented during CL. This parallel connection between Project Maths, CL and the key skills is a testament to the shift towards educating students for the 21st century society and also of Project Maths' aim to bring teaching and learning into the 21st Century. This aim reflects the objectives of several institutions to merge the social and academic needs of students. The European Council (2006); Partnership for 21st Century Learning (2015) and the research conducted by the EGFSN have all identified and supported this need for social learning in conjunction with academic learning.

5.3.2.1 Assessing the occurrence of the key skills in the Cooperative Learning Classroom

Team Communication

The most frequent key skill identified by the CL teams was the code of "Team Communication". This key skill's frequency represented a third of all the recorded codes, which highlighted the development of communication skills within this research study. Student teams reported using communication skills four times, on average, per Team Processing Sheet. This high level of communication was vital for students to formulate questions and to explain their ideas and their solutions to tasks. This reported importance of communication is also in line with that outlined in the literature review. Terwel (2011) stated the imperative role that communication plays in developing relationships within student teams in CL. Furthermore, Akdemir & Aklan (2012) have commented on the positive role that communication plays in the CL paradigm; detailing

explicitly the role of communication in providing feedback, encouragement and peer support in order to improve academic learning. Furthermore, Blatchford et al., (2003) have reinforced the requirement for communication in interactional group skills in CL.

Managing Information

Managing information was the second most frequent group skill recorded. This was no surprise, due to the nature of the subject. Students participated constantly in tasks that required them to manage information throughout group tasks. Team Gauss reported the highest frequency of managing information, with a total of 62% of their group processing representing this key skill. On the other hand, some students overlooked the recording of this key skill due to the nature of constantly managing information in Project Maths. This code of “Managing Information” is in line with that of the NCCA’s (2008) key skill of Information Processing. While the NCCA do not explicitly link this key skill to mathematics, they have highlighted the connection between this key skill and the 21st century skill of numeracy, which forms the basis of mathematics. Students applied this key skill throughout their learning tasks which included selecting an appropriate manner to illustrate their results, using different graphical methods for solutions and also by explaining and providing justifications for their team’s method and answers.

Working Together

Student teams were constantly required to work in cooperation throughout this intervention. All activities were carefully selected to ensure that cooperation was needed to achieve the shared goal. Student teams still specifically noted the occurrence of working together on their Team Processing Sheets. This code occurred twenty-one times throughout the intervention and represented 17% of all the recorded key skills. This key skill in this subject would have been new to students due to the fact that they have been taught by traditional methods prior to this intervention. Although students have

recorded the “Helpful Actions” of their team members throughout the Team Processing Sheets, not all personally completed processing sheets were positive. Some students recalled difficulties in working with some members of their team throughout this implementation. These difficulties referred to the difference of opinions and a change of the dominant student’s status within the class. Johnson & Johnson (1996) have discussed the impact that “conflict” can have when there is the rise of two different sides to a situation. Throughout this implementation, students worked together in three-member teams resulting in the opportunity for conflict to occur. Deutsch (1973) has specifically commented on the process of “conflict of interests” occurring within the CL classroom. This difference of opinions occurred throughout this intervention and it was observed on two separate occasions. From this, it is evident that there was a need for peer mediation within the CL classroom. Johnson & Johnson (1999) have discussed the importance of building and promoting positive interdependence amongst students in order for successful and productive teamwork. However, there was insufficient time to explicitly provide students with the mediating skills that are required in peer mediation to tackle and reduce controversy (Opatow, 1993). This need for the resolution of a conflict is also named as one of the elements with the key skills of the new Junior Cycle Framework. This document states that students should be able to manage and prevent conflict situations in their learning to maximise the benefits of group learning (NCCA, 2014). In addition, some students have also recorded that working cooperatively has slowed down their pace in learning mathematics, even though all curriculum aspects were covered throughout the implementation of CL. These students would traditionally be perceived as high achieving students and it is evident that developing a suitable pace for all learners is imperative when structuring CL lessons.

Creative and Critical Thinking

This research question is particularly challenging to answer due to the complexities that students have in being creative within mathematics. Traditionally, students tend to view mathematics as a non-creative subject. However, this new curriculum has aimed to address these preconceptions. The findings show that this was the fourth ranked key skill to emerge from the Team Processing Sheets. Five teams did not reveal any codes in relation to this key skill and overall Creative and Critical Thinking represented less than 10% of the recorded key skills. Although the nature of Project Maths is to equip students with the required skills to participate in problem-solving situations, these findings do not fully correlate to those outlined in the literature. The Partnership for 21st Century Learning has specifically linked problem-solving as one of the four C (Critical Thinking, Communication, Collaboration and Creativity) in conjunction with the key subject of mathematics (P21, 2015). The Partnership has also stated that students need to have the experience, ability and knowledge to work creatively with others. This entails students perceiving failure as a positive aspect of their learning journey and using this as an opportunity to learn and develop. Furthermore, the Partnership has also linked the skill of critical thinking with problem-solving (P21, 2015). Although students were engaged in tasks that demanded different levels of problem-solving, students teams did not fully reflect on this key skill throughout their team processing. This lack of reflection could be due to an oversight on the participants' behalf as a result of the strong linkage between Project Maths and problem-solving.

Personal Effectiveness

Lastly, the code for Personal Effectiveness occurred least throughout this implementation process. Students reported Personal Effectiveness a limited eleven occasions throughout this research period and four teams did not report any occurrence of this key skill. This relatively small occurrence for this code was expected due to the

strong occurrence of group learning and cooperation in the classroom as a result of CL. These low findings are not in conjunction with those outlined in the literature review. Johnson & Johnson (1990) discussed the role of the teacher in establishing a sense of “dual responsibility” within their CL classroom environment. This dual responsibility highlights that students must understand their own individual role and their secondary role as a member of a team within CL. It was imperative that students understood that their actions and lack of actions could have a subsequent effect not only on their learning but also on the learning of their team members. This required students to learn how to be personally effective while also learning how to work as part of a team. Throughout this implementation, it was vital that the concept of “free-riding” was avoided in order to establish this sense of dual-responsibility (Slavin, Hurley & Chamberlain, 2003). However, it was evident that there were some difficulties for students to change their own dominant approaches to learning and to embrace something new. As the classroom ethos was shifting from that of a typical individualistic, sometimes competitive environment to that of a classroom which focused on cooperation, it was observed that some students had some difficulties in understanding their specific function within the team framework. While students were issued with specific roles to complete as part of their group’s tasks, notably there was a certain degree of confidence needed to assert and complete these personal tasks.

The NCCA’s (2008) Senior Cycle key skill of “Being Personally Effective” and also the NCCA’s (2014) Junior Cycle key skill of “Managing Myself” have called for students to respond to external feedback and also to generate internal feedback from their performance. These findings have highlighted the difficulty of conducting personal effectiveness while also learning how to work in collaboration within the CL class.

5.3.3 Limitations to assessing the key skills within the Cooperative Learning classroom.

There were two main limitations noted in addressing this research question. Firstly, the level of difficulty in establishing a baseline level of student's engagement and participation with the key skills. Although students were taught by traditional learning methods prior to the implementation of CL, there was no explicit practice of reflection on these key skills within Project Maths prior to this intervention. Also, it can be argued that students are challenged daily to participate in practising being personally effective and managing information in maths class, there was no specific labelling of reflecting on these skills prior to CL.

Additionally, the level of ability of students to reflect on their participation within the group dynamic must also be questioned. As these research participants are in second year of post-primary education, students were between 13-15 years of age, hence it is debatable whether they have acquired the appropriate level of articulation required to fully and effectively record their actions throughout CL. Although students have recorded their experiences to the best of their ability, there is the possibility that these findings are not 100% accurate due to the level of cognitive development of the students at this time.

5.3.4 Conclusion

The findings have demonstrated a strong connection between the five basic elements of CL and the NCCA's key skills. The occurrence and frequency of the codes for the key skills were repeated numerous times throughout this research period. This discussion had highlighted the strong connection that exists between this teaching methodology and the key curricular skills. Students also reported many positive aspects of their experiences of using these key skills within Project Maths.

5.4 Key findings from the Quantitative Data: Research Question 3

Does teaching through Cooperative Learning improve 2nd-year students' assessment results in the Junior Certificate Project Maths classroom?

In order to address this research question, students in both the CL and traditional learning classes completed a common assessment paper after the ten week implementation period. This common examination was structured into three curriculum questions and one revision question. This section of this chapter will elaborate on the impact that CL had in the areas of Algebra, Probability and Sets within the Junior Certificate Project Maths classroom.

5.4.1 The impact of Cooperative Learning on Junior Certificate Project Maths Algebra

When examining the class average of students in Algebra, the findings revealed the following:

- Cooperative Learning (Experimental) generated a mean result of 12.04 marks
- Control Class One (Traditional) generated a mean result of 14.25 marks
- Control Class Two (Traditional) generated a mean result of 13.92 marks

These findings have revealed that by teaching students in Junior Certificate Algebra via CL, they scored less on average than their peers who were taught by traditional methods. The literature, as discussed in Chapter Two, has revealed that the teaching of algebra in Ireland traditionally tends to be taught based on rote learning and reinforcement, rather than taught by embracing a problem-solving approach on this topic. This difference in achievement could be due to the style of posing the question. These assessment questions were all sourced from past state examinations papers from the Project Maths Junior Certificate curriculum. These questions were very routine in nature and did not

require students to utilise their problem-solving skills that were developed throughout the CL implementation. Hence, this routine nature of the algebra question was more suited to the experienced rote learned student rather than to the CL problem-solver. Although this intervention of CL focused heavily on introducing students to problem-solving skills throughout structured teamwork, which is in conjunction with the ethos of Project Maths (Lubienski, 2011), the assessment content was not in parallel to the teaching style for Algebra in this situation.

Furthermore, while both the Chief Examiner's Report on Mathematics and the Review of Mathematics in Ireland (NCCA, 2006) have expressed concerns with rote learning in Mathematics, it is evident from these findings that rote learning in Algebra reported a higher, non-significant ($p=0.3475$), mean achievement mark over that of teaching Algebra through CL.

5.4.2 The impact of Cooperative Learning on Junior Certificate Project Maths Probability

When examining the class average of students in Probability, the findings revealed the following:

- Cooperative Learning (Experimental) generated a mean result of 21.46 marks
- Control Class One (Traditional) generated a mean result of 21.84 marks
- Control Class Two (Traditional) generated a mean result of 24.46 marks

Similarly, the findings have also revealed that students who participated in this intervention scored less than their peer classes in the curriculum topic of Probability. Although there was a minute difference of 0.27 marks between the CL group and Control Class One, there was a larger difference of 3 marks on average between the CL Group and Control Class Two. These findings also resulted in a large standard deviation

between the three class groupings. The Experimental CL has a standard deviation of 7.87, whereas both Control groupings had smaller standard deviations of 5.8 and 6.59 respectively. These findings highlight the great degree of variance that has occurred from the implementation of CL.

