The role of the affective domain in post-primary mathematics in Ireland: a comparative study between two cohorts of junior certificate students.

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Abstract

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A new mathematics syllabus, called Project Maths was introduced on a phased basis for all Irish post-primary schools in September 2010. Project Maths promotes active learning, student understanding of mathematical concepts and has a key emphasis on problem-solving skills in unfamiliar contexts.

This study set out to compare attitudes of two cohorts of Junior Certificate (Year 2) students to mathematics. Cohort 1 (n= 128) students had followed the traditional pre Project Maths syllabus while Cohort 2 (n = 138) students had been exposed to strands 1 and 2 of the new Project Maths initiative. The study sample involved students from five post-primary school types in the North West region of Ireland.

An attitudinal questionnaire, student worksheet and semi-structured interviews were used to generate quantitative and qualitative data.

Cohort 2 students reported statistically significant higher mean scores for five of the seven affective variables compared to Cohort 1 students with both Cohorts having above average scores for anxiety. Importantly, Cohort 1 students reported statistically higher ($p < .0005$) mean scores for mathematical understanding; however Cohort 2 students did better on problem-solving questions. Cohort 2 students reported difficulties with classroom pacing and the text-heavy emphasis of Project Maths questions. Student attitudes to mathematics were not found to be correlated to examination success for both Cohorts. Favourable feedback was received on active learning methodologies from Cohort 2 students.

Overall, the introduction of Projects Maths has led to improved scores in key affective variables. However, concerns around student mathematical understanding, classroom pacing and high anxiety levels remain. Recommendations are offered to address these issues.

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List of abbreviations

CSPE	Civic, Social and Political Education
FCL	Fostering a Community of Learners
ICT	Information Communication Technology
IMTA	Irish Mathematics Teachers Association
NCCA	National Council for Curriculum and Assessment
PISA	Programme for International Student Assessment
TIMSS	Third International Mathematics and Science Study
TL21	Teaching and Learning for the 21st Century
VITAE	Variations in Teachersô Work Lives and Effectiveness

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1. Rationale

1.1 Introduction

This chapter will highlight the reasons for undertaking the research study. The context of the study will be discussed along with the benefits that should be derived from the study. An overview of the chapters in the study will be delivered. Finally, a number of terms that will be used throughout the study will be described.

1.2 Background

A new mathematical syllabus (Project Maths) is currently being introduced into secondary schools nationally. It will transform the way in which the subject is taught and learned (NCCA, 2010). Mathematics is a wide-ranging subject which branches into many other subjects. This is one of the reasons why an emphasis is currently being placed on relating the subject to everyday situations. Mathematics has been reported in a very negative manner by the media over the past three years. Reports on falling numbers achieving higher leaving certificate level and high failure rate at all levels encouraged a review of post-primary mathematics (NCCA, 2006). The number of students taking higher level mathematics has fallen since 2009. Only 5.7% of students achieved A1 standard in higher level leaving certificate mathematics in 2011 (www.irishtimes.ie).

Many studentsô choice of level of mathematics at Leaving Certificate is influenced by the third level course that they wish to study. Students often decide to take ordinary level mathematics if their course does not require higher level (NCCA, 2005). Students are therefore failing to achieve their highest grade possible in mathematics. More importantly students are not influenced by the subject itself and after 13 or 14 years have still not developed a ñloveò for the subject. Students often move to ordinary level due to the heavy work load and time element attached to higher level mathematics (NCCA, 2005).

A re-introduction of bonus points for higher level leaving certificate mathematics was a welcome suggestion by third level faculty at a conference in February 2010 (Donnelly, 2010a). This was introduced for students sitting their Leaving Certificate in 2012 or after. Also there was an indication that third level institutions would be encouraged to accept an E at higher level leaving certificate mathematics. This would be welcomed as it would encourage more students to remain at higher level mathematics (Holden, 2010a). The new Project Maths syllabus hopes to increase the number of students studying higher level mathematics and the number who will study it further at third level.

Grade inflation was an issue raised in March 2010. Researchers have shown that there has been an increase in the number of people attaining third level places and also the number of first class degrees. However, it has also been shown this inflation applies to the number of students taking and achieving higher level grades (Flynn, 2010). Many multinationals do not employ students that have achieved degrees from certain third level institutes. Employers have found that these students do not possess the correct skills required for their field of work (Flynn, 2010). Similarly, Barrett (2010) spoke out about how Ireland is not competing in the field of nanotechnology, biotechnology and alternative energy, the areas of growth in the worldôs economy. The new Project Maths syllabus aims to improve student understanding of mathematical concepts and relate them to óreal-lifeô situations. Perhaps this will help develop these industries in Ireland in years to come.

Project Maths Teaching and Learning for the 21st Century is the new post-primary mathematics syllabus for both Junior and Leaving Certificate mathematics. The new syllabus involves changing how a student learns mathematics, what they learn and how they are assessed. *Teaching for understanding not teaching for learning* is the ethos of the Project Maths syllabus. The researcher has attended continuing professional development courses for the implementation of this syllabus and has observed the theme of teaching for understanding being developed in the teaching methodologies suggested for use in the classroom. Led by the National Council for Curriculum and Assessment (NCCA), it was introduced into twenty four pilot schools in September 2008. It was rolled out nationally on a phased basis in September 2010. The syllabuses are being introduced on a phased basis.

The syllabuses consist of 5 strands.

Strand 1- Statistics and Probability

Strand 2- Geometry and Trigonometry

Strand 3- Number

Strand 4- Algebra

Strand 5- Functions.

Figure 1.1 below shows the timeline for the national roll out of the Project Maths syllabuses. Strands 1 and 2 were introduced into the curriculum of year one junior and senior students in 2010. Students will be encouraged through application to real life to appreciate mathematics. The students will be encouraged to develop skills in analysing, interpreting and presenting information and applying these skills to both recognisable and unrecognisable problems (www.projectmaths.ie accessed 5/02/2012).

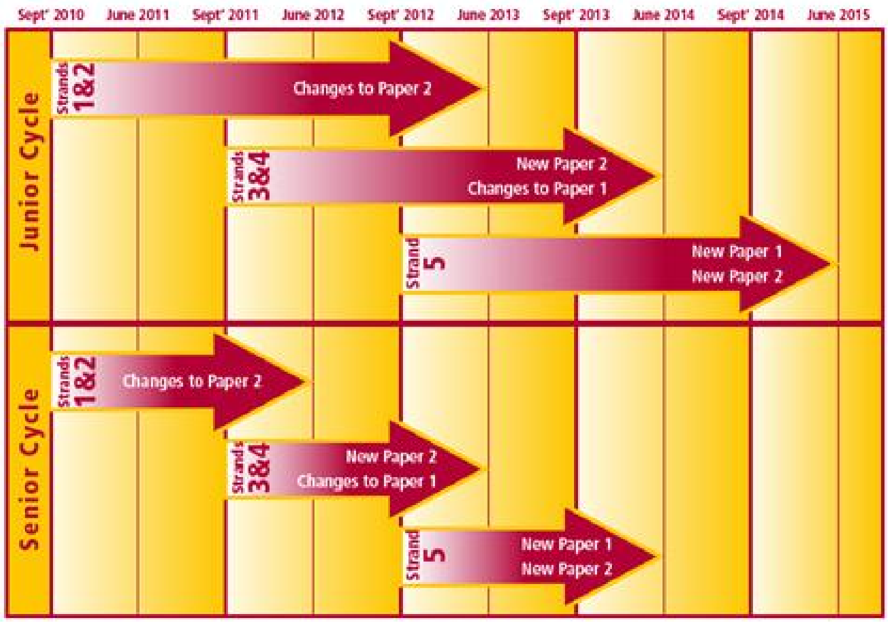

Figure 1.1 Timeline for national roll out of Project Maths syllabus

The Junior Certificate syllabuses will expand and build on the investigative approach to mathematics learned at primary school. A framework is currently being developed to link various parts of the syllabuses to primary school mathematics. Junior Certificate mathematics will be offered at both higher level and ordinary level with a target of 60% taking higher level. This is aimed at leading to a greater uptake of leaving certificate higher level mathematics. The foundation level will remain under review as the syllabuses are introduced.

The Leaving Certificate syllabuses will develop knowledge and skills for studentsô future lives as well as for third level. The Leaving Certificate syllabuses will be offered at foundation, ordinary and higher level. A target of 30% uptake at higher level is aimed for under the new Project Maths syllabus. The acceptability from foundation level to some third level courses is being explored.

The most significant change to the curriculum is in the approach to assessment. The Project Maths syllabuses emphasises the need for a varied approach to assessment. A variety of strategies will enable the teacher to modify teaching practices and in turn attempt to improve learning (NCCA Project Maths syllabuses, 2010). The syllabuses also encourage feedback to the learner to help develop the learner.

The traditional Junior Certificate examination consisted of two papers, both containing six questions with no choice and they all carried equal marks. The Leaving Certificate examination consisted of two papers; paper 1 consisted of eight questions of which six must be answered, paper two consisted of two sections. Section A contained seven questions of which five must be answered. Section B consisted of four questions of which one must be answered. All questions carried equal marks. In all papers in the traditional syllabuses the topics were fixed to questions (Appendix J).

The Project Maths examination will also be presented in two papers. Paper I consists of section A and section B. Section A will examine concepts and skills in six questions. These questions all carry equal marks. Section B will examine context and applications through 3 questions which carry equal marks. Both sections carry equal marks and the students must answer all nine questions. Paper II consists of two sections. Section A examines concept and skills in six questions. Section B consists of 2 questions and again examines the studentsô contexts and applications of mathematics. Both sections are worth equal marks. In both papers there will be no choice after the first three year cycle has occurred (Appendix J). The layout of these papers demonstrates that the studentsô ability to relate and apply mathematics to real life is more important than their ability to apply formulae.

1.3 Scope and significance of the research

The researcher has taught mathematics at all levels from Junior Certificate to Leaving Certificate for twelve years. The researcher has noticed in her teaching the difficulty students have in understanding and relating mathematics to óreal-lifeô situations. The researcher wanted to carry out the study to identify the improvement if any in student understanding in mathematics after they have been exposed to the new Project Maths syllabus (strands 1 and 2).

This research project will be carried out on two groups. Cohort 1 is the control group; these students have been taught the traditional Junior Certificate. Cohort 2 is the test group; these students have been exposed to strands 1 and 2 of the Project Maths syllabus. The study includes students from all five types of secondary level school types in Ireland.

This research differs from other similar studies as it is classroom based. It is hoped that the research will be of interest to teachers of other subjects, students and parents. It is hoped that the insights and findings will be of interest to the National Council for Curriculum and Assessment (NCCA), the Project Maths team and to the Irish mathematics teachers association.

1.4 Overview of chapters in the study

Chapter 2 is a review of literature that has relevance to this study. This chapter will develop the theme of the study through the literature and justify their inclusion. The research questions which will guide the study will be developed in this chapter.

Chapter 3 is the methodology chapter. This chapter lays down the main aim of the study. The theoretical framework which guides the study and which was developed from the literature review is outlined in this chapter. The research design including the instruments used in the study will also be described here.

Chapter 4 details the findings from the study. This chapter reveals the findings from each Cohort individually and then presents a comparison of both Cohorts together. The findings are organised under each of the research questions.

Chapter 5 exhibits the discussion on the findings from chapter 4. The discussion will relate the findings back to the literature reviewed in chapter 2. Conclusions and recommendations will then be drawn from the discussion.

1.5 Research aims and research questions

The following research aim and research questions were developed through the analysis of relevant literature and through the practical mathematical classroom experience gained by the author over the past twelve years.

1.5.1 Research Aim

The overall aim of the research project is to investigate the extent that the use of active methodologies in the classroom will improve the attitude to and the understanding of mathematics of post-primary Junior Certificate students. A new mathematics syllabus called Project Maths (strands 1 and 2) was introduced into all Irish post-primary schools in September 2010. This new syllabus has a strong emphasis on teaching mathematics for understanding using active methodologies. This study differs to previous studies carried out as it is directly connected to classroom practice.

1.5.2 Research questions

The research project was guided by the following research questions:

1. To what extent are attitudes of students related to their understanding of mathematics?
2. To what extent are student attitudes related to the methods of teaching and learning of mathematics?
3. To what extent are student attitudes related to their success in mathematics examinations?
4. What level of *confidence*, *anxiety*, *beliefs*, *enjoyment*, *self-concept*, *value*s of and *motivation* in the subject do students exhibit towards mathematics?
5. Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre Project Maths syllabus and strands 1 and 2 of the new Project Maths syllabus?