Although these findings revealed a lower level of achievement in the curriculum topic of Probability when using CL, the teaching and learning plan on Probability developed by the Project Maths Development Team (2009) has called for the use of group-work in the teaching of Probability. This document has stated that “When working together cooperatively in small groups...students will be using the language of the topic thus improving their ability to communicate effectively using the correct terminology” (PMDT, 2009, p.1). Interestingly, this key skill of communication has been developed throughout this intervention (section 5.3.2.1). This finding was in line with the aim of the teaching and learning plan to develop the communication of students, and specifically the communication of probability terms and keywords, throughout this intervention. Although these teaching and learning plans on Probability called for the constant use of teamwork in which each student was to have a specific role in achieving the group task, there were no instructions for teachers on how to achieve this aim. CL has revealed a lower, non-significant ($p = 0.4443$) average mark than traditional learning in the topic of Probability. However, there is the potential for this methodology to increase the communication skills of students in this area of mathematics.

5.4.3 The impact of Cooperative Learning on Junior Certificate Project Maths Sets

When examining the class average of students in Sets, the findings revealed the following:

- Cooperative Learning (Experimental) generated a mean result of 12.34 marks

- Control Class One (Traditional) generated a mean result of 6.34 marks
- Control Class Two (Traditional) generated a mean result of 12.63 marks

These findings have revealed that CL resulted was indifference in addressing the academic impact that CL had on the curriculum topic of Sets. The CL Class scored significantly higher (difference of 6 marks) than Control Class One. This class did not score quite as high as Control Class Two (difference of 0.29 marks). The variance in data was highest for the CL class (standard deviation of 6.6) in comparison to that of Control Class One (standard deviation of 4.2) and Control Class Two (standard deviation of 6.2). In comparing which method produces a significantly higher academic advancement, it seems that by comparing the findings of the CL Class and Control Class Two that there was no significant ($p= 0.9429$) difference between these two teaching methodologies. The results generated from Control Class One are unusual in comparison to the three classes. This difference could, however, be partially related to the absence of the class teacher which thus led to a reduction in teaching time.

5.5 Conclusion

This discussion was structured to answer the three research questions. In addressing research question one, it was concluded that the majority of students indicated that CL had a positive impact on their opinion of Project Maths. This discussion highlighted that the issue of “mathophobia” was non-existence amongst these students and their parents. Overall students stated that they preferred to learn mathematics through the team-oriented approach to CL rather than through traditional learning methodologies.

The second research question addressed the potential use of CL as a teaching and learning methodology of integrating the key curricular skills within Project Maths. The most frequent key skill that emerged from the findings was communication. This high

occurrence of communication is a testament to the building of positive interdependence in CL. However, the low occurrence of the key skill of Personal Effectiveness was slightly worrying in the process of developing dual responsibility. Overall, it was evident that students experienced and practised all of the required key skills through their engagement with CL in Project Maths.

Lastly, research question three discussed the impact that CL had on academic achievement. The discussion described the impact that CL has on three major aspects of the Project Maths curriculum. In algebra, students in both Control Classes scored higher in a non problem-solving routine question than the CL class. It was debated whether these Control students would have achieved as well on an algebraic question that required problem-solving skills to complete. Similarly, students in the Control Classes One and Two achieved a higher mean score than the CL Class in Probability. However, it can be argued that CL students advanced in their communication skills by working together to complete shared tasks. Lastly, there was no significant difference in teaching the topic of Sets via CL methods in comparison to Control Class Two. Due to teacher absence, Control Class One was viewed as an outlier in this comparison. Overall, it was revealed that there is no significant difference in achievement by teaching through CL or through Traditional teachings methods. However, teaching through CL resulted in students having an improved attitude to mathematics, along with engagement with the key skills required for life in the 21st century. This difference in teaching and learning methodologies for different mathematical topics is in line with that discussed in the Literature Review. The European Commission's Eurydice Report (2011) stated that there is "no one correct way of teaching mathematics, with some researchers arguing that different methods work in different contexts and others that teachers ought to select the most appropriate method for their context"(p. 52). This report concluded that professional development for teachers in a variety of different teaching and learning

methodologies should be provided and thus, the teacher can select the most appropriate methodology. This discussion revealed the same opinion as that of the Eurydice Report, it highlighted that different methodologies have difference outcomes for the student learners and that CL must be considered as one such method.

Chapter Six: Conclusion

6.1 Introduction

The main aim of this chapter is to conclude on the main findings of this dissertation. A summary of this research study will be outlined at the start of this chapter and will outline the main findings from each of the investigated questions of this study. Next, the contribution that this research has made to mathematics education and, in particular, Project Maths will be highlighted. Finally, a list of recommendations, future research opportunities, and limitations are provided. This chapter concludes with the author's final comments on this dissertation.

6.2 Summary

Since 2010, Irish post-primary mathematics teachers have been engaging with the newly formed mathematics curriculum of Project Maths. This ambitious curriculum reform called for an update of the curriculum content, assessment procedures and finally teaching and learning methodologies. Although extensive supports have been provided to all mathematics teachers, the published Project Maths teaching and learning plans have provided limited guidance for teachers into the methods to deliver this new curriculum. In addition to selecting suitable and efficient approaches to teaching Project Maths, teachers must also strive to engage with the key curricular skills as outlined by numerous national and international standards. Teachers are partially responsible for ensuring that students are prepared for living and working successfully in the 21st Century.

Having identified the need to select a suitable teaching methodology to meet this new curriculum and to best prepare students for their future careers, a suitable teaching and

learning methodology was sought. The author desired a methodology which promoted a positive attitude towards this new curriculum, while also incorporating the key curricular skills. CL was selected as such a methodology. A case study approach to this research was developed and implemented with twenty-seven second year Project Maths students over a ten-week academic period. This case study aimed to investigate three main research questions including the impact that CL had on the students' attitudes towards Project Maths, its ability to encompass the key curricular skills and finally, the effect that this methodology had on the students' academic results.

This case study methodology generated data from a variety of sources, of both qualitative and quantitative nature, and data was triangulated to increase reliability and validity. These findings were recorded, sorted and illustrated in Chapter Four. A discussion was formulated in order to assist the researcher to answer the three unique research questions of this dissertation. The main findings of this study can be summarised as follows:

- CL had a positive impact on students' attitudes towards Project Maths. Students reported that they enjoyed and preferred to learn mathematics cooperatively in comparison to working in isolation. The issue of "mathophobia" was also discovered to be non-existent amongst this sample of students (NCCA, 2005).
- CL was a successful teaching and learning methodology to encompass the key curricular skills as outlined by both the key skills Framework for Leaving Certificate (NCCA, 2008) and also the new key skills for the Junior Cycle Framework (NCCA, 2011). This methodology was particularly beneficial in incorporating the key skills of communication, managing information and working together. However, this methodology lacked a strong level of Personal Effectiveness.

- CL resulted in a decrease in attainment in the second year curriculum components of Algebra, Probability, and Sets when tested against their traditionally taught peers. However, this difference was deemed to be statistically non-significant overall.

6.3 Dissertation Contributions

This dissertation has contributed to the research into mathematics education on a local, national and international level. The author cited the following as the main contributions that have emerged from this research study:

- On a local level, the author used CL as a teaching and learning methodology to meet the widely used “group-work” reference as described throughout the PMDT teaching and learning plans. Although the PMDT has issued comprehensive teaching instructional plans that strive for a high level of cooperation amongst students, there were no formal instruction on how to achieve this goal. The author believes that this research into CL, which followed the recommended plans and teacher handbooks of Project Maths, can assist Project Maths teachers in implementing structured group-work into their mathematics lessons.
- Nationally, the author believes that this research will be directly relevant to future curriculum developments in Ireland. As the National Council for Curriculum and Assessment (NCCA) has outlined their transition to the use of CL within the new framework for the Junior Cycle curriculum (NCCA, 2014), this research may provide policy makers with an insight into the impact that CL has in the Junior Cycle classroom.
- Internationally, as education reform evolves to meet the demands of the 21st Century and policy makers move towards executing key curricular skills, the

author believes that this research may strengthen the argument for utilising CL as a teaching and learning methodology which embraces these skills.

6.4 Author's Recommendations

After the introduction of CL in the Junior Certificate Project Maths classroom, the author has generated the following recommendations:

- CL requires a large investment of time to implement within the classroom. However, the author recommends that once established, this methodology can enable successful and structured group-work to occur.
- While the author recommends the use of the Project Maths Development Team's published resources, teachers must modify these resources to ensure that they are fully compatible with the CL model.
- In conjunction with the viewpoints of the Eurydice Report (2011), the author recommends that CL is appraised with other aspects of the Junior Certificate Project Maths curriculum to assess the most appropriate teaching methodology for different parts of the Project Maths curriculum.

6.5 Further Research

On completion of this case study, the author believes that there are further opportunities for research to occur, including:

- Research into the implementation of CL throughout both the Junior Certificate and Leaving Certificate Project Maths curricula. This should include the impact that CL has on different aspects of the five core curriculum strands of Project Maths.

- Research into the long-term impact that CL has on the students' connection with the key curricular skills. This study should be conducted over a long time period to best assess the trustworthiness of CL as a teaching and learning methodology which promotes these key curricular skills (NCCA, 2008).

6.6 Limitations of this research

The limitations of this research have been stated throughout the dissertation, the author wishes to further acknowledge the following key limitations of this dissertation:

- The first limitation to this research was the relatively small sample size and geographical spread of participants. The research class was deemed to be twenty-seven students and all students were chosen from the same post-primary school. If given the opportunity the author would like to expand on this sample size and to include students from different school types and other locations throughout Ireland. This would enable a more comprehensive investigation into the impact that CL has on Project Maths.
- The second limitation to this research was the confined time framework of the research process. Although this research was carried out over a ten week period, the author believes this to be a relatively small timeframe to fully appraise the impact of CL (Terwel, 2011; Akdemir & Arslan, 2012; Pewewardy, 2002; Hossain & Tarmizi, 2013). On consideration, the author would suggest an extended time to elaborate on this research.

6.7 Conclusion

“Coming together is a beginning. Keeping together is progress. Working together is success”

-Henry Ford

The quotation above sums up the implementation of CL within the Irish classroom. The author has provided the reader with an insight into the impact that CL has had on delivering certain aspects of the Project Maths curriculum. This study was generated as a result of the need for revival of the pedagogical approach of mathematics in Irish classrooms. The author believes that the success of this research is two-fold. Firstly, it provides an insight into the implementation of CL within the Irish post-primary classroom. Secondly, as the newly proposed Junior Cycle curriculum moves towards the CL method, it will enable teachers to form an understanding of the impact that CL can have on the students’ attitudes, their ability to engage with the key skills and on their academic results.