The research questions developed from the review of relevant literature which will be explored in chapter 2. The research questions were answered using three methods of data collection. These methods were a student questionnaire (Appendix E), a student worksheet (Appendix F) and semi-structured interviews (Appendix G). The methods of data collection will be described in chapter 3. The development of the research aims and questions will be discussed in chapter 3.

1.6 Description of terms used throughout the study

Terms which are referred to throughout this chapter will be explained here first.

The Programme for International Student Assessment (PISA) is an international assessment that is administered to 15 year old students in the main industrialised countries. It tests studentsô knowledge and skills required for life after full time education. PISA tests students in the areas of literacy, mathematical and science proficiency. It was first introduced in 2000 and the assessment is carried out every three years (PISA report, 2011).

The Organisation for Economic Co-operation and Development (OECD) is an organisation which helps governments to foster prosperity and fight poverty through economic growth and financial stability. This organisation funds the PISA project.

Variations in Teachersô Work Lives and Effectiveness (VITAE), was a study carried out from 2001 to 2005 in various parts of the UK. The project involved three hundred primary and secondary school teachers of varying age and experience. The aim of the project was to explore teachersô personal and work lives in order to investigate a change in effectiveness in teaching over time.

The Teaching for Learning for the 21st century (TL21) was a project which aimed to enhance innovation and creativity in post-primary schools in Ireland. The project involved action research in classrooms in the participating schools. Students were encouraged to become active learners and responsible for their own learning (TL21 report, 2007).

Trends in International Mathematics and Science study (TIMSS). This is a worldwide research project, taking place every four years and providing data about trends in mathematics and science achievement over time. It assesses the knowledge and skills of pupils aged 9-10 and 13-14 around the world, and enables researchers to collect extensive background information about the quantity, quality, and content of teaching, which can be used to make comparisons between participating countries. Findings from the survey are used to inform education policy and to improve teaching and learning in mathematics and science for pupils around the world.

Project Maths is the new mathematics syllabus introduced into all second level schools in Ireland in 2010. A full description of the syllabus has been given above in section 1.2.

Cohort is the group of students that the study is being carried out on. Cohort 1 is the control group. These students were not exposed to Project Maths. Cohort 2 is the test group. Cohort 2 students were exposed to strands 1 and 2 of the new Project Maths syllabus.

2. Literature Review

2.1 Introduction

The main theories and concepts relating to affective variables and teaching methodologies connected to mathematical understanding will be examined in this chapter.

One of the aims of the traditional mathematics syllabus is to enable students ñto develop a positive attitude towards mathematics as an interesting and valuable subject of studyò (Department of Education, 1996). Attitudes to mathematics along with other related issues such as student understanding, assessment, etc. were addressed in the ñReview of Mathematics in Post-Primary Educationò (NCCA, 2005).

This chapter will begin by discussing the various definitions of attitude that exist and how attitude relates to mathematics. The author has found during her twelve years of classroom experience that studentsô social background, parents, peers and learning environment influence their attitude towards mathematics and therefore these are reviewed in the chapter. Finally, student understanding, their learning styles and assessment processes will be examined.

2.2 Affective Variables

2.2.1 Attitude

Allport (1935) believed that an attitude was a complex interaction between the mind, body and emotion. An attitude is learned, causes a behavioural reaction, is either positive or negative and is held with a certain amount of energy (Allport, 1935). He accepted that an opinion was an expression of an attitude. Fishbein and Ajzen (1972) agree that a person evaluates a situation or has a belief about an object. McGuire (1969, 1985, 1989) concurred with Allport (1935) that heredity had a role to play in ethical or racial attitudes. McGuire (1969, 1985, 1989) developed the tripartite definition which extends from Allportộs definition. This definition looks at attitudes in terms of behaviour, affect and cognition. In addition other researchers have linked feelings, thoughts and behaviour, and have tied these in with the tripartite definition (Millar and Tesser, 1986, Wilson and Dunn, 1986 and Isen, 1987).

Similar to Allport (1935), McGuire (1985, 1989) also believes that attitudes are predictions on any object and that evaluation plays a central role in attitudes (Fazio, 1989 and Zanna and Rempel, 1988). A definition of attitude which intertwines all of the above definitions is given by Eagly and Chaiken, (2007, p 585). This definition is:

> ña psychological tendency that is expressed
> by evaluating a particular entity with some
> degree of favour or disfavourò.

In this definition, evaluation of an attitude towards an object is emphasised. beliefs, thoughts, emotions and feelings are also tied into this definition.

2.2.2 Attitudes towards mathematics

Affective variables influence both teaching and learning of mathematics (Klinger, 2006). Mathematical *anxiety* is recognised as an impediment to performance (Gourgey, 1982). Aiken (1974) found that students express strong feelings of fear towards mathematics which results in avoidance of the subject. This fear can result in people making negative comments towards the subject.

Zan, Brown, Evans, and Hannula, (2006) link emotions with decision-making and attitude. Eynde and Hannula (2006) illustrated the emotions that a student goes through while solving a mathematical problem. *Motivation*, *anxiety*, *confidence*, *enjoyment* and *self-belief* were expressed by the student while solving the problem.

This study will concentrate on seven affective variables that the researcher has found to impact on a studentsô attitude towards mathematics. These affective variables are: *confidence*, *anxiety*, *beliefs*, *enjoyment*, *self-concept*, *value* and *motivation*.

Fennema and Sherman (1976) developed nine scales aimed at improving female participation and performance in mathematics. The scales that have been used in this research project are; óConfidence in Learningô (*confidence*), óMath Anxietyô (*anxiety*), and óEffectance Motivationô (*motivation*). The scales of both Gourgey (1982) and Crawford, Gordon, Nicholas, and Prosser (1998) have been used to measure *value* in this project. Gourgey (1982) developed a scale for the measurement of *self-concept* in mathematics. This scale was developed from studentsô reflection of their own mathematical ability. Crawford *et al* (1998) developed their scale based on conceptions of mathematics.

Completed questionnaire items from high school students led Tapia and Marsh (2002) to identify four affective variables. These were self-confidence, *value*, *enjoyment* and *motivation*. The resulting scales were used in the questionnaire to measure *confidence*, *anxiety*, *enjoyment* and *motivation*. Schoenfeld (1989 and 2004) concentrated on studentsô acknowledgement of mathematical success or failure. The studies concentrated on student perception of and relationship with mathematics. The scales taken from the Schoenfeld (1989 and 2004) will measure *beliefs* about mathematics, *self-concept* and *value* of mathematics.

Value and *enjoyment* were measured using items from Aiken (1974) scale. Aiken (1974) created a scale which measures these two variables together. Aiken (1974) found that *enjoyment* was more linked to mathematical ability and interest while *value* was correlated to verbal and general academic ability. Grouws, Howald, and Colangelo (1996) aimed to measure conceptions of mathematics. This was achieved by carrying out a comparative study on talented mathematical students and average mathematical students. *Confidence*, *beliefs* about mathematics, *self-concept* and *value* of mathematics were measured using items from this scale.

Klinger (2006) based his study on student *confidence* in mathematics and self efficacy *beliefs*. His study found a relationship between maths-anxiety and mathematical language. This scale was used to measure *confidence*, *anxiety*, *beliefs* about mathematics, *enjoyment*, *self-concept* and *value*.

2.3 The influence of social background, parents, peers and learning environment on students' attitude towards mathematics

The attitude of a student towards mathematics is influenced by their social background, parents, peers, and learning environment (Singh, Granville and Dika, 2002 and Lyons, Lynch, Close, Sheerin, and Boland, 2003).

2.3.1 Social background and students' attitude towards mathematics

In the past a studentøs social status has determined, not only the class a student is placed in but also the school which they attend (Boaler, 1997). Studentøs socioeconomic status was related to mathematics proficiency in the PISA report 2006 (Eivers, Shiel and Cunningham, 2006). The PISA study found that students with higher socioeconomic status out preformed those with a low socioeconomic status. This was emphasised in a study published which investigated the high number of early school leavers in Ireland (Byrne and Smyth, 2010). Walshe (2010a) pointed out the negative effect this would have on the economy. Early school leavers face a ólow-qualityô of life and unemployment. This costs the economy more and undermines the attempt by the government to up-skill people to create a ósmartô economy (Walshe, 2010a).

However, there is reason to believe that the problem of early school leaving may be linked to attitudes towards education. Lyons *et al* (2003) carried out a study on ten different post-primary schools in Ireland. The study found that children from working class backgrounds were more likely to attend vocational or community co-educational school, while middle-class children were more likely to attend single-sex or fee paying schools. A greater proportion of middle-class children were in higher or middle stream classes. Parents were found to have chosen a school due to reputation (Lyons *et al,* 2003). Therefore, the education of their children is very important to them. This was influenced by their own knowledge of the education system, social class and their own experience of education (Lyons *et al,* 2003). Therefore, parental influence on their childrenøs attitude towards mathematics will be discussed in the next section. The researcher has found from her twelve years of classroom experience that children from working class background have a negative attitude towards education, usually are in low stream classes and usually leave school early.

2.3.2 Parents influence on students' attitude towards mathematics

Studentsô attitude towards mathematics is influenced by parents and teachers (Singh *et al,* 2002). Research has shown that these social forces can have a positive influence on the studentsô learning of mathematics. Schreiber (2002) observed that the magnitude to which parents were educated influenced their childôs attitude towards mathematics. English, OôDonoghue and Bajpai (1992) had the same opinion when his study found that parents recognise the importance of doing well in class, but were unable to help their son or daughter with a problem. This may be due to parents leaving school early or having had a negative school experience themselves. An initiative has now been put in place to help parents support their childôs numeracy (Department of Education and skills, 2011).

Parents are the primary educators of their children. Many studies have been carried out to measure the impact parents have on their childôs learning. Henderson and Mapp (2002) established that families can improve their childôs academic performance and have a positive impact on both school attendance and behaviour. Steinberg, Lamborn, Dornbusch and Darling (2008) concurred with this and revealed that authorative parenting in the home environment leads to better adolescent school performance and stronger school engagement. Aubrey, Bottle and Godfrey (2003) confirmed this theory through a study revealing that early intervention by parents helped improve numeracy and foster positive attitudes towards future learning. Henderson and Mapp (2002) also suggest that schools should support parents in helping their children. The researcher has found from direct observation that students who have parents that show interest in their progress and support them during study perform better than students who donôt have the same support.

Studentsô peers also have an influence on their attitude towards mathematics (Kang, 2006). This issue will now be examined in the next section.

2.3.3 Peers influence on students' attitude towards mathematics

Social development of students takes place inside and outside the classroom. Student to student relationships maximise achievement, socialisation and healthy development (Johnson, 1981). Chionh and Fraser (2009) found that achievement was better in classrooms that had more student cohesiveness. However, Kang (2006) discovered that low achieving students tend to interact with other low achieving students which had a negative effect on their learning. Similarly, high achieving students relate better to other high achievers which helped improve their learning (Kang, 2006). Contrastingly, mixed ability groups have higher expectations than a streamed ôlow-abilityô group (Sullivan, 2007). Regardless of this evidence, Johnson (1981) established that student to student interaction was omitted to make room for teacher to student interaction. Evidence of this was reported by Lyons *et al* (2003) who reported that 96% of all interactions that take place in the classroom are teacher led. This study also found that competitive individual learning was dominated over cooperative learning experiences which promote positive educational outcomes (Johnson, 1981). The researcher has found that teachers tend to prevent student to student interaction in order to control discipline in the classroom. Stassen (2003) confirmed that students show more positive outcomes when involved in group work rather than through individual work. Arnold and Lawler (2012) also promote group work as their study found that group work not only made students more comfortable it also led to higher self-confidence.

Males and females show different learning styles of mathematics. Girls have a more positive view towards the subject, teaching of the subject and eagerness to do well in mathematics (Lyons *et al,* 2003). House (2002) found that males who worked in groups had lower test scores. Becker (1995) complemented the previous study when his evidence showed that males seem to work well on their own and in pressurised, competitive situations, whereas girls work best in group environments with support.

2.3.4 Learning environment and its influence on students' attitude towards mathematics

The environment in which teaching takes place can have an influence on the learning and understanding that occurs. Boaler (1999) found that the students from a school which reflected everyday life i.e. no uniform or a bell, had a better understanding of mathematics and were better able to relate it to their everyday life. While, the students from a more traditional school had a narrow view of mathematics and saw it as a classroom based subject with no relevance to their everyday life.

Students who have a fear of mathematics do not ask questions in class in case they are criticised and prefer to ask a peer or a parent rather than speaking out in class (Lyons *et al,* 2003). When a positive learning environment was fashioned studentsô anxiety decreased (Lyons *et al*, 2003). Brosnan (2008) proved this by increasing the wait time after a question and studentsô confidence improved greatly.

Boaler (2002) highlighted the large number of students that gave up the study of mathematics as soon as possible, even if these students were capable of further study. Her study showed that this problem can be connected to a social or psychological issue. Teachers have the ability to strengthen positive attitudes in students towards mathematics. According to Singh *et al* (2002), this can be carried out by providing a positive learning environment for the students. Similarly, Walshe (2010c) discovered that a positive learning environment is more likely to encourage students to remain in education. Students most at risk of leaving school early are those in lower streamed classes. Comparably, Klinger (2006) found that the most effective learning experiences occurred when there was a positive relationship between the teacher and student.

Studentsô understanding of mathematics also affects their attitude towards mathematics (Orhun, 2007). As will be discussed in the next section evidence has shown that students learn in a variety of approaches (Orhun, 2007) and so teaching methods should also be varied to suit these learning styles.

2.4 Students’ understanding of mathematics

2.4.1 Instrumental Understanding

Instrumental understanding is óknowing howô to do something (NCCA, 2010). In mathematics instrumental understanding allows students to recognise a topic and input numbers into a formula in order to gain an answer. Instrumental understanding tests basic mathematical ability.

Mathematics is seen by many people as a collection of disconnected procedures and formulae which must be memorised and applied in examinations in order to gain high grades (Boaler, 2002). This can demonstrate a lack of understanding of mathematics and therefore an inability to apply mathematics to everyday problems. Brosnan (2008) in her Ph.D study found that students were unable to discuss mathematics. Students in her study believed that mathematics was a series of procedures and notes that should be learned off. This was due to exposure to traditional methods of teaching (Brosnan, 2008).

Studies have shown that a large proportion of the interactions that take place in the classroom are teacher led (Lyons *et al,* 2003) and that many pre-service teachers use a traditional didactic approach to teaching (Liston and OöDonoghue, 2009). There is an over reliance on textbooks and teaching is exam driven (Lubienski, 2011). These trends favour an emphasis on instrumental understanding. The TL21 project showed that teachers covered the course in the order the chapters were in the book (TL21 report, 2007). Brosnan (2008) reported on the influence of exams in the classroom. Teachers felt they needed to cover the course as quickly as possible to leave time for revision at the expense of the studentsô understanding. The NCCA (2006) reported that teachers found that there was inadequate time given to complete the course especially at Junior Certificate.

In the twenty classrooms that Lyons *et al* (2003) studied, a traditional approach to teaching mathematics was found to be in use. During these classes the students rarely interacted in the class. Ninety six percent of all interactions in the classroom were teacher led. This problem can be connected to the training which teachers receive and the influence of their own school experience (Pauolucci and Meehan, 2009).

Teachers tend to teach in a manner similar to how they were taught (Eaton and OôReilly, 2009 and Paolucci and Meehan, 2009). This point is further emphasised by the findings of Liston and OôDonoghue (2009). In their study they found that pre-service teachers approach the teaching of mathematics in a rote traditional manner. This approach favours instrumental learning. Many student teachers surveyed did not see how mathematics could be made interesting or how they could be creative in the classroom with the subject (Paolucci and Meehan, 2009). The VITAE project report (2007) found that teacher effectiveness did not increase with experience.

The amount of ómathematics content knowledgeô held by primary school teachers was the focus of research for Hourigan and OôDonoghue (2007). This study showed that many primary school teachers believed that because the content was ñeasyò, then teaching it would be too. However, they must be able to explain concepts, interpret student understanding and adapt the content to suit a variety of learners. Therefore, primary teachers need a ódeep and richô knowledge of the subject matter. This is not often held by primary school teachers due to the training that they receive (Hourigan and OôDonoghue, 2007) and therefore learning is often only at an instrumental level.

Statistics relating to ñout of fieldò teaching in mathematics were reported recently (Ní Ríordáin and Hannigan, 2009). This is a worrying issue, as forty eight percent of teachers are currently teaching levels of mathematics which they are not qualified to do. An extension of this issue is that sixty three percent of the unqualified teachers surveyed did not know that they were unqualified (Ní Ríordáin and Hannigan, 2009).

The teacher is responsible for harvesting the interest of a student in the subject. There is a place for both traditional and active teaching methodologies in the classroom.

2.4.2 Relational Understanding

Relational understanding is ‘knowing why’ you have done something (Skemp, 1979 and NCCA, 2010). In mathematics this type of understanding tests higher order thinking.

Relational understanding versus instrumental understanding was investigated in a comparative study between Japanese and American mathematics lessons Stigler *et al* (1996). Japanese teachers saw errors as a natural learning process and an important source of information about the student. While, the American teachers tried to keep errors out of the classroom. Japanese teachers encouraged discussion in the classroom and questions were phrased to initiate this. However, American teachers questioned at a low level of thinking and did not encourage discussion. In fact, American students thought that whatever was important came from the teacher not a student (Stigler *et al,* 1996).

One aspect of the Japanese lessons was adapted for an Irish study carried out by Corcoran (2009). The study involved reflecting on comments made by pupils in a secondary level class and then discussing these and mathematical skills with colleagues and observers of the lesson. This enabled the teachers to adapt the lesson to the learners’ needs and also evaluate student understanding (Corcoran, 2009). The student teachers that carried out the research in this study found that there were improved teaching and learning outcomes (Corcoran, 2009). Auster and Wylie (2006) emphasised similar findings when they stressed the importance of listening to student feedback which is often neglected. This feedback leads to changes and improvements in content delivery.

Schoenfeld (2004) finds resonance in the heightened emphasis on relational understanding in Project Maths, Schoenfeldôs study encouraged the ethos of óteaching for understandingô. Fostering a Community of Learners (FCL) was implemented into classes in his study. This strategy allowed large topics to be broken down and taught as a number of sub-topics and then ójig-sawedô back together. FCL like other active learning methodologies came up against resilience as teachers found it difficult to change their teaching methods (Schoenfeld, 2004).

Kupari (2007) carried out a study on Finlandôs high achievement after the 2006 PISA results (mean score of 548) were published. His study found that one of the main reasons for Finlandôs high score is the emphasis on problem-solving in mathematics (Kupari, 2007). The PISA 2009 study shows that Ireland had a mathematical mean score of 487. Ireland was significantly below the OECD average and is ranked 32 out of the 65 participating countries in mathematics proficiency. One of the five schools involved in the authorôs research study also took part in the PISA (2009) study. The school had a mean mathematics score of 541 which was higher than the OECD average of 496. However, this school does not achieve above average Leaving or Junior Certificate results in mathematics. Contrastingly, Schulman (1996) found that high achieving students were unable to cope with basic number operations outside the classroom and especially without the backup of a pen and paper. The students in Schulmanôs (1996) study had little understanding of the mathematical procedures they had learned and were unable to build on the mathematical concepts that they had memorised (Schulman, 1996).

Project Maths is the new mathematics syllabus which was launched nationally in September 2010. The new syllabus will encourage teaching for understanding, problem-solving, the use of active learning methodologies, active discussion, increase the use of technology in the classroom and application of mathematics to ‘real-life’ situations (NCCA, 2010). The National Council for Curriculum and Assessment (NCCA), the statutory body which informs the government on educational matters, carried out an extensive review of mathematics in post-primary schools in 2005. This resulted in a model of curriculum development being published in 2007 which led to the Project Maths syllabus.

Project Maths has been developed on the ethos of *teaching for understanding* and not *teaching for learning by rote*. The new syllabus hopes to change the way mathematics is taught in post-primary schools. There will be an emphasis placed on active learning methodologies being used within the mathematics classroom. There is also an increased importance placed on the relation of mathematics to everyday life and connections between different topics in the syllabus (NCCA, 2007).

The traditional mathematics syllabus (Department of Education, 1996) and the Project Maths syllabus (NCCA, 2010) have similar aims including relating mathematics to ‘real-life’ situations. Surprisingly, the objectives of both syllabuses are similar also. Both detail the need for instrumental and relational understanding, the application of mathematics and the development of an appreciation of mathematics. However, the most significant difference between the two syllabuses is the delivery of the subject in the classroom. Active learning and problem-solving are encouraged in the Project Maths syllabus whereas there is an absence of explicit prescription of methodologies to be used in the traditional syllabus.

A survey of the 24 pilot schools was carried out by the Irish Mathematics Teachers’ Association (IMTA) in October 2011. The purpose of the survey was to elicit information on the implementation of the new syllabus. There was a fifty percent response rate. This survey asked each school to contribute five pieces of advice in relation to the implementation of the Project Maths syllabus (B. O’Sullivan, personal communication, October 2011 Appendix L). This survey found that students were enjoying the new methodologies for mathematics teaching being used in the classroom. The pilot schools emphasised the importance of the use of the syllabus as opposed to textbooks. The pilot schools stressed the importance of problem solving and hence student understanding. Whilst this is only a small sample, this feedback is encouraging in terms of teachers moving away from textbooks and rote learning to an emphasis on teaching for understanding and active methodologies for teaching mathematics. The interim report on Project Maths (2011) suggests that the up-skilling of teachers would help to remedy the criticism attached to the new syllabus.

Relational understanding is not just an aspirational objective of Project Maths it is now clearly being demanded from students in examinations.

2.4.2.1 Learning styles

Relational understanding requires a student to know why an answer is right, wrong or reasonable (Skemp, 1979). This is a skill that students need to develop through there own learning. There are a variety of learning styles that students use (Orhun, 2007). If students are aware of their own learning style they can become better learners. Supporting this, Boaler (2002) argues that as students learn mathematics they not only increase their knowledge, they also make connections to how they hold that knowledge and use that knowledge. Therefore, teachers have the responsibility to teach using a variety of methods so that as many learning styles as possible are catered for (Orhun, 2007).

Orhun (2007) carried out a detailed study on the learning styles of both male and female students. The findings of this study showed that male and female students preferred different learning styles. Females were found to be ñConverger Learnersò. These learners are active learners and solve problems using facts and discovery learning whereas; males prefer the ñAssimilator Learningò style. Males learn by observation and then thinking about the problem (Orhun, 2007). Girls want to understand mathematics more than males. Males were happier to just get through the work without gaining an understanding (Boaler, 1997). This study also found that girls were more confident than boys when group or project work was used in the classroom. In the researchers own teaching experience of mathematics, problem-solving is not utilised as a learning tool in the classroom. The development of this skill is encouraged in the Project Maths syllabus.

Biggs, Kember and Leung (2001) separated learning approaches into surface or deep learners. Surface learners are focused on reproduction of knowledge and depend on rote learning. Deep learners are more motivated to learn and seek meaning in the content. The NCCA Review of Mathematics in Post-Primary Education (2005) reported rote learning styles and therefore surface learners to be predominant among post-primary students in Ireland.

Boaler (2002) makes the argument that students must make connections in mathematics to everyday problems, only then will understanding of mathematical concepts develop. It is from this understanding that students will be able to increase their knowledge of mathematics. Carroll and O'Donoghue (2009) discovered that students were unable to link topics in mathematics to real-life situations. If students find purpose in their learning, they can connect it to the world around them or connect it to a career path then their attitude towards the topic will improve (English *et al,* 1992).

One of the aims of the Project Maths syllabus is that students will have an understanding of mathematical concepts and be able to relate these to the world around them (NCCA, 2010). Technology is playing an ever increasingly important role in human life. ICT (information and communication technologies) have been used by students in schools for many years now. It has been shown that effective use of technology can promote problem-solving and reasoning (McKinney, Chappell, Berry, and Hickman, 2009). The Interim report on Project Maths (2011) suggests that contextualising mathematics in everyday life is very difficult and this should be approached with caution. While the report believes there is benefit in this practice it also notes that it is a very difficult concept to fulfil (Interim report on Project Maths, 2011). Lubienski (2011) echoed the same caution that some problem-solving questions are useful in the classroom to help students understand concepts but they are not always representative of practical situations.