References

- Akdemir, E., & Arslan, A. (2012). From past to present: Trend analysis of cooperative learning studies. *Procedia-Social and Behavioural Sciences*, 55, 212-217.
- Aliaga, M., & Gunderson, B. (2000). Introduction to quantitative research.
- Atweh, B., Forgasz, H., & Nebres, B. (2001). Sociocultural research on mathematics education: An international perspective. Psychology Press.
- Ballantine, J., & McCourt Larres, P. (2007). Cooperative learning: A pedagogy to improve students' generic skills? *Education + Training*, 49(2), 126-137.
doi:10.1108/00400910710739487
- Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, 13(4), 544-559.
- Bertucci, A., Johnson, D. W., Johnson, R. T., & Conte, S. (2012). Influence of group processing on achievement and perception of social and academic support in elementary inexperienced cooperative learning groups. *The Journal of Educational Research*, 105(5), 329-335.
- Bielenberg, K. (2012). The project maths course divides teachers -- but does it add up? *The Irish Independent*. Retrieved from
<http://www.independent.ie/life/family/learning/the-project-maths-course-divides-teachers-but-does-it-add-up-26819989.html>
- Blatchford, P., Kutnick, P., Baines, E., & Galton, M. (2003). Toward a social pedagogy of classroom group work. *International Journal of Educational Research*, 39(1), 153-172.

- Bruner, J. S. (2009). *Actual minds, possible worlds*. Harvard University Press.
- Clements, D. H., & Battista, M. T. (1990). Constructivist learning and teaching. *Arithmetic Teacher*, 38(1), 34-35.
- Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of educational research*, 64(1), 1-35. Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge.
- Conway, P. F., & Sloane, F. C. (2005). *International trends in post-primary mathematics education: Perspectives on learning, teaching and assessment*.
- Cosgrove, J., Perkins, R., Shiel, G., Fish, R., & McGuinness, L. *Insights from Teachers who Participated in PISA 2012*.
- Creswell, J. W. (2009). *Research design: Qualitative and mixed methods approaches*. London and Thousand Oaks: Sage Publications.
- Cuban, L. (1993). The lure of curricular reform and its pitiful history. *The Phi Delta Kappan*, 75(2), 182-185.
- Denzin, N. K., & Lincoln, Y. S. (1994). *Handbook of qualitative research*. Sage Publications, Inc.
- Department of Children & Youth Affairs (2012). *Guidance for developing ethical research projects involving children*. Retrieved from http://www.dcy.gov.ie/documents/Publications/Ethics_Guidance.pdf
- Department of Education & Science (DES),. (2002). *Junior Certificate Guidelines for Teachers (Mathematics)*. Dublin: Stationery Office.

Department of Education & Skills (DES),. (2009). Aistear: The Early Childhood Curriculum Framework. Dublin: Stationery Office.

Department of Education & Skills (DES),. (2013). Leaving Certificate Project Maths Syllabus. Dublin: Stationery Office.

Department of Education & Skills (DES),. (2015). Framework for Junior Cycle 2015. Dublin: Stationery Office.

Department of Education & Skills,. (1999). Primary School Curriculum: Teacher Guidelines (pp. 1-87). Dublin: Stationery Office.

Department of Education & Skills,. (2010). Report of the Project Maths Implementation Support Group (pp. 1-57). Dublin: Stationery Office.

Deutsch, M. (1973). The resolution of conflict. New Haven, CT: Yale.

Doolittle, P. E. (1995). Understanding Cooperative Learning through Vygotsky's Zone of Proximal Development.

Drake, P., Noyes, A., & Wake, G. (2012). School Mathematics Qualifications and Work. Australian Association for Research in Education (NJ1).

European Commission,. (2011). Mathematics Education in Europe: Common Challenges and National Policies (pp. 1-184). Brussels: Education, Audiovisual and Culture Executive Agency.

European Communities,. (2007). Key Competences for Lifelong Learning: European Reference Framework (pp. 1-16). Luxembourg: Office for Official Publications of the European Communities.

- European Council. (2006). Recommendation of the European Parliament and the Council of 18 December 2006 on key competencies for lifelong learning. Brussels: Official Journal of the European Union, 30(12), 2006.
- Felder, R. M., & Brent, R. (2007). Cooperative learning. In *Active learning: Models from the analytical sciences*, ACS Symposium Series (Vol. 970, pp. 34-53)
- Finnish National Board of Education,. (2003). National Core Curriculum for Upper Secondary Schools 2003. Helsinki: Finnish National Board of Education.
- Gago, J. M., Ziman, J., Caro, P., Constantinou, C., Davies, G., Parchmann, I., Rannikmae, M & Sjoberg, S. (2004). Increasing human resources for science and technology in Europe. Brussels: European Commission.
- Gath, E. (2012). Project Maths is not the answer to tough question. *The Irish Examiner*. Retrieved from <http://www.irishexaminer.com/viewpoints/analysis/project-maths-is-not-the-answer-to-tough-question-187777.html#!>
- Gillham, B. (2000). *Case study research methods*. Bloomsbury Publishing.
- Gillies, R. M., & Boyle, M. (2010). Teachers' reflections on cooperative learning: Issues of implementation. *Teaching and teacher Education*, 26(4), 933-940.
- Goodwin, M. W. (1999). Cooperative learning and social skills: What skills to teach and how to teach them. *Intervention in School and Clinic*, 35(1), 29-33.
doi:10.1177/105345129903500105
- Grannell, J. J., Barry, P. D., Cronin, M., Holland, F., & Hurley, D. (2011). Interim report on project maths. Cork: School of Mathematical Sciences, University College Cork.

Graves, T. (1991). The controversy over group rewards in cooperative classrooms. Alexandria: Association Supervision Curriculum Development.

Grek, S. (2009). Governing by numbers: The PISA 'effect' in Europe. *Journal of education policy*, 24(1), 23-37.

Handal, B., & Herrington, A. (2003). Mathematics teachers' beliefs and curriculum reform. *Mathematics education research journal*, 15(1), 59-69.

Hertz-Lazarowitz, R. (1992). Understanding interactive behaviors: Looking at six mirrors of the classroom. *Interaction in cooperative groups: The theoretical anatomy of group learning*, 71-101.

Hossain, A., & Tarmizi, R. A. (2013). Effects of cooperative learning on students' achievement and attitudes in secondary mathematics. *Procedia-Social and Behavioral Sciences*, 93, 473-477.

Humphreys, J. (2015). Project Maths linked to decline in third level performance. *The Irish Times*. Retrieved from <http://www.irishtimes.com/news/education/project-maths-linked-to-decline-in-third-level-performance-1.2242148>

Hurrell, S. (2004). Data collection challenges.

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

Johnson, D. W. (1991). Cooperative Learning: Increasing College Faculty Instructional Productivity. ASHE-ERIC Higher Education Report No. 4, 1991. ASHE-ERIC Higher Education Reports, George Washington University, One Dupont Circle, Suite 630, Washington, DC 20036-1183.

- Johnson, D. W., & Johnson, F. P. (1991). *Joining together: Group theory and group skills*. Prentice-Hall, Inc.
- Johnson, D. W., & Johnson, R. T. (1979). Conflict in the classroom: Controversy and learning. *Review of Educational Research*, 49(1), 51-69.
- Johnson, D. W., & Johnson, R. T. (1990). Social skills for successful group work. *Educational leadership*, 47(4), 29-33.
- Johnson, D. W., & Johnson, R. T. (1990). Using cooperative learning in math. *Cooperative learning in mathematics: A handbook for teachers*, 103-125.
- Johnson, D. W., & Johnson, R. T. (1996). Conflict resolution and peer mediation programs in elementary and secondary schools: A review of the research. *Review of Educational research*, 66(4), 459-506.
- Johnson, D. W., & Johnson, R. T. (1999). Making cooperative learning work. *Theory into Practice*, 38(2), 67-73. doi:10.1080/00405849909543834
- Johnson, D. W., & Johnson, R. T. (2008). Social interdependence theory and cooperative learning: The teacher's role. In *The teacher's role in implementing cooperative learning in the classroom* (pp. 9-37). Springer US.
- Johnson, D. W., & Johnson, R. T. (2008). *Cooperative learning*. Blackwell Publishing Ltd.
- Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1988). *Cooperation in the classroom*. Interaction Book Co.
- Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Cooperative learning returns to college what evidence is there that it works?. *Change: the magazine of higher learning*, 30(4), 26-35.

- Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Cooperative learning returns to college what evidence is there that it works?. *Change: the magazine of higher learning*, 30(4), 26-35.
- Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Maximizing instruction through cooperative learning. *ASEE Prism*, 7(6), 24.
- Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Active learning: Cooperation in the college classroom Interaction Book Company.
- Johnson, D. W., Johnson, R. T., Holubec, E. J., & Association for Supervision and Curriculum Development, Alexandria, VA. (1994). The new circles of learning: Cooperation in the classroom and school. Alexandria, Va: Association for Supervision and Curriculum Development.
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), 14-26.
- Joyce, W. B. (1999). On the free-rider problem in cooperative learning. *Journal of Education for Business*, 74(5), 271-274.
- Kirkland, S. (2012). Major flaws in the curriculum design of project maths and the dire consequences for Irish mathematics education and the knowledge economy. Retrieved from <http://media.tcm.ie/media/documents/m/MathsCurriculumReport.pdf>
- Kirwan, L. (2015). Mathematics Curriculum in Ireland: The Influence of PISA on the Development of Project Maths. *International Electronic Journal of Elementary Education*, 8(2), 317.
- Kohn, A. (1994). The Risks of Rewards. *ERIC Digest*.

- Kuhn, T. S. 1961. The Function of Measurement in Modern Physical Science. *Isis*, 52(2): 161-193
- Kyndt, E., Raes, E., Lismont, B., Timmers, F., Cascallar, E., & Dochy, F. (2013). A meta-analysis of the effects of face-to-face cooperative learning. Do recent studies falsify or verify earlier findings?. *Educational Research Review*, 10, 133-149.
- Laal, M. (2013). Positive interdependence in collaborative learning. *Procedia-Social and Behavioral Sciences*, 93, 1433-1437.
- Laal, M., Geranpaye, L., & Daemi, M. (2013). Individual accountability in collaborative learning. *Procedia-Social and Behavioral Sciences*, 93, 286-289.
- Lubienski, S. (2011). Mathematics education and reform in Ireland: An outsider's analysis of Project Maths. *Bulletin of the Irish Mathematical Society*, 67, 27-55.
- Lyons, M., Lynch, K., Close, S., Sheerin, E., & Boland, P. (2003). Inside classrooms: The teaching and learning of mathematics in social context. Dublin: Institute of Public Administration.
- Mello, J. A. (1993). Improving Individual Member Accountability in Small Work Group Settings. *Journal of management Education*, 17(2), 253-59.
- Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.
- Ministry of Education Singapore. (2008). Opening address by Dr Ng Eng Hen, Minister for Education and Second Minister for Defence, International Conference on Teaching and Learning with Technology (iCTLT). Retrieved June 27, 2016,

from <http://www.moe.gov.sg/media/speeches/2008/08/05/opening-address-by-dr-ng-eng-h-1.php>.