Mathematics and ICT are heavily linked. Students who took part in the Teaching and Learning for the 21st Century project (TL21), showed increased confidence in the use of ICT in the classroom. Teachers in this project also reported increased student involvement, engagement and learning (TL21 report, 2007). Computer games should be incorporated into mathematics education. The skills of computer gaming encourage problem-solving (Ahlstrom, 2010). Reinforcing these studies there is significant research to suggest that the use of computer mathematical programmes in the classroom can improve the number skills, geometry and problem-solving skills of students (House, 2006).

Ernest (1991) argues that student teachers must learn in the same way as their students i.e. through projects and reflection. Teachers must make a connection between theory and practice and not concentrate on either one alone. OôMeara and OôDonoghue (2009) have developed a ñladder of knowledgeò. This instrument shows the steps required by teachers to gain the knowledge needed for effective teaching. The knowledge required is more than being comfortable with the course content. Teachers should have a historical knowledge of mathematics, be able to teach the course in a sequence of topics that the students can comprehend, link elements of the course and deal with the unexpected in class.

Active learning can be defined as; ñanything that involves students in doing things and thinking about what they are doingò (Bonwell and Elison, 1991 p.2). Active learning dates back to the 4th century when Plato encouraged children to learn through play and not through ñenforced learningò (Connolly, 2007). Extensive research (Lyons *et al*, 2003 and Brosnan, 2008) has shown that the role of the student in the traditional classroom is passive. Lyons *et al* (2003) found that ninety six percent of all interactions that take place in the classroom at post-primary level are teacher led. In the traditional type of learning environment, it has been found that there is little or no higher form of cognitive thinking and students do not problem-solving independently (Brosnan, 2008).

Research (Auster and Wylie, 2006) has shown that using a variety of teaching methods in the classroom not only allows the teacher to engage students with various learning styles, it also challenges students to think and learn in new ways. Auster and Wylie (2006) argue that active learning involves the student in the learning process. This allows the student to develop skills such as reflecting on learning and problem-solving. Pettyǿs (2004) findings support these studies. Active learning methodologies assist the encouragement of deep learning in students. Conceptualisations of what is being done are developed through neural connections. Passive learning does not require this (Petty, 2004). Only good students are able to create meaning from passive methods. Benefits of active learning are student self-assessment of their understanding, teacher assessment of student understanding and the development of analytical and problem-solving skills (Petty, 2004). The advantages of active learning methodologies tie into the objectives of the Project Maths syllabus. Thus active learning methodologies have many advantages which relate to improving relational understanding which is a key objective behind the Project Maths syllabus.

The use of active learning methodologies develops conceptual understandings of mathematical processes and concepts (McKinney *et al,* 2009). Singh *et al* (2002) found that studentsô motivation to learn increased significantly when the meaning and relevance of mathematics was part of the lesson. Further evidence to support this came from House (2006), who carried out a study on 13 year old students in Japan. House (2006) found that the use of active learning methodologies in the classroom significantly increased the test scores of students in algebra. These results are similar to the findings of the Third International Mathematics and Science Study (TIMSS, 1999).

2.4.3 Assessment

According to Suskie (2009) there are six principles of assessment. These are: usefulness, accuracy and truth, fairness, ethics, regularity/review and cost effectiveness. These principles should be taken into consideration when deciding upon a method of assessment that is used in the classroom (Suskie, 2009).

Schulman (1996) emphasises that assessment should be aligned with instructional understanding but also hints at relational understanding being important in the assessment process. Understanding should not be divorced from assessment.

> ñAn assessment system that focuses on broad learning outcomes, uses tasks that are aligned with instructional practices, involves students actively in the process and informs teachersô instructional and curricular decisions is recommendedò
>
> (Schulman, 1996 p 61).

Assessment in the classroom is a continuous process and acts to help students improve their understanding and learning (Schulman, 1996). One of the most significant changes that have taken place with the introduction of Project Maths is the change in emphasis on problem-solving and relational understanding on the examination paper. According to the NCCA (2007) this will improve the studentsô problem-solving skills.

An example of a question designed to test instrumental understanding from a Leaving Certificate higher level paper is given in figure 2.1 below.

> A circle with centre $(-3, 2)$ passes through the point $(1, 3)$.
> Find the equation of the circle.

Figure 2.1. Question from 2008 Leaving Certificate higher Level mathematics Paper 2.

Evidence from Chief Examinerôs Reports suggests that students have difficulty with a question of this nature involving basic numerical operations and conceptual understanding (Chief examiners report Leaving Certificate, 2001, 2005).

In the new Project Maths syllabus students will be expected to give a reason for an answer in examinations. An example of this type of question is given in figure 2.2 below. Copies of full Leaving Certificate papers for both syllabuses can be found in appendix J.

Twenty five students each measure and record a particular angle of elevation, in degrees, each using his or her own home-made clinometer. The results are as follows:

24	20	22	15	70
15	16	15	16	15
18	16	21	21	73
16	20	12	18	20
18	18	14	22	18

(i) Find what you consider to be the best estimate of the true value of the angle, explaining your reasoning.

Figure 2.2. Project Maths question from 2011 Leaving Certificate higher level mathematics Paper 2.

To develop this type of reasoning teaching for understanding rather than teaching for learning by rote is required. Chief Examiners Reports (2005, 2001) have all listed an inadequate understanding of mathematical concepts and under developed problem-solving and decision making skills (Chief Examiners Reports Leaving Certificate, 2005, 2001). According to feedback from the State Examinations Commission on the 2011 Leaving Certificate for strands 1-4 examined in 24 pilot schools, candidates were more likely to attempt all parts of the questions (Chief Examiners Report, 2011). This report accounted evidence of the use of discussion and exploration in the classroom from the responses of the candidates (Chief Examiners Report, 2011). This demonstrates relational understanding in the students. However, the Interim report on Project Maths (2011) suggests that the questions are phrased so that the answer requires the student to display some understanding.

A terminal written examination is the only form of assessment mentioned in the traditional syllabus (Department of Education, 1996). A coursework component that would assess problem solving, communication and creative skills is mentioned as a possibility in the traditional syllabus (Department of Education, 1996) but this was never implemented. The Project Maths syllabus (NCCA, 2010) encourages the use of a variety of assessment strategies including investigations, class tests, investigation reports, oral explanation, etc. These strategies can be altered to best suit the learners and to help the teacher reflect on teaching methods used. The Project Maths syllabus (NCCA, 2010) also highlights the importance of feedback from the assessment process to the learner. The theme of teaching for understanding is continued in this manner. However, the terminal examinations will remain to be the only form of assessment used for the entrance into third level courses.

2.5 Conclusion

This literature review has shown that the attitudes of students towards mathematics are related to their understanding, teaching methodologies used and to their success in examinations. There is a gap between showing that these relationships exist and to what extent they exist. This study was employed to investigate the extent of this relationship. A comparative study was used.

This chapter has given an overview of literature related to the subject of attitudes towards mathematics. A definition of attitude was developed which intertwines emotions, beliefs, thoughts and feelings. Leading on from this, the influence of attitude in mathematics was investigated. Seven affective variables emerged as items that influence the teaching and learning of mathematics. These were anxiety, motivation, confidence, enjoyment, belief, self-concept and value. Attitudes change depending on external influence. Some of these external influences were then investigated. It was found that students from higher socioeconomic backgrounds appeared to stay at school longer and achieve higher grades than students from lower socioeconomic backgrounds. Also, parents, peers and learning environment appear to impact studentøs attitude towards mathematics. Types of understanding and learning styles of students were examined and it was established that there are two types of understanding; instrumental (knowing what to do) and relational understanding (knowing why you do it). However, the types of learner that exist were found to be more varied. Converger learners are active learners while assimilator learners, learn from observation. Also, surface learners focus on the reproduction of knowledge and depend on rote learning whereas deep learners are motivated to learn and seek meaning in the content. All these learning styles have to be accommodated for in the classroom. Assessment style has changed with the introduction of the new Project Maths syllabus. Students are required to give a reason for their answer and method is more important than result. The variety of assessment techniques used should be broadened to accommodate the variety of learners in the classroom and the new assessment style. The affective variables and other items discussed in the literature review form part of the theoretical framework which directed the study and impacted on the research instruments used. The methodology used in this research project will be discussed in chapter 3.

3. Methodology

3.1 Introduction

This chapter will outline the research methodology. The chapter begins by describing the aim and the research questions which guided the study. Next, a synopsis of the theoretical framework which helped direct the choice of the research instruments is presented. The choice of research design is then described and justified using relevant and current literature. The chapter then proceeds to outline the data collection methods employed in detail together with the study population and research sample. The data analysis section explains how the data was analysed using descriptive statistics (e.g. mean and standard deviation) and inferential statistics (e.g. correlations and independent t-tests). Finally, issues pertaining to validity, reliability, ethics and limitations of this study are addressed.

3.2 Research Aim

The overall aim of the research project is to investigate the extent that the use of active methodologies in the classroom will improve the attitude to and the understanding of mathematics of post-primary Junior Certificate students. A new mathematics syllabus called Project Maths (strands 1 and 2) was introduced into all Irish post-primary schools in September 2010. This new syllabus has a strong emphasis on teaching mathematics for understanding using active methodologies. This study differs to previous studies carried out as it is directly connected to classroom practice.

3.2.1 Research questions

The research project was guided by the following research questions:

1. To what extent are attitudes of students related to their understanding of mathematics?
2. To what extent are student attitudes related to the methods of teaching and learning of mathematics?
3. To what extent are student attitudes related to their success in mathematics examinations?
4. What level of *confidence*, *anxiety*, *beliefs*, *enjoyment*, *self-concept*, *value*s of and *motivation* in the subject do students exhibit towards mathematics?
5. Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre Project Maths syllabus and strands 1 and 2 of the new Project Maths syllabus.

These questions arose from the literature review in chapter 2 and from the researcherøs own experience in the classroom. It emerged from the literature review that there were a variety of items which influenced the attitude of students towards mathematics. Type of understanding, learning styles, external influences, affective variables and success in examinations all emerged as items which influence student attitude towards mathematics. These issues gave rise to the first four research questions. The introduction of the new Project Maths syllabus has encouraged a change in teaching methodologies and assessment techniques. Cohort 2 was a distinctive Cohort, in that these students experienced topics taught from the traditional syllabus and from the new Project Maths (strands 1 and 2) syllabus. For this reason the researcher developed the final research question which compared both syllabuses.

3.3 Theoretical Framework

The theoretical framework was developed from the review of the relevant literature. The theoretical framework illustrates the connections between the affective variables and the external variables which influence the attitude of students towards mathematics. The questionnaire, worksheet and semi-structured interviews will use insights which emerge from this framework to collect data.

McLeod (1992) divided affective variables into three branches; beliefs, emotions and attitudes. This study will make use of this branching and investigate the influence of these three variables on mathematics. However, each of these variables have been broken down further.

Skemp (1979) found that emotions are influenced by *enjoyment*, *motivation*, *value* and *confidence*. Each of these emotions was then investigated with respect to mathematics. Scales to measure each of these emotions or affective variables were found. The author will employ items from each scale to test the impact of each of these emotions on a studentôs attitude towards mathematics.

McLeodôs (1992) second branch óbeliefs about mathematicsô were found to have studies carried out investigating this affective variable. Klinger (2006), Schoenfeld (2004) and Grouws *et al* (1996) all developed scales which measure beliefs about mathematics. Auster and Wylie (2006) and Porter and Masingila (2000) found that various teaching methods used in the mathematics classroom influences a studentôs beliefs about mathematics. Therefore, this study recognises the influence of the variety of teaching methods on studentsô beliefs about mathematics. However, the researcher has also found that the variety of teaching methods used impacts upon studentsô understanding of mathematics.

McLeodôs (1992) third affective variable, attitude has been defined by Albarracin and Wyer (2001) as evaluative judgements or affective or evaluative responses. However, not all responses or expressions are connected directly to an attitude. Therefore, it is worth noting that attitudes belong to each individual and it is the attitude that gives rise to a judgement which in turn will cause a response either through behaviour or emotion (Eagly and Chaiken 2007). Attitude towards mathematics is more specific to this study.