Muijs, D. (2010). Doing quantitative research in education with SPSS. Sage.

National Council for Curriculum & Assessment. (2005). Review of Mathematics in Post-Primary Education: a discussion paper. Dublin: Stationery Office.

National Council for Curriculum & Assessment. (2006). Review of Mathematics in Post-Primary Education. Dublin: Stationery Office.

National Council for Curriculum & Assessment. (2008). Key Skills at Senior Cycle (Draft Interim Report) (pp. 1-80). Dublin: Stationery Office.

National Council for Curriculum & Assessment. (2013). Junior Certificate Mathematics Syllabus: Foundation, Ordinary & Higher Level. Retrieved from http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Project_Maths/Syllabuses_and_Assessment/JC_Maths_English_2013.pdf

National Council for Curriculum and Assessment. (2010). Innovation and Identity: Ideas for a new Junior Cycle (pp. 1-75). Dublin: Stationery Office.

National Council for Curriculum and Assessment. (2008). Senior Cycle Key Skills Framework. Dublin: NCCA.

National Council for Curriculum and Assessment. (2011). Towards a Framework for Junior Cycle (pp. 1-44). Dublin: Stationary Office.

National Council for Curriculum and Assessment. (2014). Key Skills of Junior Cycle. Dublin: NCCA.

- National Council of Teachers of Mathematics (Ed.). (2000). Principles and standards for school mathematics (Vol. 1). National Council of Teachers of.
- National Economic & Social Council (NESC),. (2008). The Irish Economy in the Early 21st Century. Dublin: Stationery Office.
- Nolen, A. L., & Vander Putten, J. (2007). Action research in education: Addressing gaps in ethical principles and practices. *Educational Researcher*, 36(7), 401-407.
- Oakley, B., Felder, R. M., Brent, R., & Elhajj, I. (2004). Turning student groups into effective teams. *Journal of student centered learning*, 2(1), 9-34.
- Opatow, S. (1993). Animals and the scope of justice. *Journal of Social Issues*, 49(1), 71-85.
- Organisation for Economic Co-operation & Development (OECD),. (2013). PISA 2015: Draft Collaborative Problem Solving Framework. Paris: OECD.
- Organisation for Economic Co-operation and Development,. (2004). Learning for Tomorrow's World - First Results from PISA 2003 (pp. 109-158). Paris.
- Partnership for 21st Century Learning,. (2015). Framework for 21st Century Learning. Washington DC: Unknown.
- Patton, M. Q. (1990). Qualitative evaluation and research methods . SAGE Publications, inc.
- Pewewardy, C. (2002). Learning styles of American Indian/Alaska Native students: A review of the literature and implications for practice. *Journal of American Indian Education*, 41(3), 22-56.

Project Maths Development Team,. (2009). Teaching & Learning Plans. Plan 1:

Introduction to Probability (pp. 1-19). Dublin: Stationery Office.

Rizvi, F., & Lingard, B. (2009). Globalizing education policy. Routledge.

Rose, S., Spinks, N., & Canhoto, A. I. (2014). Management research: applying the principles. Routledge.

Rubin, R., Morgan, B., & Galván, C. V. (2009). Cooperative Learning, Mathematical Problem Solving, And Latinos, The University Of Texas At Brownsville And Texas Southmost College. Colección Digital Eudoxus, 1(3).

Saldana, J. (2009). An introduction to codes and coding. The coding manual for qualitative researchers, 1-31.

Sharan, S. (1990). Cooperative learning: A perspective on research and practice. Cooperative learning: Theory and research, 285-300.

Shiel, G., Perkins, R., Close, S., & Oldham, E. (2007). PISA Mathematics: A Teacher's Guide. Dublin, Ireland: Department of Education and Science.

Shúilleabháin, A. N. (2015). Lesson Study as a form of in-School Professional Development.

Siegel, C. (2005). Implementing a Research-Based Model of Cooperative Learning. The Journal of Educational Research, 98(6), 339-349. Retrieved from <http://www.jstor.org/stable/27548099>

Slavin, R. E., Hurley, E. A., & Chamberlain, A. (2003). Cooperative learning and achievement: Theory and research. Handbook of psychology.

- Smyth, E., McCoy, S., & Darmody, M. (2004). *Moving up: The experiences of first-year students in post-primary education*. Dublin: Liffey Press.
- Struik, D. J. (1948). *A history of mathematics*. London: Dover Publications.
- Tarmizi, R. A., & Bayat, S. (2012). Collaborative problem-based learning in mathematics: A cognitive load perspective. *Procedia-Social and Behavioral Sciences*, 32, 344-350.
- Terwel, J. (2011). Cooperative learning and Mathematics Education: A happy marriage?.
- Udofa, A. I., & Udo, I. E. (2013). Globalisation and its influence on mathematics education in secondary schools in Akwa Ibom state, Nigeria. *Journal of Educational and Social Research*, 3(6), 33.
- Van Maanen, J. (1979). Reclaiming qualitative methods for organizational research: A preface. *Administrative science quarterly*, 520-526.
- Wood, T., Cobb, P., & Yackel, E. (1995). Reflections on learning and teaching mathematics in elementary school. *Constructivism in education*, 401-422.
- Yager, S., Johnson, R. T., Johnson, D. W., & Snider, B. (1986). The impact of group processing on achievement in cooperative learning groups. *The Journal of Social Psychology*, 126(3), 389-397.
- Yin, R. K. (2011). *Applications of case study research*. Sage.
- Yin, R. K. (2013). *Case study research: Design and methods*. Sage publications.
- Zaslavsky, O., & Leikin, R. (2004). Professional development of mathematics teacher educators: Growth through practice. *Journal of mathematics teacher education*, 7(1), 5-32.

Zeni, J. (1998). A guide to ethical issues and action research [1].*Educational Action Research*, 6(1), 9-19.

Appendices

Appendix A

Overview of Mathematics Education in Ireland

Overview of Mathematics Education in Ireland

Mathematics has featured as an important element of the Irish Education System since the formal establishment of the primary school system in 1831. The educational system in Ireland for students is composed of four main tiers, consisting of Early Childhood, Primary, Secondary and Third level education. Mathematics features predominantly in all of these different academic levels.

Early Childhood Curriculum (0-6 years of age)

Aistear, the Early Childhood Curriculum Framework for children from birth to six years of age, places a strong emphasis on the development of numbers from an early age. The DES (2009) stated that students should “develop counting skills, and a growing understanding of the meaning and use of numbers and mathematical language in an enjoyable and meaningful way” (p. 35). It is important to note that this pre-school curriculum intends for these children to develop in the area of “identity and belonging” and explicitly states that students should be taught to “interact, work co-operatively and help others” (DES, 2009, p.26).

Primary Curriculum (5-12 years of age)

The Irish Primary Curriculum is described as meeting the needs of students in their developing years from five to twelve. The primary school mathematics curriculum was revised in 1999 as a result of the changes to society and the different skills that students needed to acquire. This curriculum highlights the important role that mathematics plays in society by stating “the application of increasingly sophisticated mathematics in a

growing range of economic, technical, scientific and social and other contexts has had a profound influence on the development of contemporary society” (DES, 1999, p. 8). This curriculum states that in order for a child to be an informed and confident member of society, they require a good working knowledge of all areas of mathematics (DES, 1999).

The Irish primary curriculum consists of eight years in duration ranging from junior infants to sixth year. Mathematics is a major component of each year of the eight year programme. As students progress throughout their primary education journey, it is envisaged that their mathematics education is built upon and advanced. The primary mathematics curriculum is composed of five main mathematical strands that are all interconnecting in content and not uniquely isolated. These five strands are (DES, 1999):

- Number
- Algebra
- Shape and Space
- Measures
- Data

Secondary Curriculum (12 – 18 years of age)

Mathematics is a compulsory subject for all students within the secondary school system in Ireland. This means that every student of all ranges of abilities must receive mathematical instruction as part of their mandatory education. The secondary school curriculum of mathematics education in Ireland is referred to as “Project Maths”. This is a newly reformed curriculum which has been introduced on a phased basis since 2008 to all schools across the county. This curriculum consists of two stages namely: Junior Certificate and Senior Certificate. The Junior Certificate Project Maths course consists of a three year programme for students aged between 12 – 15 years of age and is offered

at three distinctive levels of difficulty, namely foundation, ordinary and higher. The Leaving Certificate Project Maths course consists of a two-year programme for students, typically aged between 15 – 18 years of age. Similarly, this course is offered at three different levels of difficulty namely foundation, ordinary and higher. There is a voluntary and additional school year known as Transition year situated between the Junior Certificate and Leaving Certificate programmes. This course also directs that mathematics instruction must be received by all students.

The curriculum structure of Project Maths is constructed in a similar manner to that of the primary mathematics curriculum. Students are educated in the following five main areas of mathematics known as “strands” (DES, 1999):

- Strand One: Statistics and Probability
- Strand Two: Geometry and Trigonometry
- Strand Three: Number
- Strand Four: Algebra
- Strand Five: Functions

Appendix B

The overview of the reasons leading to mathematical reform in Ireland

The development of Project Maths

This dissertation focuses solely on the secondary mathematics education curriculum in Ireland and, in particular, the second year of the three year Junior Certificate course of Project Maths. This section will provide the reader with the required background which gave rise to the reformation of mathematics education in Ireland.

Globalisation and Project Maths

Udofa & Udo (2013) defined globalisation as the process of “interaction among the people, companies and governments of different nations, a process driven by international trade and investment and aided by information technology” (p. 33). This process of globalisation has undeniably had an impact on education as we know it today due to the strong links between education and the technological and economic world. Rizvi & Lingard (2009) have spoken about the direct relationship between schooling and the contribution that this has on a nation’s economy. Gago et al. (2004) have discussed the impact on educational policy that results from globalisation and in particular the emphasis on Science, Technology, Engineering and Mathematics (STEM) related subjects globally. The author argues that international governments are forming their policies on improving these STEM-related subjects in order to achieve an increased economic growth. Drake, Noyes & Wake (2012) state that there are two major intentions of international governments, firstly to increase the amount of mathematically qualified graduates from the third level sector and secondly to expand on the mathematical capability of all citizens of a country’s workforce.

This international opinion has also been echoed by the Expert Group in Future Skills Needs in Ireland (EGFSN) in 1997. This joint government body, established by the Department of Jobs, Enterprise and Innovation in conjunction with the Department of Education and Skills (DES), has clearly identified from an economic position, the importance of raising the national mathematical achievement (NESC, 2008). The EGFSN has correlated the connection between mathematical achievement and employment and stressed that mathematics is a vital key component for working and living in the 21st century (NESC, 2008).

As a result of the move towards globalisation for economic benefits, it was evident that an overview and overhaul of mathematics education in Ireland needed to occur. Atweh, Forgasz & Nebres (2001) stated that “pedagogy is deeply influenced by the economic and political environment, particularly at a time of massive change” (p.1992). The shift towards Ireland competing for large international investments is a key factor for seeking reform of the mathematics curriculum in Ireland.

The Comparative Nature and Mathematics Reform

Another key factor in the journey of reform in mathematics education was the fact that Ireland was participating in a series of international comparative assessments. Drake, Noyes & Wake (2012) have highlighted that international comparison assessments are very influential on government perceptions about levels of skills in schools.

Ireland's Participation in IAEP and TIMSS

Ireland's participation and performance in the International Assessment of Educational Progress (IAEP) of 13-year-old students was quite positive in 1988. Ireland's second performance in 1991 was also positive, Ireland scored similarly to Scotland; this can be due to the similar curriculum content. However, it was noted in 1991 that there was some worrying developments relating to results, especially at the lower end of results (NCCA, 2005). However, Ireland's performance in the similar curriculum content comparative test of the Third International Mathematics and Science Study (TIMSS) 1994 was better than then several named appropriate comparable countries of equal cultural and developmental status. Although Ireland has achieved acceptable assessment scores when tested, based on a similar curricular content, when faced with more mathematical real life applications and problem solving questions that were atypical of the Junior Certificate, Ireland has achieved a lower ranking.

Appendix C

Nine forms of Positive Interdependence

Laal (2013) has outlined the nine forms of Positive Interdependence dispersed throughout CL.

1. Positive Goal Interdependence

This enables the group to unite as one and enables individual members to realise that they can only achieve their goal when the teams' goal is met.

2. Positive Reward Interdependence

The use of mutual rewards enables students to strive for successful group work.

3. Positive Resource Interdependence

By providing each student with only part of the information required to reach the group goal, this enables the team to share their ideas in order to achieve the goal.

4. Positive Role Interdependence

By dividing the responsibilities of the team and rotating these roles, this enables each student to understanding the positions of others throughout CL.

5. Positive Identity Interdependence

By utilising strategies such as a team flag, motto or logo, this enables the sense of team unity to be developed and cherished.

6. Environment Interdependence

This form of positive interdependence enables the members to feel safe and comfortable in their surroundings.

7. Positive Fantasy Interdependence

The sharing of an imaginary task enables students to discover the importance of team work in a life threatening situation.

8. Positive Task Interdependence

The organization of each team member's input enables for a pattern of work to develop. This allows for the helpful actions of each team member to occur in order leading to the completion of a task.

9. Positive Outside Enemy Interdependence

The use of competition challenges student teams to work together to ensure success against neighbouring teams.

Appendix D

Four Levels of Cooperative Skills

Johnson, Johnson & Holubec (1994) have outlined four unique sub-sections of social skills that are required for CL, these include:

- Forming
- Functioning
- Formulating
- Fermenting

These Cooperative Skills are composed in a hierarchal manner with “forming” being the minimum requirement for social skills in CL. “Fermenting” tends to be reserved for the highest team productivity. The diagram is displayed below.

Forming	Functioning	Formulating	Fermenting
• moving into groups with undue noise	• giving directions to the group	• summarizing	• disagreeing without criticizing
• staying with the group	• expressing support and acceptance toward ideas	• providing constructive feedback	• extending member's answers
• using quiet voices	• asking for help or clarification	• elaborating on a comment or answer	• probing by asking questions
• encouraging others	• paraphrasing	• checking for understanding	• generating further answers
• looking at the speaker	• using humor to motivate group	• demanding vocalization to make implicit reasoning overt	• integrating ideas into a single position
• exhibiting self-control (keeping hands to self)	• offering to explain	• asking members to plan out loud	• testing reality by checking out the group's work with the instructions

Johnson, Johnson & Holubec (1994)

Appendix E

Eight key competences as described by the European Union (2011)

1. Communication in the mother tongue
2. Communication in foreign languages
3. Mathematical competences and basic competences in science and technology
4. Digital competence
5. Learning to learn
6. Social and Civic Competences
7. Sense of Initiative and Entrepreneurship
8. Cultural Awareness and Expression

Appendix F

Recommended Problem Solving Techniques for Project Maths

Since the development of Project Maths, students have been challenged to utilise different and creative ways of presenting their mathematical solutions. The Project Maths Development Teacher has issued this poster to all post-primary schools in order to encourage such strategies:



Appendix G

Current International Research into Mathematics Education

Moving towards the New Junior Cycle Model

Further to the national roll out of Project Maths, it is clear that the NCCA is now transitioning to a model of CL within the new Junior Cycle programme and has explicitly utilised the approach of CL. These new key skills for the reforming Junior Cycle programme are similar to that of the key skills for Leaving Certificate and include managing myself, staying well, managing information and thinking, being creative, working with others and communicating (DES, 2015). The NCCA acknowledges the potential benefits of utilising CL in conjunction with the curriculum and the required key skills and has highlighted the fact that humans have for decades worked together in all aspects of society.

Lesson Study within Project Maths

Furthermore, the NCCA has commissioned further research into Lesson Study as a means of professional reflection and development for teachers. Ní Shúilleabháin (2015) conducted research based on mathematics teaching in two Irish schools. This research highlighted that there was a major shift in classroom practices from that of a teacher-led environment to that of more student pair and group-work. This group-work was cooperative in nature and as a result of implementing lesson study into mathematics education one teacher stated:

“I think we’ve all looked at the way our classrooms are set up to facilitate cooperative learning. All of our classrooms were the traditional single look-at-the-board and everybody has used cooperative learning practices as a result of the lessons that we designed.”

This report, commissioned at the peak of mathematics curriculum reform in Ireland, concluded that this process had a positive impact on teachers facilitating student group-work and their ability to promote student communication and problem solving in the classroom setting (Ní Shúilleabháin, 2015).

PISA and Collaborative Problem Solving

Internationally, it is interesting to note that the OECD's PISA testing, which is largely responsible for this curriculum reform in mathematics in Ireland, is now moving towards the importance of incorporating a CL element in the problem solving classroom. Its new focus is described as Collaborative Problem Solving (CPS) (OECD, 2013). The importance of social interaction within the classroom has been explicitly noted by this new PISA report. It is highlighted that currently there is not sufficient collaboration due to limited shared task goals and that there is no reason to appreciate the different student viewpoints (OECD, 2013). It has been recommended that the testing of these collaboration skills be completed in parallel to the curriculum, especially in science, mathematics and history. Countries, such as Singapore, that have implemented collaboration and 21st century teaching and learning skills have typically score higher in international rankings (Ministry of Education Singapore, 2008, as cited in OECD, 2013). Similarly, the Finnish education system has also stated the necessity to teach students the skills to be able to work in a collaborative and cooperative manner with their peers (Finnish National Board of Education, 2003).

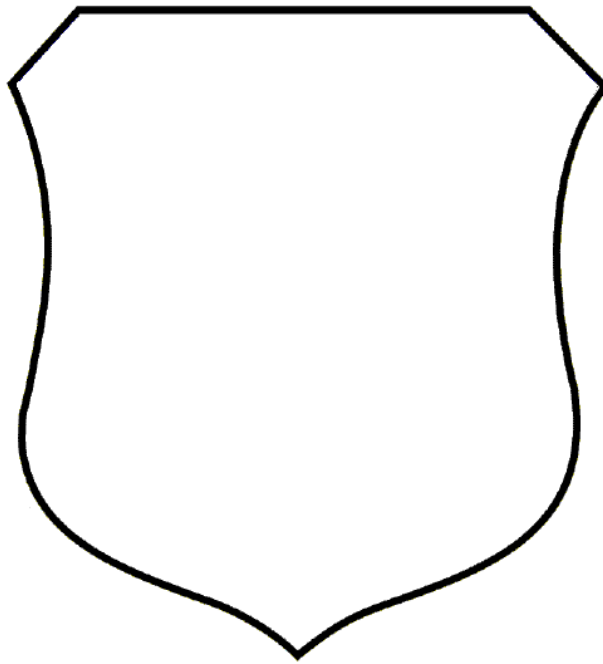
Appendix H: Team Folder utilised throughout the implementation of Cooperative Learning

OUR TEAM FOLDER

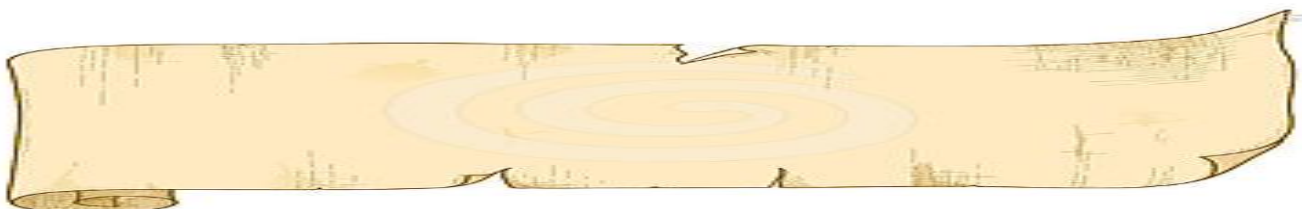
Our Team Name (Remember to be creative!):



Our Team Crest (Get Artistic!):



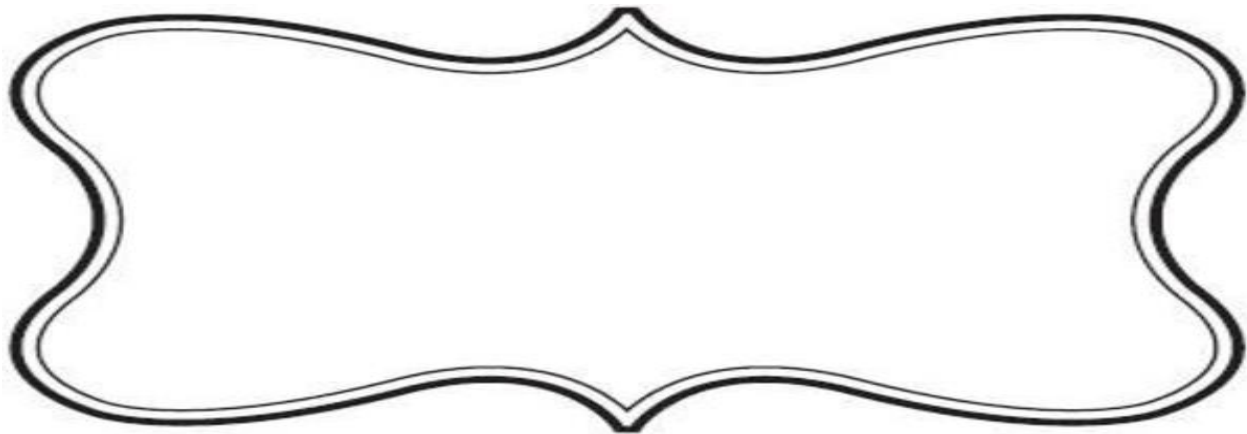
Our Team Motto (One for All and All for One):



Our Team Members:



What is the definition of a team?