Attitude towards mathematics in this study was found to be influenced by the type of understanding emphasised in the mathematics classroom (Skemp, 1996, Schoenfeld, 2004 and Stigler *et al*, 1996). This emphasis has seen a shift from instrumental to relational understanding since the introduction of the Project Maths syllabus. As mentioned above the variety of teaching methods used in the mathematics classroom also has an effect on attitude. Peers, parents and the learning environment were also seen to influence student attitude on mathematics (Singh *et al*, 2002, Lyons *et al*, 2003 and English *et al*, 1992). All these variables have an impact on studentsô achievement and *anxiety*.

Achievement (Ajzen and Fishbien, 1980) and *anxiety* towards mathematics (Tapia et al, 2002) also come under the umbrella of attitude. Therefore these variables will also be employed in the study. *Self-concept* (Klinger, 2006, Schoenfeld, 2004, and Grouws *et al*, 1996) was found to impact on achievement in mathematics. How students view their own ability in mathematics is an important part of this study.

The theoretical framework (figure 3.1) is displayed overleaf. The theoretical framework outlines the items that impact on attitudes.

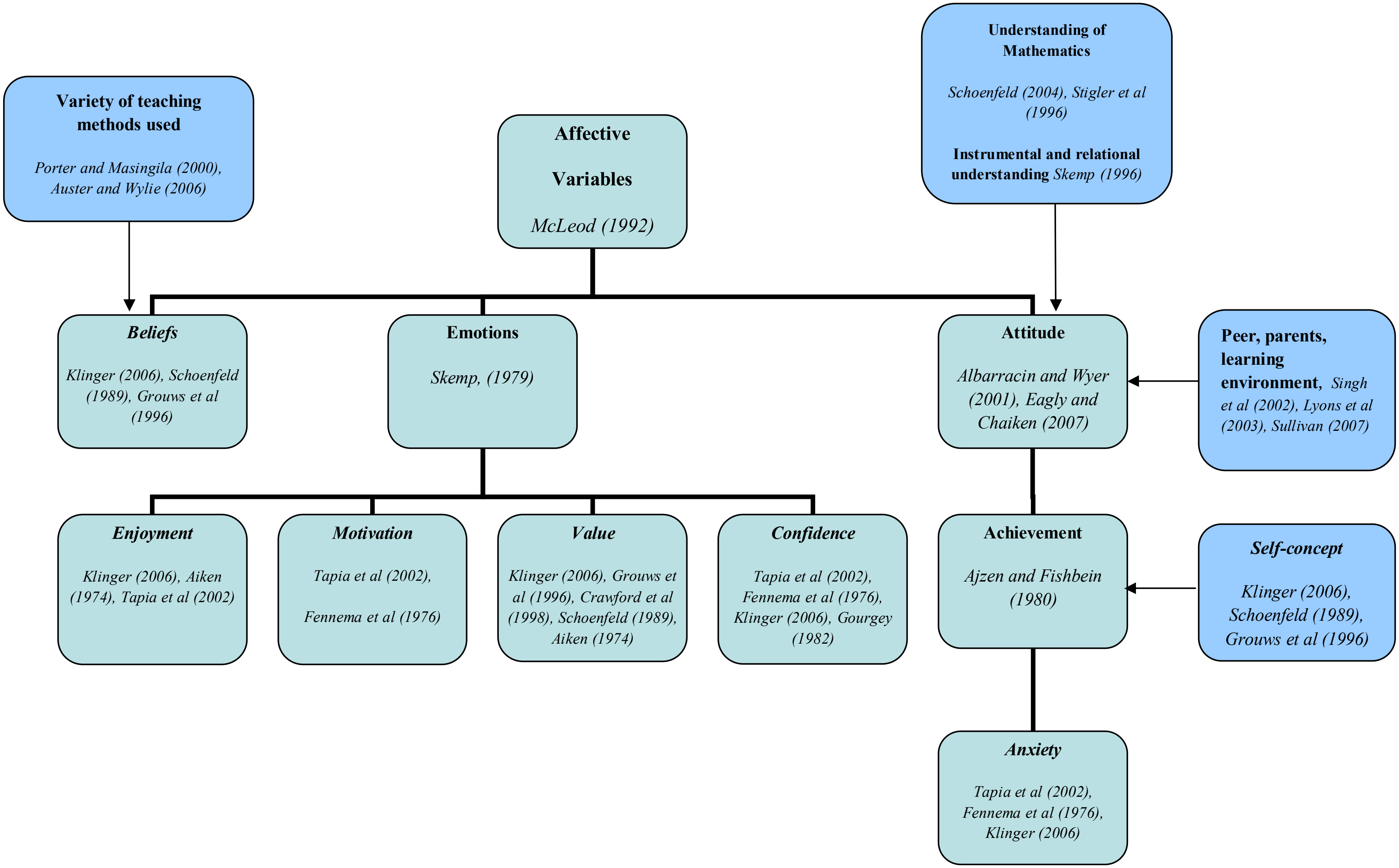

Figure 3.1 Theoretical Framework

3.4 Research design

3.4.1 Quantitative and qualitative research

Quantitative research is carried out by the collection of data in numerical form whereas qualitative research concentrates on the collection of data in non-numerical form, for example words, audio-recordings, pictures or videos (Onwuegbuzie and Leech 2005). Quantitative research generates numbers usually from questionnaires or observations (Denscombe, 2010). Denscombe (2010) describes quantitative data under six headings depending on the type of data produced. These are described in table 3.1 overleaf. The data types described here were used by the researcher in the development of the questionnaire. Nominal data was used to gather basic information about the students taking the questionnaire e.g. male/female. Ordinal data was used in the main part of the questionnaire. The items were answered using a ñLikertò type scale which graded the strength of agreement or disagreement felt by a student towards an item on the questionnaire. Qualitative data collection methods may help to explain quantitative data collected.

Qualitative research evolves through out the study, it generalises the study and the experience of the researcher is a factor in the research (Denscombe 2010). Remenyi *et al* (2010) describes qualitative research as a narrative of the data collected in the study. Ritchie (2001) believes that qualitative research can further help to explain the outcomes of quantitative research. The two methods represent a continuum of research which interacts with each other. One method can be used to build on the findings of the other method. Onwuegbuzie and Leech (2005) ague that the purpose of qualitative research is theory initiation and theory building, whereas, the purpose of quantitative research is theory testing and theory modification. It is reasonable therefore to suggest that one method will benefit from the other.

Qualitative and quantitative methods begin on very different premises. Qualitative allows a theory to develop as the research is being carried out. However, quantitative is more theory based from the outset (Wiersma and Jurs 2009). The basis for the latter is to control variability and to legitimise the outcomes (Bogard and Wertz 2006). Gerdes and Conn (2001) argue that quantitative research begins with extensive hypothesis testing and statistical interpretation. Qualitative data can be used to describe quantitative and help to explore quantitative findings further. For this reason it was important to look at the benefits of a mixed methods approach in this study.

Data type	**Description**
Nominal	Data that can be placed into a category e.g. male/female.
Ordinal	Data in categories but ranked in órderô e.g. responses to a questionnaire can be placed in five point scale.
Interval	Similar to ordinal data but the scale has a ranked distance between the categories e.g. years
Ratio	Similar to interval data but the scale begins at a ótrue zeroô e.g. income
Discrete	Data measured in whole numbers only e.g. number of children in a family
Continuous	Data that is measured to the nearest unit e.g. height

Table 3.1 Types of quantitative data (Denscombe, 2010)

3.4.2 Mixed methods approach

Mixed methods research can help to bridge the division between quantitative and qualitative research (Onwuegbuzie and Leech 2004). Triangulation refers to the use of quantitative research to corroborate qualitative research findings and vice versa (Webb *et al* 1966). Triangulation was developed to help employ more than one method in research and thus improve confidence in the findings (Webb *et al* 1966). Sechrest and Sidana (1995) highlighted the importance of a mixed methods approach to reduce the problems associated with the use of one method only. A combination of quantitative and qualitative approaches may be the best option to achieve confirmation and completion of the findings (Adami and Kiger 2005).

Creswell (2003) encourages the use of three elements of inquiry (Knowledge claims, strategies and methods) which combine to form different approaches to learning. From these, methods of data collection were chosen depending on which are best suited to the individual research study. These data collection methods will yield the results of the study which can then be analysed. This study has incorporated both qualitative and quantitative methods of data collection. Therefore, this study has followed a ómixed methodsô approach (Creswell, 2003). The quantitative method was used to collect data which was further explored using a qualitative method. It was felt that the use of a mixed methods approach may eliminate the biases inherent in the use of any single method (Creswell, 2003).

In this study the focus was on collecting data on the attitudes of students. The data generated numbers and thus a quantitative approach was employed. To further explain the results from the quantitative data semi-structured interviews were carried out. This involved a qualitative research approach. Therefore, it was decided that this study would benefit from the use of a mixed methods approach (Remenyi *et al* 2010), combining both qualitative and quantitative methods. Triangulation was achieved in this manner and it will be further discussed in the section 3.4.3 overleaf.

3.4.3 Triangulation

The quantitative method (Remenyi *et al* 2010) employed in this study involved a questionnaire completed by the students. A questionnaire is designed to collect data that can be used for analysis (Denscombe 2010). Questionnaires can be administered in a number of ways for example, mailed, computer, or telephone. Before the questionnaire is developed the researcher must know what is required and how to measure the variables (Sekaran 2003). The questionnaire was used to establish the attitudes of students towards mathematics. A Likert type scale was used in the questionnaire. This type of questionnaire is used extensively in the research of education to measure attitudes (Kulm, 1980). Therefore, it was an appropriate method to measure attitude, *beliefs*, *anxiety*, *confidence*, *enjoyment*, *motivation, self-concept* and *value*s of mathematics. The means of these scales can be viewed as interval data (Remenyi *et al* 2010). The questionnaire (Appendix E) will be discussed in detail in 3.5.2.1.

A worksheet was also completed by the students. The worksheet consisted of ten questions. These problems were Programme for International Student Assessment (PISA) like questions. These questions are of a problem-solving nature and emphasise application involving context. Cohort 1 would not be accustomed to this practice. The worksheet was used to establish the students understanding of mathematics and to assess their problem-solving capabilities in mathematics. The worksheet (Appendix F) will be discussed in detail in section 3.5.2.2.

Interviews allow the researcher to use conversation to collect data. However, they involve understandings about the situation and so differ from casual conversation (Denscombe 2010).There are many types of interviews that can be used in research (Denscombe 2010 and Brynam 2008). Informal semi-structured interviews were used as a qualitative method in order to offer the students an opportunity to shed further light on findings which emerged from the questionnaire and to help answer the research questions. The sample included in the research was not huge so genuine attention was paid to triangulation of data by the semi-structured interviews to validate the findings from the questionnaire. The use of this type of interview allowed the researcher to prompt and probe deeper into the findings from the questionnaire (Cohen and Mannion 2000). The semi-structured interviews will be discussed in detail in section 3.5.2.3.

Methodological triangulation (Denscombe 2010) was used to compare data in this research. The data produced in the questionnaires, worksheets and semi-structured interviews were compared to give a ñfuller pictureò of the findings (Denscombe 2010). It is hoped that the use of triangulation will add confidence and validity to the findings. Figure 3.2 overleaf shows the triangulation of research methods incorporated into the research.

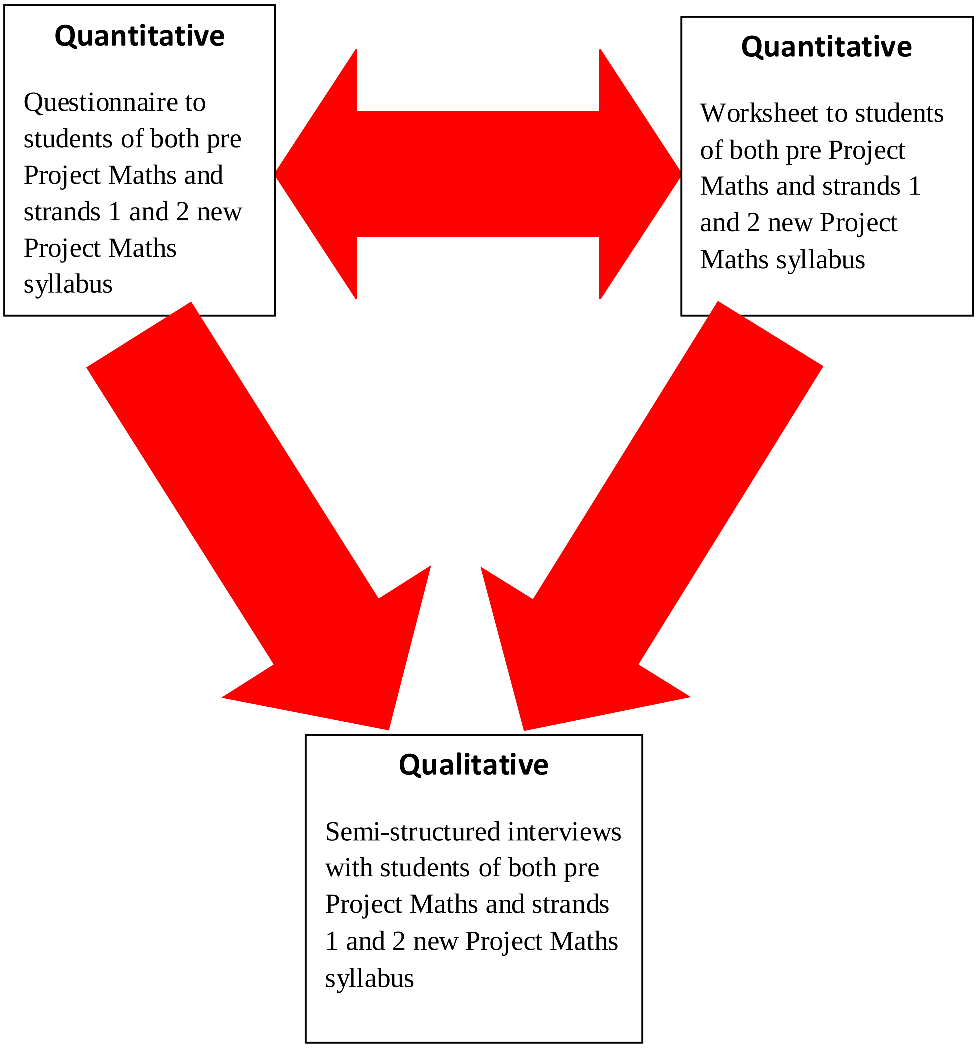

Figure 3.2 Triangulation of research methods.

3.5 Data collection and research instruments

3.5.1 Research Sample

Two groups were involved in the study. Cohort 1 is the control group; these students were not exposed to the Project Maths syllabus and were taught in the traditional manner. Cohort 2 is the test group; these students were exposed to the Project Maths syllabus (strands 1 and 2) and were taught using active learning methodologies. Both groups filled out a questionnaire to assess their attitudes and a worksheet to assess their mathematical ability. Cohort 1 completed the questionnaire and worksheet in April/May 2011, while Cohort 2 completed the same in April 2012. Semi-structured interviews were used to investigate findings from the questionnaire. Cohort 1 semi-structured interviews took place in March 2012 while Cohort 2 semi-structured interviews took place in April 2012. Correlations were then carried out on the findings.

The study population comprised all year 2 students in all post-primary schools in Ireland. The study was carried out over the two school academic years 2010-2011 and 2011-2012. The new mathematics syllabus (*Project Maths*) was introduced into 24 pilot schools in Ireland in 2009. Two of these pilot schools were in Northwest region of the Republic of Ireland. No pilot school was considered for this study.

Purposive and convenience sampling (Denscombe 2010) using five post-primary schools in the Northwest region of the Republic of Ireland was employed. The justification for this was that all five types of post-primary schools namely Vocational, Community, Comprehensive and Voluntary secondary schools are all located in the Northwest region of the Republic of Ireland. Purposive sampling thus allowed the researcher to concentrate óon instances which display a wide varietyô (Denscombe 2010). The Vocational and Community schools were óhand pickedô for convenience to the researcher. From this point of view the study sample is a typical cross-section of the five types of schools within the study population. Random sampling (Denscombe 2010) was employed to select one class of year 2 students from within each of the five schools. It transpired that four classes randomly chosen were taking the higher level syllabus and one was a mixture of both higher and ordinary level students. To achieve further balance it was decided to include one class which was exclusively ordinary level. This class was chosen at random from the five post-primary schools and the resulting outcome was an ordinary level class from the all-boys school (school 4) in Cohort 1. This spread of ability level was maintained for Cohort 2 students in this research study to facilitate meaningful comparisons. The ordinary level class was in school 1 for Cohort 2. This is a mixed community college. Table 3.2 below shows the final make up of schools in the study.

School Number	School Type	Number of students in each school in Cohort 1	Number of students in each school in Cohort 2
1	Vocational community college	26	40
2	Mixed community school	25	24
3	All girls convent	21	21
4	All boys college	31	28
5	Comprehensive mixed school	25	25

Table 3.2 School types and assigned numbers in the study

3.5.2 Research Instruments

The questionnaire (Appendix E) and worksheet (Appendix F) were completed by year 2 students in five post-primary schools in the northwest region of Ireland. It was administered to both Cohort 1 and Cohort 2 students by the class teacher. The aim of the worksheet was to establish studentsô understanding of a range of mathematical problems and to ascertain their competency in problem solving skills. The purpose of the questionnaire was to elicit the attitudes of students towards mathematics, using a number of affective scales. The target of the semi-structured interviews was to probe deeper into the findings of the questionnaire.

The questionnaire and worksheet were piloted with fifty year 2 students in two of the five schools in April 2010. These students did not belong to Cohort 1 and had not been exposed to Project Maths. The aim of the pilot was to elicit the level of satisfaction with the wording and length of the questions in the questionnaire. The exercise also highlighted issues relating to the difficulty of some questions in the worksheet. It was found that the questionnaire was very long. The worksheet contained too many arithmetical questions. Amendments, according to feedback received from the pilot group, were made to both the questionnaire and worksheet.

Examination scores for each student were obtained from the mathematics teachers. These scores were taken from the most recent semester mathematics examination that the students had completed before the survey. These semester examinations were all teacher developed tests and no two classes had the same test. These mathematics semester examination results were then used to compare with their attitudes and worksheet scores. Each student semester test score was coded to link with a number which corresponded to the number on the worksheet and questionnaire completed by the student.

The semi-structured interviews were used to illicit information from the students which arose from preliminary analysis of the questionnaire. The interviews took place after the preliminary analysis of the questionnaire took place. The semi-structured interviews will be discussed further in section 3.5.2.3.

3.5.2.1 Questionnaire

The final questionnaire (Appendix E) was used to measure seven scales or affective variables. These were *confidence* in mathematics, *anxiety* in mathematics, *beliefs* in mathematics, *enjoyment* in mathematics, *self-concept*, *value* of mathematics and *motivation* in mathematics. These arose from the literature review. A description of all statements and their scales is given in appendix H.

The questionnaire was administered by the class teacher to Cohort 1 students in April and May 2011 and to Cohort 2 students in April/May 2012. The students were given 35 to 40 minutes to fill out the questionnaire.

Demographic information required by the researcher included the respondentsô school type and gender. Each respondent was given a number by their teacher to place on top of both their questionnaire and worksheet to link both items. There were 54 questions on the questionnaire, each based on a Likert type scale, which were used to collect data on respondentsô affective variables. The statements for each scale were intermingled on the questionnaire to prevent respondents developing a pattern.

Respondents were asked to indicate their level of agreement to each statement. There were 5 levels of agreement on the Likert type scale: 1 = strongly disagree (SD), 2 = disagree (D), 3 = unsure (U), 4 = agree (A) and 5 = strongly agree. A number of questions were negatively worded and the researcher reversed these by creating new variables in SPSS (Statistical Package for the Social Sciences) with new reversed scores. This was necessary when calculating the total score for each scale. The negatively worded statements are denoted with a minus and are listed in the Appendix E. These statements were item 3 in the *confidence* scale (Q22), items 1-5 on the *anxiety* scale (Q 2, 10, 19, 27 and 35), items 1, 2, 3, 5 and 6 on the *beliefs* about mathematics (Q 3, 14, 18, 32 and 44), item 3 on the *enjoyment* scale (Q 38), items 1, 3 and 4 on the *self-concept* scale (Q 1, 7 and 11), items 3 and 4 on the *value* scale (Q 16 and 20) and items 4 and 5 on the *motivation* scale (Q 33 and 50).

3.5.2.1.1 *Confidence* in Mathematics

Confidence in Mathematics was measured using 8 items. 1 item was from Gourgey (1982) óMathematical *Self-concept*ô which was developed from studentsô reflections of their own ability. 5 items were from Tapia *et al* (2002) óAttitudes towards Mathematicsô which aimed to measure self-*confidence* in students. 1 item was from

Fennema-Sherman (1976) óMathematics Attitudes Scalesô aimed at improving female participation. 1 item was from Klinger (2006) óChallenging Negative Attitudesô a scale which was developed to improve student confidence in mathematics and self efficacy *beliefs*.

3.5.2.1.2 ***Anxiety* in Mathematics**

Anxiety in Mathematics was measured using 6 items. 2 items from Tapia *et al* (2002) óAttitudes towards Mathematicsö, 2 items from Fennema-Sherman (1976) óMathematics Attitudes Scalesô and the final 2 items from Klinger (2006) óChallenging Negative Attitudesö.

3.5.2.1.3 ***Beliefs* about Mathematics**

The *Beliefs about Mathematics* scale contained 7 items. These were taken from; Schoenfeld (1989) óExplorations of Studentsô Mathematical *Beliefs* and Behaviourô (4 items). This scale was developed from studentsô acknowledgement of mathematical success or failure and student perception of and relationship with mathematics. Klinger (2006) óChallenging Negative Attitudesô made up the scale (2 items) and Grouws *et al* (1996) óConceptions of Mathematicsô (1 item). The latter scale was developed from a comparative study carried out on talented mathematical students and average mathematical students.

3.5.2.1.4 ***Enjoyment* in Mathematics**

The *Enjoyment in Mathematics* consisted of 7 items. 3 items were taken from Aiken (1974) óTwo Scales of Attitude towards Mathematicsö. This scale developed from a study which found that *enjoyment* was linked to mathematical ability and interest while *value* was correlated to verbal and general academic ability. 2 items were taken from Klinger (2006) óChallenging Negative Attitudesô and 2 items were from Tapia *et al* (2002) óAttitudes towards Mathematicsô.

3.5.2.1.5 ***Self-concept***

Self-concept was measured using 8 items. 5 items were from Klinger (2006) óChallenging Negative Attitudesô, 2 items were from Grouws *et al* (1996) óConceptions of Mathematicsô and 1 item was from Schoenfeld (1989) óExplorations of Studentsô Mathematical *Beliefs* and Behaviourô.

3.5.2.1.6 ***Value* in Mathematics**

The *Value in Mathematics* scale consisted of 12 items. 4 items were taken from Aiken (1974) óTwo Scales of Attitude towards Mathematicsô, 3 items were from Klinger (2006) óChallenging Negative Attitudesô, 2 items were from Grouws *et al* (1996) óConceptions of Mathematicsô and 2 items were from Schoenfeld (1989) óExplorations of Studentsô Mathematical *Beliefs* and Behaviourô and 1 item was from Crawford *et al* (1994) óConceptions of Mathematicsô.

3.5.2.1.7 ***Motivation* in Mathematics**

Motivation in Mathematics scale contained 6 items. 2 items from Tapia *et al* (2002) óAttitudes towards Mathematicsô and 4 items were from Fennema-Sherman (1976) óMathematics Attitudes Scalesô.

The questionnaire will elicit the attitudes of the students towards mathematics using a variety of scales. The questionnaire will be used to answer research question 1: ***To what extent are attitudes of students related to their understanding of mathematics?***, research question 2: ***To what extent are attitudes of students related to the methods of teaching and learning of mathematics?,*** research question 3; ***Are attitudes related to student success in examinations?,*** research question 4; ***What level of confidence, anxiety, beliefs, enjoyment, self-concept, values of and motivation in the subject do students exhibit towards mathematics?*** and research question 5; ***Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre Project Maths and strands 1 and 2 of the new Project Maths syllabus***?