Our Team Questions

	Where is your favourite place in the world?	What is your favourite part of maths?	What's your biggest fear of maths?	What's your future career going to be? Will it involve some maths?	What's your lucky number?
Team Member Name:					
Team Member Name:					
Team Member Name:					

Responsibilities and Rights of Team Members

When we are working as part of a group, it is really important that we all have responsibilities and rights as part of the group.

I have the responsibility		I have the right	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	

Social Skills in Cooperative Learning

When we are working together in groups it is important that we have a strong understanding of the skills needed to work as part of a group.

Skill One: Listening to Each Other

Looks Like	Sounds Like

Social Skills in Cooperative Learning

When we are working together in groups it is important that we have a strong understanding of the skills needed to work as part of a group.

Skill Two: Helping Each Other

Looks Like	Sounds Like

Social Skills in Cooperative Learning

When we are working together in groups it is important that we have a strong understanding of the skills needed to work as part of a group.

Skill Three: Teamwork

Looks Like	Sounds Like

Social Skills in Cooperative Learning

When we are working together in groups it is important that we have a strong understanding of the skills needed to work as part of a group.

Skill Four: Checking for Understanding

Looks Like	Sounds Like

Role Descriptions Sheet



When working as part of a team – it is really important that each member knows what their own personal role is within the team. When each member completes their own individual role then the team can really start to grow and develop.

Role Title:	What are the responsibilities of this role?
Reader	
Recorder	
Time-Keeper	
Checker	
Summarizer	
Encourager	

Appendix I: Pre-Questionnaire and Draft Documents

Pre-Questionnaire Draft One

Student Pre-Questionnaire



Pupil Number: _____

Prior Experience of Teamwork:

Q1. Have you been asked to work as a team over the last year in secondary school?

☐ Yes ☐ No

Q2. If yes, how often are you asked to work as a team member in school?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q3. Have you ever been taught the required skills to work as a team member?

☐ Yes ☐ No

Q4. Do you think that teamwork is an important skill to learn in secondary school?

☐ Yes ☐ No

Attitudes to Teamwork:

Q5. Do you enjoy working as part of a team?

☐ Yes ☐ No

Q6. Which method of learning maths do you prefer?

☐ Learning by myself ☐ Learning as part of a group

Q7. Is it important for you to help your other class mates if they are having difficulties with maths?

☐ Very Important ☐ Important ☐ Somewhat Important ☐ Not Important

☐ Unsure

Q8. Are you part of a team outside of school (sports team / scouts / dance group)?

☐ Yes ☐ No

Skills required for teamwork:

Q9. What skills do you need to work as part of a team?

- ☐ Listening Skills ☐ Contributing Ideas ☐ Helping Others ☐ Respecting Others
- ☐ Group Roles

Q10. Have you ever been taught how to listen as part of a group?

- ☐ Yes ☐ No

Q11. What do you think are the three most important factors to having a successful team?

1. _____
2. _____
3. _____

Opinions of maths:

Q12. Do you enjoy studying maths in secondary school?

- ☐ Yes ☐ No ☐ Unsure

Q13. Maths is an important skill to have in life.

- ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q14. Do your parents / guardians have a fear of mathematics?

- ☐ Yes ☐ No ☐ Unsure

Q15. Did you enjoy maths in primary school?

- ☐ Yes ☐ No ☐ Unsure

Q16. Do you think that maths homework is beneficial to you?

- ☐ Yes ☐ No ☐ Unsure

Q17. If you get stuck on a maths problem, who do you turn to for help?

- ☐ Mother/Father ☐ Classmate ☐ Brother/Sister ☐ Internet ☐ Leave it blank ☐ Other

Q18. In your opinion, what's the best way of learning maths?

- ☐ Watching the teacher doing examples
- ☐ Practicing maths questions from the text book
- ☐ Working in groups to solve questions
- ☐ Playing maths games
- ☐ Other

Q19. Describe your maths ability:

- ☐ Excellent ☐ Great ☐ Good ☐ Bad ☐ Weak

Maths Statements:

Q20. I have a certain amount of maths ability and I can't do much to change it:

- ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q21. Asking questions helps me to learn maths.

- ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q22. Maths involves creativity and new ideas:

- ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q23. Maths helps to solve everyday problems and tasks:

- ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Pre-Questionnaire Draft Two



Student Pre-Questionnaire

Pupil Number: _____

Prior Experience of Teamwork:

Q0. Describe what you think teamwork is?

Q1. Have you been asked to work as a team over the last year in secondary school?

☐ Yes ☐ No

If you answered 'No' to Question 1, then you can skip straight to question 4 and continue on.

If you answered 'Yes' to Question 1, then you can continue to Question 2 and continue on.

Q2 (i) How often are you expected to work as a part of a team in school?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q2 (ii) How often are you asked to work in a team during maths class?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q2 (iii) What is the worst part of working as part of a team?

☐ People being lazy ☐ People not taking the task seriously
☐ Not knowing how to work as a group ☐ Unsure

Q3. Have you ever been taught the required skills to work as a team member?

☐ Yes ☐ No

Q4. Do you think that teamwork is an important skill to learn in secondary school?

☐ Yes ☐ No

Attitudes to Teamwork:

Q5. Do you enjoy working as part of a team?

☐ Yes ☐ No

Q6. Which method of learning maths do you prefer?

- ☐ Learning by myself ☐ Learning as part of a group

Q7. Is it important for you to help your other class mates if they are having difficulties with maths?

- ☐ Very Important ☐ Important ☐ Somewhat Important ☐ Not Important
☐ Unsure

Q8. Are you part of a team outside of school (sports team / scouts / dance group)?

- ☐ Yes ☐ No

Skills required for teamwork:

Q9. What skills do you need to work as part of a team?

- ☐ Listening Skills ☐ Contributing Ideas ☐ Helping Others ☐ Respecting Others ☐
Patience ☐ Unsure

Q10. Have you ever been taught how to listen as part of a group?

- ☐ Yes ☐ No

Q11. What do you think are the three most important factors to having a successful team?

1. _____

2. _____

3. _____

Opinions of maths:

Q12. Do you enjoy studying maths in secondary school?

- ☐ Yes ☐ No ☐ Unsure

Q13. Please rate the following statement: "Maths is an important skill to have in life":

- ☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q14. Do your parents / guardians have a fear of mathematics?

☐ Yes ☐ No ☐ Unsure

Q15. Do you think that maths homework is beneficial to you?

☐ Yes ☐ No ☐ Unsure

Q16. Do you think that by correcting your classmates' homework that it will help you to improve on your maths skills?

☐ Yes ☐ No ☐ Unsure

Q17. If you get stuck on a maths problem at home who do you turn to for help?

☐ Mother/Father ☐ Classmate ☐ Brother/Sister ☐ Internet ☐ Leave it
blank/unfinished ☐ Other

Q18. In your opinion, what's the best way of learning maths?

☐ Watching the teacher doing examples
☐ Practising maths questions from the text book
☐ Working in groups to solve questions
☐ Playing maths games
☐ Other

Q19. Describe your maths ability:

☐ Excellent ☐ Great ☐ Good ☐ Bad ☐ Weak ☐ Unsure

Maths Statements:

Please read the statements and tick the box that you think describes you best.

Q20. I have a certain amount of maths ability and I can't do much to change it:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q21. Asking questions helps me to learn maths.

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q22. Maths involves creativity and new ideas:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q23. Maths helps to solve everyday problems and tasks:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q24. It is easier to do maths by working together as a team:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q25. I think that it is important to help people:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q26. Do you think that each member of the group should have a particular job to do :

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q27. By helping my classmates with maths, it helps me to understand the topic better:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q28. By working as a group in maths class will enable me to improve my grades:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q29. By reflecting on group activities, helps the group to improve and work better:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Pre-Questionnaire Draft Three (Final Draft)



Student Pre-Questionnaire

Pupil Number: _____

Prior Experience of Teamwork:

Q0. Describe what you think teamwork is?

Q1. Have you been asked to work as a team in the classroom over the last year in secondary school?

☐ Yes ☐ No

If you answered 'No' to Question 1, then you can skip straight to question 4 and continue on.

If you answered 'Yes' to Question 1, then you can continue to Question 2 and continue on.

Q2 (i) How often are you expected to work as a part of a team in school?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q2 (ii) How often are you asked to work in a team during maths class?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q2 (iii) What is the worst part of working as part of a team?

☐ People being lazy ☐ People not taking the task seriously

☐ Not knowing how to work together ☐ Unsure

Q3. Have you ever been taught the required skills to work as a team member?

☐ Yes ☐ No

Q4. Do you think that teamwork is an important skill to learn in secondary school?

☐ Yes ☐ No

Attitudes to Teamwork:

Q5. Do you enjoy working as part of a team?

☐ Yes ☐ No

Q6. Which method of learning maths do you prefer?

☐ Learning by myself ☐ Learning as part of a team

Q7. Is it important for you to help your other class mates if they are having difficulties with maths?

☐ Very Important ☐ Important ☐ Somewhat Important ☐ Not Important
☐ Unsure

Q8. Are you part of a team outside of school (sports team / scouts / dance group)?

☐ Yes ☐ No

Skills required for teamwork:

Q9. What skills do you need to work as part of a team? (Tick all relevant answers)

☐ Listening Skills ☐ Contributing Ideas ☐ Helping Others ☐ Respecting Others ☐
Patience ☐ Unsure

Q10. Have you ever been taught how to listen as part of a group?

☐ Yes ☐ No

Q11. What do you think are the three most important factors to having a successful team?

1. _____

2. _____

3. _____

Opinions of maths:

Q12. Do you enjoy studying maths in secondary school?

☐ Yes ☐ No ☐ Unsure

Q13. Please rate the following statement: "Maths is an important skill to have in life":

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q14. Do your parents / guardians have a fear of maths?

☐ Yes ☐ No ☐ Unsure

Q15. Do you think that maths homework is beneficial to you?

☐ Yes ☐ No ☐ Unsure

Q16. Do you think that correcting your classmates' homework will help you to improve on your maths skills?

☐ Yes ☐ No ☐ Unsure

Q17. If you get stuck on a maths problem at home who do you turn to for help?

☐ Parent ☐ Classmate ☐ Brother/Sister ☐ Internet ☐ Leave it blank/unfinished ☐ Other _____

Q18. In your opinion, what's the best way of learning maths?

☐ Watching the teacher doing examples
☐ Practising maths questions from the text book
☐ Working in groups to solve questions
☐ Playing maths games
☐ Other

Q19. Please rate your maths ability (pick one only):

☐ Excellent ☐ Great ☐ Good ☐ Bad ☐ Weak ☐ Unsure

Maths Statements:

Please read the statements and tick the box that you think describes you best.