3.5.2.2 Worksheet

The aim of the worksheet was to establish studentsô understanding of mathematics and to assess their competency in problem solving skills. The worksheet consisted of 10 questions. A copy of this worksheet can be found in Appendix F. These questions were taken from a number of sources. Questions 1, 4 and 5 are from a PISA sample paper. Question 6 was taken from the quantitative reasoning instruction section of an online sample UKcat (United Kingdom Clinical Aptitude Test) paper. This question was altered to make it appropriate for an Irish classroom setting. Questions 2, 3, 7, 8, 9 and 10 were given to the researcher by experienced mathematics colleagues at post-primary level who are members of the Irish Mathematics Teachers Association (IMTA). These questions had been used by colleagues on previous occasions as óteasersô in the classroom. The questions were unseen. However, the questions were based on topics which were common to both the traditional and the new Project Maths syllabuses. Thus, neither Cohort 1 nor Cohort 2 students were at any disadvantage when completing the worksheet. The questions covered arithmetic, problem-solving and geometry as follows: Q1 arithmetic-currency exchange, Q2 and Q3 arithmetic-problem solving, Q4 geometry- length and area, Q5 arithmetic- time, Q6 arithmetic-time and money, Q7 and Q8 arithmetic- problem solving and Q9 and Q10 geometry-angles and area respectively.

Each question had a space to allow the respondent to work out the answer. The respondents were allowed to use mathematical equipment including a calculator. The respondents were given between 35 and 40 minutes to complete the worksheet.

The worksheet (Appendix F) was used to determine a studentsô understanding of mathematics. The worksheet was used to answer research question1; ***Are the attitudes of students related to their understanding of mathematics?*** It will also be used to answer research question 3; ***Are attitudes related to student success in examinations?*** The worksheet will also be used to answer research question 5; ***Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre Project Maths and strands 1 and 2 of the new Project Maths syllabus***?

It is hypothesised that the results from the worksheet completed by the students who studied the new Project Maths syllabus (Cohort 2) will show that there is an improvement in the understanding of mathematical problems compared to results from the pre-Project Maths group of students (Cohort1). Project Maths aims to place greater emphasis on the understanding of mathematical concepts. The new syllabus also aims to help students relate mathematics to everyday life (NCCA, 2010). This data was analysed using Independent t-tests using SPSS (Statistical Package for the Social Sciences) version 17 for Windows.

3.5.2.3 Semi-structured Interviews

Semi-structured interviews were used to elaborate and provide additional insights on findings which emerged from an analysis of the questionnaire and worksheet. The purpose of the interviews was to probe students in order to highlight the main findings of the questionnaire (Sekaran, 2003). In particular information was sought from respondents on the predominant mode of instruction (passive versus active) employed by their mathematics teacher in the classroom. The interviews took place for Cohort 1 in February and March 2012 after the initial analysis of the questionnaire, worksheet and semester examinations scores had taken place. This allowed the interviewer to develop appropriate interview questions. The interviews with Cohort 2 students took place in April and May 2012 using the same questions.

Four interviews took place, two were for Cohort 1 and two were for Cohort 2. The interviews consisted of students from two schools. The schools chosen were schools 1 and 2. These schools were chosen as they were convenient in location. There were eight students in each interview. The students were chosen to include a variety of abilities reflected from their semester results and worksheet scores. Also, students who had reported high *confidence* and *anxiety* levels on the questionnaire were included in the interviews. A gender mix was employed where possible

Permission for the respondents to take part in the interviews was sought from their parents prior to the interviews via a signed letter of consent. The interview framework consisted of a number of open and closed questions (Appendix G) allowing the researcher to be flexible. This allowed the interviewee to speak openly about the issues and develop ideas and elaborate points of interest.

Group interviews allowed a greater number of opinions to emerge and gave more variety of student responses (Denscombe, 2010). The groups consisted of a maximum of 8 respondents. However, in a small number of cases individual interviews were necessary where the researcher required an explanation of sensitive data on *anxiety*, *confidence* and semester mathematics examination scores. The initial analysis of the questionnaire, worksheet and semester scores gave rise to interesting points which were then further explored in the interviews.

Issues that were raised in the interviews included affective variables and approaches to solving mathematics problems in class. The studentsô views on the applications and value of mathematics were also explained. Finally, the important issue of the relationship between mathematics teaching methodologies and studentsô attitudes towards mathematics in the classroom was addressed.

The groups of questions (Appendix G) used in the interviews developed from the literature review and preliminary results of the questionnaires, worksheets and semester results. *Motivation and enjoyment* and the *Anxiety in mathematics* questions developed from the literature review and the results of the questionnaire and worksheet. This group of questions were used to investigate the influence of parents, peers, teachers, homework questions and learning environment on student *enjoyment* and *motivation* of mathematics. These issues developed from the literature review and were used to help further clarify findings from the questionnaire and to answer research question 4: ***What level of confidence, anxiety, beliefs, enjoyment, self-concept, values of and motivation in the subject do students exhibit towards mathematics?***

The group of questions titled *Relating mathematics to the outside world and the importance of mathematics* developed from the worksheet scores and the questionnaire. These questions were used to elicit how students relate mathematics to the world around them. This is also an aim of the Project Maths syllabus. These questions were connected to research question 2: ***To what extent are attitudes of students related to the methods of teaching and learning of mathematics?***

Understanding of mathematics questions developed from the worksheet scores. These questions were used to test if the students understood why they were studying particular topics in mathematics and if they were able to make a connection between different topics in mathematics. These questions were used to further investigate research question 1: ***To what extent are attitudes of students related to their understanding of mathematics?***

The questions based on *Variety and effectiveness of teaching methodologies* examined the impact of active teaching methodologies on student learning. These questions developed from the literature review and the questionnaire and were related to research question 2 ***To what extent are attitudes of students related to the methods of teaching and learning of mathematics?*** The *Attempts at worksheet* questions were used to identify reasons why students fail to complete or attempt a mathematics question. These questions developed from the preliminary analysis of the worksheets and are tied into research question 1 ***To what extent are attitudes of students related to their understanding of mathematics?***

The *Project Maths versus the Old syllabus* section was used to answer research question 5 ***Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre Project Maths syllabus and strands 1 and 2 of the new Project Maths syllabus***. The questions were used to draw out the opinion of students on the differences between the two syllabuses.

Other issues that arose in the interviews were addressed as they occurred. The purpose of the interview was explained to the students and that they were allowed to opt out at any time. Students were reassured before the interview took place that:

- there was no right or wrong answer to any question as it was not a test,
- they did not have to answer all questions,
- openness and honesty were important.

The interviewer acknowledged each student response either verbally or by a gesture and no judgemental comment was made about any response a student gave to the questions.

3.6 Data analysis

Statistical Package for the Social Sciences (SPSS) version 17 for Windows software was used to analyse the questionnaires. Cohort 1 had 128 respondents from the five post-primary schools and Cohort 2 had 138 respondents from the same five post-primary schools. Each student questionnaire and corresponding worksheet was given a unique code to facilitate SPSS analyses. Each item on the questionnaire was coded according to the affective variable that it was testing. The codes used for the purpose of analysis using SPSS are given in table 3.3 overleaf. The œexclude cases pairwiseô option in SPSS was used to ensure that cases missing data were excluded in particular analyses. These cases were included in other analyses. Descriptive statistics were used to find means and standard deviations (Appendix I). Following this more in-depth analysis focused on correlations and independent t-tests. A 5% significance level was used in all statistical tests. Collectively these analyses were used to address the research questions.

Items that were given a code in SPSS are shown in table 3.3 below.

Scale	**Analysed code**
Total *Confidence*	TCon
Total *Anxiety* towards Mathematics	TAnx
Total *Beliefs* about Mathematics	TBAM
Total *Enjoyment*	TEnj
Total *Self-concept*	TSC
Total *Value* in Mathematics	TAaV
Total *Motivation*	TMot

Table 3.3 Scale codes used in SPSS

3.7 Validity and Reliability

3.7.1 Validity

Validity refers to the ability to gain meaning and measurable results from research (Remenyi *et al,* 2010). The data collected must be precise, accurate and appropriate (Denscombe, 2010). Remenyi *et al* (2010) suggest testing validity with three approaches. Construct validity, internal validity and external validity ensure correct operational methods and generalisability (Remenyi *et al,* 2010). However, Sekaran (2003) extends this list with a further seven types of validity. These types measure correlation with a variable, differentiation to predict a criterion variable and ability to measure the concept.

Validity was ensured as sufficient time was spent analysing responses and ensuring that these were interpreted correctly. Validity for the quantitative data was achieved by careful statistical and analytical analysis of the data (Cohen *et al,* 2007). The questions in the questionnaire were taken from scales that have validity built into them due to the extensive studies carried out by the authors of the scales.

Validity for the qualitative data was achieved by demonstrating the methods used and decisions made in the study (Denscombe, 2010). Honesty, depth, richness and scope of data achieved, the participants approached and the extent of triangulation used also ensured validity (Cohen and Mannion, 2000). Validity was guaranteed by using the same set of questions for both Cohorts. The wording of questions during the interviews was kept the same and the same routine was adhered to in all the interviews. Multiple responses were received using the same set of questions in all interviews. The data was recorded to the computer in the same manner for all interviews. The researcher hopes to show the lines of enquiry that led to each conclusion and that these were not influenced by the researcher.

3.7.2 Reliability

Reliability relates to the consistency of responses (Brynam, 2008). Reliability was ensured through the justification of each research design decision (Remenyi *et al,* 2010). Reliability demonstrates the procedures and decisions that other researchers would replicate (Denscombe, 2010). Cronbachôs alpha coefficient was used to test the internal consistency of the items in the questionnaire.

Cronbachôs alpha coefficient values above 0.7 suggest acceptable internal consistency reliability for a scale. Values above 0.8 suggest strong internal consistency reliability. Values below 0.5 suggest weak internal consistency reliability.

3.8 Ethical Considerations

Before beginning the research study ethical approval was sought (February 2010) and granted (March 2010) by the Research Ethics Committee of the Letterkenny Institute of Technology (LYIT) in accordance with standard guidelines on research on human beings (LYIT Ethical Guidelines, 2010). An application by the researcher of this study to broaden the scope of the study was requested (March 2011) and granted (April 2011) by the Research Ethics Committee of the Letterkenny Institute of Technology (LYIT). This was due to the researcher wishing to include one school from each of the five types of post-primary schools in Ireland.

An information sheet (Appendix A) and a consent letter (Appendix B) was sent to the Principal of each of the five participating post-primary schools. An information sheet (Appendix A) and a consent letter (Appendix C) was also sent to the mathematics teachers involved in the study. Before the questionnaire and worksheet were administered, parental permission was sought. An information sheet (Appendix A) and consent letter (Appendix D) was sent to the parents of all students involved in the study. It was made explicit to both parents and students that their participation in the study was voluntary and that withdrawal from the study was possible at any time. This also applied to those students who agreed to take part in the follow up interviews. Letters to the Principals, teachers and parents also gave details of the purpose of the study along with outlining issues pertaining to anonymity, confidentiality and analysis of the data received in the study.

The Data Protection (Amendment) Act (2003) legislates that it is the responsibility of the researcher to store the data securely. All data will be stored in a secure locked filing cabinet in Moville Community College. Data will also be stored electronically on a password controlled database on a data-encrypted hard-drive. All data will be destroyed when the research project has been completed.

3.9 Limitations of the Study

The study was limited by the number of schools and the number of each school type included in the study. A larger number of students and a wider variety of ability levels would have strengthened the study findings. Cohort 2 students had only been exposed to strands 1 and 2 of the new Project Maths syllabus and the traditional syllabus still made up a large proportion of their course. The study was limited by this restriction but nevertheless a number of important findings emerged.

The study was also limited by the instruments used. The questionnaire consisted of Likert type questions which should prevent the respondent growing tired of reading the questionnaire. However, this type of questionnaire can cause respondents to simply ‘tick any box’. Patterns in answering were avoided by the number of questions and by intermingling questions from each of the scales used. The questionnaire did not allow the opinion or honesty of the respondent to be recorded. To address this issue the author deployed semi-structured interviews with students to allow their voice to be heard. The Likert type scale in the questionnaire generates ordinal data.