Q20. I have a certain amount of maths ability and I can't do much to change it:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q21. Asking questions helps me to learn maths.

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q22. Maths involves creativity and new ideas:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q23. Maths helps to solve everyday problems and tasks:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q24. It is easier to do maths by working together as a team:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q25. I think that it is important to help people:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q26. Do you think that each member of the group should have a particular job to do :

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q27. By helping my classmates with maths, it helps me to understand the topic better:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q28. Working as a group in maths class will enable me to improve my grades:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q29. Reflecting on group activities helps the group to improve and work better:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Appendix J: Post Questionnaire



Post-Questionnaire Draft One (Final Draft)

Student Post-Questionnaire

Pupil Number: _____

Prior Experience of Teamwork:

Q0. Describe what you think teamwork is?

Q1. Have you been asked to work as a team over the last year in secondary school?

☐ Yes ☐ No

If you answered 'No' to Question 1, then you can skip straight to question 4 and continue on.

If you answered 'Yes' to Question 1, then you can continue to Question 2 and continue on.

Q2 (i) How often are you expected to work as a part of a team in school?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q2 (ii) How often are you asked to work in a team during maths class?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Q2 (iii) What is the worst part of working as part of a team?

☐ People being lazy ☐ People not taking the task seriously
☐ Not knowing how to work as a group ☐ Unsure

Q3. Have you ever been taught the required skills to work as a team member?

☐ Yes ☐ No

Q4. Do you think that teamwork is an important skill to learn in secondary school?

☐ Yes ☐ No

Attitudes to Teamwork:

Q5. Do you enjoy working as part of a team?

☐ Yes ☐ No

Q6. Which method of learning maths do you prefer?

☐ Learning by myself ☐ Learning as part of a group

Q7. Is it important for you to help your other class mates if they are having difficulties with maths?

☐ Very Important ☐ Important ☐ Somewhat Important ☐ Not Important
☐ Unsure

Q8. Are you part of a team outside of school (sports team / scouts / dance group)?

☐ Yes ☐ No

Skills required for teamwork:

Q9. What skills do you need to work as part of a team?

☐ Listening Skills ☐ Contributing Ideas ☐ Helping Others ☐ Respecting Others ☐ Patience ☐ Unsure

Q10. Have you ever been taught how to listen as part of a group?

☐ Yes ☐ No

Q11. What do you think are the three most important factors to having a successful team?

1. _____

2. _____

3. _____

Opinions of maths:

Q12. Do you enjoy studying maths in secondary school?

☐ Yes ☐ No ☐ Unsure

Q13. Please rate the following statement: "Maths is an important skill to have in life":

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q14. Do your parents / guardians have a fear of mathematics?

☐ Yes ☐ No ☐ Unsure

Q15. Do you think that maths homework is beneficial to you?

☐ Yes ☐ No ☐ Unsure

Q16. Do you think that by correcting your classmates' homework that it will help you to improve on your maths skills?

☐ Yes ☐ No ☐ Unsure

Q17. If you get stuck on a maths problem at home who do you turn to for help?

☐ Parent ☐ Classmate ☐ Brother/Sister ☐ Internet ☐ Leave it blank/unfinished ☐ Other _____

Q18. In your opinion, what's the best way of learning maths?

☐ Watching the teacher doing examples
☐ Practising maths questions from the text book
☐ Working in groups to solve questions
☐ Playing maths games
☐ Other

Q19. Describe your maths ability:

☐ Excellent ☐ Great ☐ Good ☐ Bad ☐ Weak ☐ Unsure

Maths Statements:

Please read the statements and tick the box that you think describes you best.

Q20. I have a certain amount of maths ability and I can't do much to change it:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q21. Asking questions helps me to learn maths.

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q22. Maths involves creativity and new ideas:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q23. Maths helps to solve everyday problems and tasks:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q24. It is easier to do maths by working together as a team:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q25. I think that it is important to help people

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q26. Do you think that each member of the group should have a particular job to do :

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q27. By helping my classmates with maths, it helps me to understand the topic better:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q28. Working as a group in maths class will enable me to improve my grades:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Q29. Reflecting on group activities helps the group to improve and work better:

☐ Strongly Agree ☐ Agree ☐ Unsure ☐ Disagree ☐ Strongly Disagree

Appendix K: Team Processing Sheet



Team Processing Sheet

Name: _____

Team: _____

Date: _____

1. What did we find good about working together today?

2. What did we do well together as a team?

3. Write down two ways that each member helped the team today?

Team Member Name	Helpful Action	Helpful Action

4. If you were to do this project over, what would you do differently to improve your work?

Team Signatures:

_____, _____, and _____.

Appendix L: Informed Consent and Guidelines for Parents



Dear Parents/Guardians,

I am currently completing a Masters of Education (M.Ed) programme in the School of Education, Trinity College Dublin. My area of speciality for this Masters Programme is Cooperative Learning. The educational methodology of Cooperative Learning can be defined as a teaching strategy of utilising small teams of students of different levels of ability using a variety of different learning activities to improve students' understanding of a subject.

As part of this research, I am obliged to receive written consent from all the parents/guardians of the participants in this research. This research will be conducted in a non-stressful and sensitive manner. This research project is in line with the ethical approval structure of Trinity College Dublin. This research will be classified as level one. This means that the research carries little or no risk or no discomfort greater than usually encountered during normal daily life.

I aim to construct a thesis dissertation based on my practice as a post-primary mathematics teacher. My proposed thesis is entitled 'What impact does Cooperative Learning have on assessment in the mixed ability Junior Certificate Project Maths classroom?' I aim to research if Cooperative Learning in mathematics improves students' assessment results and their attitudes to mathematics as a whole.

Throughout this research, I aim to ask students to complete two questionnaires (one pre and another post implementation) anonymously based on the following headings: attitudes to mathematics, experiences of mathematics and attitudes to teamwork. Students will also be asked to fill in a daily/weekly feedback sheet based on their opinions and successes of working as part of a team during classroom lessons in mathematics.

This data generated from these anonymous questionnaires will then form part of my findings of my research into Cooperative Learning in mathematics. I will ensure that this anonymous data is stored safely and upon completion of this thesis, these questionnaires and feedback sheets will be destroyed.

I also hope to use anonymous examples of students' work as part of my research (for example: a solution to a particular question in a test) and also students' class assessment results. This information will also be anonymous. Please note that the participant has the right to cease participation at any stage throughout this research without need for explanation.

If you have any further questions or any aspect that you would like clarify, you can contact me via the School reception on xx-xxxxxxx or via email at xxxxxxx@tcd.ie.

Sincerely,

Derek Maher (Maths Teacher)



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Informed Consent Form for the Masters of Education (Cooperative Learning) thesis into the impact of Cooperative Learning in the mixed ability mathematics class.

Student Name: _____

Please tick all the corresponding boxes.

I have read and understood the accompanying information sheet provided and I have had time to review this information if necessary ☐

I understand that it is acceptable for me to remove my child from the research process at any time without having to provide any reason ☐

I understand that the research may anonymously use examples of my child's work (questionnaire, assessment results and feedback sheets) and quotes (written and verbal) throughout this period of research ☐

I understand that data used for this research will be conducted anonymously and that it will be destroyed after the research has concluded ☐

I agree for my child to take part in this research study.

Name: _____

Signature: _____

Date: _____

Appendix M: Informed Consent and Guidelines for Student Participants

Student Information and Consent Form

Dear Class,

I am currently completing a project about the different ways that students learn maths in secondary school. Normally students learn maths by themselves and don't use any group or teamwork during maths class. As part of my project, I am hoping to see if learning maths in teams helps you to improve your maths understanding rather than you learning maths on your own.

As part of this project, I will need you to do the following:

- Fill in two questionnaires sheets honestly (one in December and one in May). I might take some examples of the things that you say in these questionnaires and include them in my project report, but your name, class or school will not be included. It will be anonymous.
- I will also need you to work in maths teams together during maths class and to complete some quick feedback sheets on your opinions of the activities and experiences of working together in maths class. I might take some examples of the things that you say in these questionnaires and include them in my project report, but your name, class or school will not be included. It will be anonymous.

For this research, I would like to use your assessment results from class tests and from your exams in school. These results won't contain your name, class, school or any information about you. They will be completely anonymous. These results will help me to see if working in teams, helps to increase your understanding of maths or not.

All the information that you provide me with will only be seen by me. When I am finished writing about it, I will ensure that it will be destroyed fully. It will also be stored securely.

It is OK, if you don't want to be part of my research project and you don't have to give me a reason for this at all. If you decide during the project that you no longer want to take part in this project, that's OK too.

If you are happy to be part of my research project, can you please read and tick all five boxes on the next page and bring back this form to Mr. Maher as soon as possible.

You can ask me any questions that you may have and I will answer them for you fully. You can discuss questions that you may have with your parents/guardians too.

If you would like a summary of my findings at the end of my project, I will be happy to provide these to you at the end of the project.

Thank You,

_____ (Mr. Maher)



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Student Consent Form

Please read and tick all five boxes

I have had time to think about this research project and to talk to my parents/guardians about it. I have also asked the researcher any questions that I had . ☐

I understand that it is OK for me to stop being part of this project at any time without having to explain why ☐

I understand that I will need to complete two questionnaires, one in December and another in May. These answers will be used in the researcher's report but won't contain my name, class or school. ☐

I understand that the researcher will use my class tests and exam results in the writing of his report but my name, class or school won't be mentioned in the report ☐

I understand that the researcher will use some relevant things that I say (written, verbal) in their reports, when they are talking at conferences or in research papers and I give my permission for them to do this. They will not use my name, school or class and all my work will be anonymous. ☐

I agree to take part in this research project:

Name: _____

Date: _____

Signature: _____

Appendix N: Informed Consent and Guidelines for Principal in research school.



Trinity College Dublin

Coláiste na Tríonóide, Baile Átha Cliath

The University of Dublin

23rd November, 2015.

Dear Ms. XXXXXXXXXX,

Further to our conversation regarding the research project I am planning to undertake in my second year maths class, I am writing to inform you of my progress to date before any research is conducted. My research is under the supervision of Mr. Brendan Keenan, Trinity College, and is entitled '*What impact does Cooperative Learning have on assessment in the mixed ability Junior Certificate Project Maths classroom?*'

I am interested in examining how Cooperative Learning methodologies can be used by mathematics teachers as a tool to improve the quality of teaching and learning of mathematics, to improve students' opinions of mathematics and to support all learners in the mathematics classroom. As my research is topical at the moment, due to the recent implementation of Project Maths, I am keen to seek new methodologies to teach this new curriculum.

The proposed data collection for the project will take place in my classroom between November and May. Data collection will include student pre and post- questionnaires on their levels of teamwork and opinions of mathematics, weekly student team feedback sheets and assessment results of students at periodic times throughout the year.

I do not foresee any risks being associated with the participation of any individuals or the school. The information gathered will be treated with the appropriate confidentiality, privacy and anonymity. No information about the school or the participants will be identified in the research, and all information will be stored safely with access only available to the researcher and supervisor. As our school is the primary research location, a copy of the results can be made available to you if requested.

Please note that the school and the pupils involved will not be under any obligation to participate in this study, and the administration of this project would not interfere with the day to day running of the class or instruction. Information letters and consent forms will be issued to the parents/guardians of each of the children in my class. No research will be conducted in class until ethical approval has been granted by Trinity College and consent forms have been completed. If, at any time, a participant wishes to withdraw from the study they may do so.

If you have any questions regarding this research, please do not hesitate to contact me.

Thank you for your continued support.

Kind regards,

Derek Maher

Signed: _____ (XXXXXXXX XXXXXXXXXX)

Principal of Research School

Appendix O: Student (Individual) Reflection Sheet

Student Post-Questionnaire



Pupil Number: _____

Based on the past 10 weeks of implementing Cooperative Learning into your maths class, what do you think have been the three best elements of this?

Based on the past 10 weeks of implementing Cooperative Learning into your maths class, what do you think have been the three worst elements of this?

Which method of teaching do you enjoy most; working alone or working together? Why?

What did you learn from working as part of a team? List three main things.

What did you learn about your communication skills? Have these increased/decreased since participating in this project?

Overall comments?

Appendix P: Figure 6.1 Experimental Class Results (C L)

	Question 1 (Algebra)	Question 2 (Probability)	Question 3 (Sets)	Question 4 (Revision)	Total (105 marks)	Result as a Decimal	Rounded Result (%)
Student1	5	22	5	14	46	0.438095238	44
Student2	12	27	20	25	84	0.8	80
Student3	*	*	*	*	*	*	*
Student4	13	22	15	17	67	0.638095238	64
Student5	8	12	5	4	29	0.276190476	28
Student6	18	27	20	25	90	0.857142857	86
Student7	10	7	5	10	32	0.304761905	31
Student8	16	22	7	0	45	0.428571429	43
Student9	13	24	17	13	67	0.638095238	64
Student10	5	5	12	25	47	0.447619048	45
Student11	15	20	20	18	73	0.695238095	70
Student12	12	32	20	14	78	0.742857143	75
Student13	13	17	5	0	35	0.333333333	34
Student14	10	30	20	14	74	0.704761905	71
Student15	23	25	20	10	78	0.742857143	75
Student16	5	35	3	23	66	0.628571429	63
Student17	13	22	12	25	72	0.685714286	69
Student18	16	32	20	25	93	0.885714286	89
Student19	14	18	17	17	66	0.628571429	63
Student20	13	25	20	7	65	0.619047619	62
Student21	8	24	3	14	49	0.466666667	47
Student22	**	**	**	**	**	**	**
Student23	**	**	**	**	**	**	**
Student24	14	20	10	0	44	0.419047619	42
Student25	15	25	7	14	61	0.580952381	59
Student26	8	5	5	7	25	0.238095238	24
Student27	10	17	8	5	40	0.380952381	39
	289	515	296	326			
							1367
	12.0416667	21.45833333	12.3333333	13.58333333			56.95833333
	Average Mark for Algebra	Average Mark for Probability	Average Mark for Sets	Average Mark for Revision			Average Class Mark

*denotes that this student was absent on the date of the assessment.

**denotes results that could not be included due to ethical constraints.

*Figure 6. 2 – Post Implementation Non- Cooperative Learning Class
(Control Class One) Results*

	Question 1 (Algebra)	Question 2 (Probability)	Question 3 (Sets)	Question 4 (Revision)	Total (105 marks)	Result as a Decimal	Rounded Result (%)
ControlStudent1	20	32	5	14	71	0.6761905	68
ControlStudent2	21	17	5	23	66	0.6285714	63
ControlStudent3	20	22	7	10	59	0.5619048	57
ControlStudent4	13	15	5	0	33	0.3142857	32
ControlStudent5	15	24	5	10	54	0.5142857	52
ControlStudent6	9	27	5	14	55	0.5238095	53
ControlStudent7	20	29	10	10	69	0.6571429	66
ControlStudent8	12	30	3	10	55	0.5238095	53
ControlStudent9	*	*	*	*	*	*	*
ControlStudent10	17	17	5	4	43	0.4095238	41
ControlStudent11	*	*	*	*	*	*	*
ControlStudent12	18	19	10	10	57	0.5428571	55
ControlStudent13	15	22	15	17	69	0.6571429	66
ControlStudent14	5	25	5	10	45	0.4285714	43
ControlStudent15	13	19	7	0	39	0.3714286	38
ControlStudent16	*	*	*	*	*	*	*
ControlStudent17	20	35	20	17	92	0.8761905	88
ControlStudent18	13	17	7	10	47	0.447619	45
ControlStudent19	10	17	0	20	47	0.447619	45
ControlStudent20	19	22	10	4	55	0.5238095	53
ControlStudent21	13	22	5	23	63	0.6	60
ControlStudent22	8	15	0	10	33	0.3142857	32
ControlStudent23	*	*	*	*	*	*	*
ControlStudent24	23	25	5	5	58	0.552381	56
ControlStudent25	7	15	5	4	31	0.2952381	30
ControlStudent26	10	14	5	10	39	0.3714286	37
ControlStudent27	8	27	5	0	40	0.3809524	38
ControlStudent28	13	17	3	0	33	0.3142857	31
	342	524	152	235			1202
	14.25	21.83333333	6.3333333	9.791666667			50.08333
	Average Mark for Algebra	Average Mark for Probability	Average Mark for Sets	Average Mark for Revision			Average Class Mark

**denotes that this student was absent on the date of the assessment.*

*Figure 6.3 – Post Implementation Non- Cooperative Learning Class
(Control Class Two) Results*

	Question 1 (Algebra)	Question 2 (Probability)	Question 3 (Sets)	Question 4 (Revision)	Total (105 marks)	Result as a Decimal	Rounded Result (%)
ControlStudent29	18	32	17	0	67	0.63809524	64
ControlStudent30	16	7	5	14	42	0.4	40
ControlStudent31	*	*	*	*	*	*	*
ControlStudent32	9	30	17	0	56	0.53333333	54
ControlStudent33	5	25	17	9	56	0.53333333	54
ControlStudent34	21	22	20	4	67	0.63809524	64
ControlStudent35	*	*	*	*	*	*	*
ControlStudent36	13	17	17	0	47	0.44761905	45
ControlStudent37	15	27	5	23	70	0.66666667	67
ControlStudent38	14	29	5	0	48	0.45714286	4
ControlStudent39	*	*	*	*	*	*	*
ControlStudent40	21	35	20	23	99	0.94285714	95
ControlStudent41	12	20	5	0	37	0.35238095	36
ControlStudent42	3	20	15	6	44	0.41904762	42
ControlStudent43	15	24	5	10	54	0.51428571	52
ControlStudent44	24	25	5	14	68	0.64761905	65
ControlStudent45	8	24	15	0	47	0.44761905	45
ControlStudent46	18	32	20	25	95	0.9047619	91
ControlStudent47	7	27	17	14	65	0.61904762	62
ControlStudent48	21	35	3	23	82	0.78095238	79
ControlStudent49	10	25	26	25	86	0.81904762	82
ControlStudent50	*	*	*	*	*	*	*
ControlStudent51	*	*	*	*	*	*	*
ControlStudent52	27	25	17	14	83	0.79047619	80
ControlStudent53	14	17	7	10	48	0.45714286	46
ControlStudent54	8	32	10	8	58	0.55238095	56
ControlStudent55	9	15	10	10	44	0.41904762	42
ControlStudent56	10	27	20	14	71	0.67619048	68
ControlStudent57	16	15	5	10	46	0.43809524	44
	334	587	303	256			1377
	13.9166667	24.45833333	12.625	10.66666667			57.375
	Average Mark for Algebra	Average Mark for Probability	Average Mark for Sets	Average Mark for Revision			Average Class Mark

**denotes that this student was absent on the date of the assessment.*

Appendix Q: Frequency of the codes for key skills.

Figure 7.1 – Results from Team Pythagoras

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication	✓ (3)		
2. Personal Effectiveness and Interdependence			
3. Working Cooperatively as a team	✓ (2)		
4. Creative and Critical Thinking			✓ (1)
5. Managing Information	✓ (1)	✓ (3)	✓ (3)

Figure 7.2 – Results from Team Euler

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication	✓ (3)	✓ (3)	✓ (3)
2. Personal Effectiveness and Interdependence			
3. Working Cooperatively as a team		✓ (2)	✓ (3)
4. Creative and Critical Thinking			
5. Managing Information		✓ (1)	

Figure 7.3 – Results from Team Gauss

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication	✓ (2)	✓ (1)	✓ (2)
2. Personal Effectiveness and Interdependence	✓ (1)		
3. Working Cooperatively as a team	✓ (1)		
4. Creative and Critical Thinking			
5. Managing Information	✓ (2)	✓ (5)	✓ (4)

Figure 7.4 – Results from Team Newton

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication			
2. Personal Effectiveness and Interdependence			
3. Working Cooperatively as a team			
4. Creative and Critical Thinking			
5. Managing Information			

Figure 7.5 – Results from Team Turing

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication	✓(3)	✓(2)	✓(3)
2. Personal Effectiveness and Interdependence	✓(1)		
3. Working Cooperatively as a team	✓(2)		✓(2)
4. Creative and Critical Thinking			
5. Managing Information		✓(2)	✓(1)

Figure 7.6 – Results from Team Leibniz

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication			✓(2)
2. Personal Effectiveness and Interdependence		✓(2)	
3. Working Cooperatively as a team			
4. Creative and Critical Thinking			
5. Managing Information	✓(3)	✓(2)	✓(3)

Figure 7.7 – Results from Team Riemann

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication	✓(1)		✓(3)
2. Personal Effectiveness and Interdependence	✓(3)		✓(3)
3. Working Cooperatively as a team			
4. Creative and Critical Thinking		✓(4)	
5. Managing Information		✓(2)	

Figure 7.8 – Results from Team Fibonacci

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication	✓(2)	✓(1)	✓(1)
2. Personal Effectiveness and Interdependence		✓(1)	
3. Working Cooperatively as a team	✓(1)	✓(1)	✓(2)
4. Creative and Critical Thinking	✓(1)		✓(3)
5. Managing Information	✓(2)	✓(3)	

Figure 7.9 – Results from Team Einstein

Codes	1 st Processing Sheet	2 nd Processing Sheet	3 rd Processing Sheet
1. Team Communication		✓(3)	✓(2)
2. Personal Effectiveness and Interdependence			
3. Working Cooperatively as a team	✓(3)	✓(1)	✓(1)
4. Creative and Critical Thinking		✓(2)	✓(1)
5. Managing Information	✓(2)		