The semi-structured interviews and worksheet also caused limitations. The semi-structured interview produced data that was not pre-coded. Each interview could slightly differ from each other. The interviewer remained consistent and objective during the interview to ensure reliability. The worksheet was developed from questions used in the classroom by the researcher and her colleagues in conjunction with a number of PISA type questions. The questions developed by teachers were not tested outside the classroom and represent a further limitation. Therefore, their reliability may have limited the study.

The students involved in this study were year two students averaging 13-14 years of age. They had not yet begun to focus on their career after post-primary school. Therefore, this may have prevented them from relating mathematics to their future career.

3.10 Summary

This chapter introduced the main aim of this study. It described the research questions and how they were developed from the literature review. The theoretical framework which guided the study has been described in this chapter. The link between the theoretical framework and the research instruments was explained. The development of each of the research instruments was discussed in this chapter. The computer package that was used to analyse the questionnaire findings was described and the validity, reliability, ethics and limitations were discussed.

The findings for both Cohort 1 and Cohort 2 will be now outlined in the next chapter. A comparison of the findings from both Cohorts will also be addressed in chapter 4.

4. Results

4.1 Introduction

This chapter starts by looking at the composition of the research sample. The findings from each of the research instruments are then reported for both Cohort 1 (pre-Project Maths students) and Cohort 2 (Project Maths strands 1 and 2) students. The results are presented for each research question in turn.

4.2 Research sample composition

Cohort 1 (n = 128)

The 2010-2011 group (n = 128) was the pre Project Maths group (Cohort 1). These students were **not** exposed to Project Maths.

Figure 4.1 overleaf shows the distribution of students in the five schools in Cohort 1 that were surveyed. School 1 accounted for 26 students (20.3%), School 2 had 25 students (19.5%), 21 (16.4%) students from School 3 took part in the study, 31 (24.2%) students were from School 4 and 25 (19.5%) students were from School 5.

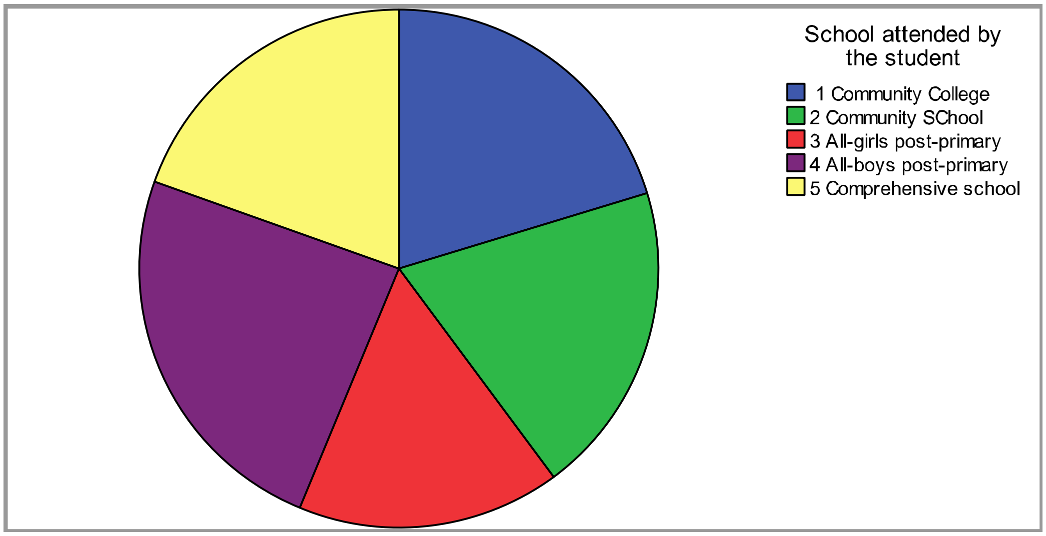

Figure 4.1 Distribution of schools attended by respondents Cohort 1.

Figure 4.2 shows the distribution of gender in Cohort 1. There was 67 (52.3%) male and 61 (47.7%) female in Cohort 1.

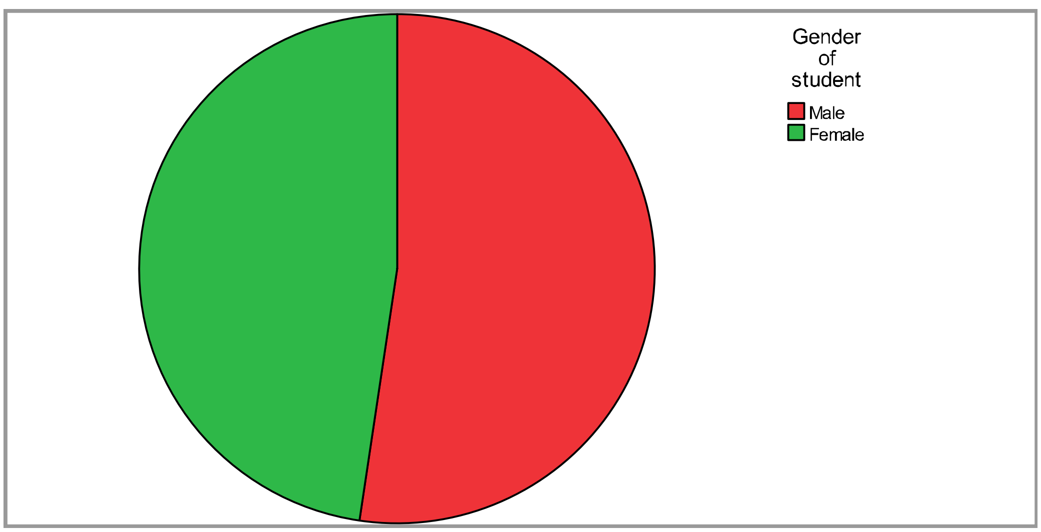

Figure 4.2 Gender distribution of Cohort 1.

Cohort 2 (n = 138)

The 2011-2012 group were students (n = 138) who had been exposed to the Project Maths syllabus (strands 1 and 2 only). This group was the first Cohort nationally to be exposed to the new Project Maths syllabus (Strands 1 and 2).

Figure 4.3 shows the distribution of students in the five schools in Cohort 2 that were surveyed. School 1 accounted for 40 students (29%), School 2 had students 24 (17.4%), 21 (15.2%) students from School 3 took part in the study, 28 (20.3%) students were from School 4 and 25 (18.1%) students were from School 5.

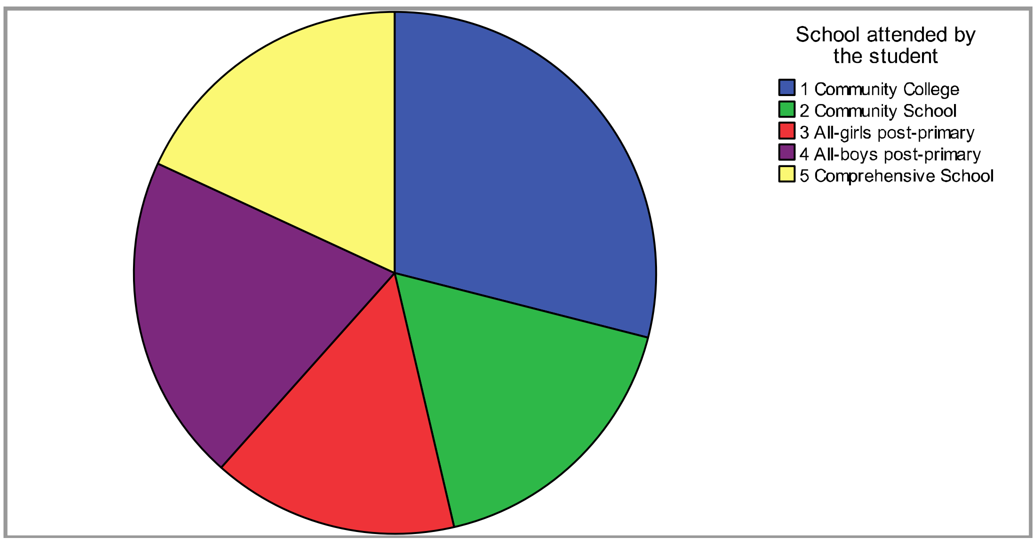

Figure 4.3 Distribution of schools attended by respondents Cohort 2.

Figure 4.4 overleaf shows the distribution of gender in Cohort 2. In Cohort 2 there was 75 (54.3%) male and 63 (45.7%) female.

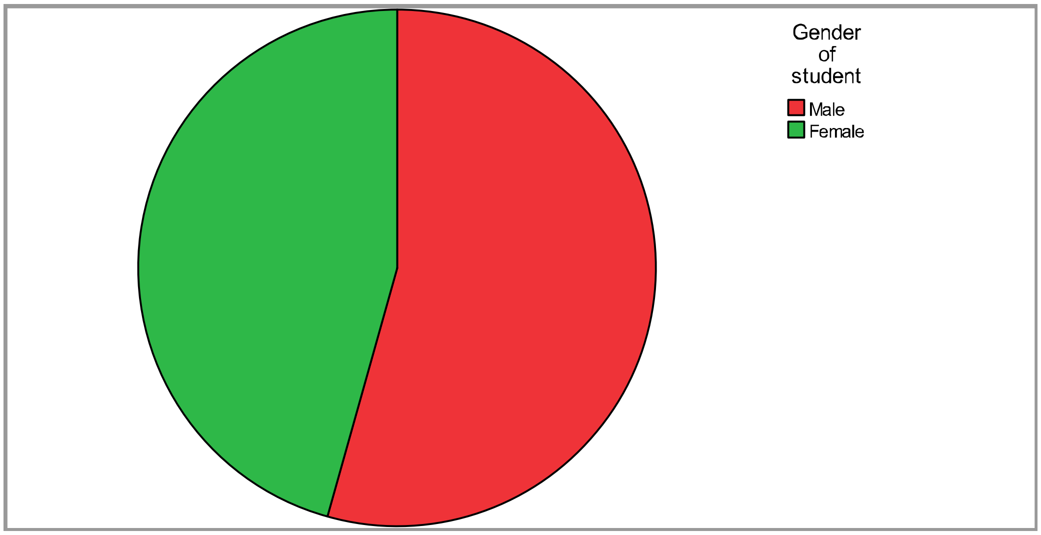

Figure 4.4 Gender distribution of Cohort 2.

4.3 Findings from the questionnaire

4.3.1 Reliability findings

Cronbachôs alpha coefficient was used to test the internal consistency in the statements in the questionnaire. Cronbachôs alpha coefficient values above 0.7 suggest acceptable internal consistency reliability for a scale. Values above 0.8 suggest strong internal consistency reliability. Values below 0.5 suggest weak internal consistency reliability.

<u>Cohort 1</u> (n = 128)

The scales measured all had acceptable or strong internal consistency reliability except *beliefs* about mathematics as illustrated in table 4.1 overleaf. In the case of the latter, the reported value of 0.4 is very weak. The mean inter-question correlation is 0.085 with values ranging from -0.304 to 0.358. This shows a weak relationship between the questions and is a reassurance that the questions measured different scales. However, two of the items used in the questionnaire Q14 (*Real mathematics problems can be solved by commonsense instead of the mathematics rules you learn at school)* and Q18 (*To solve mathematics problems you have to be taught the right procedure, or you cannot do anything)* were found to be difficult to interpret (similar findings were reported by Miller-Reilly, 2005). These items were originally part of a much larger instrument developed by Schoenfeld (1989).

Scale	**Cronbach's alpha coefficient *value***
Confidence in Mathematics	0.8
Anxiety towards Mathematics	0.8
Beliefs about Mathematics	0.4
Enjoyment in Mathematics	0.9
Self-concept	0.7
Value in Mathematics	0.8
Motivation in Mathematics	0.8

Table 4.1 Cronbach's Alpha coefficient *values* for Cohort 1

Cohort 2 (n = 138)

Again the scales measured all had acceptable or strong internal consistency reliability except *anxiety* as illustrated in table 4.2 overleaf. In contrast to Cohort 1 the value for *beliefs* in mathematics returned to an acceptable value.

Scale	Cronbach's alpha coefficient *value*
Confidence in Mathematics	0.8
Anxiety towards Mathematics	0.6
Beliefs about Mathematics	0.7
Enjoyment in Mathematics	0.9
Self-concept	0.7
Value in Mathematics	0.8
Motivation in Mathematics	0.7

Table 4.2 Cronbach's Alpha coefficient *value*s for Cohort 2

4.3.2 Preliminary statistics for the questionnaire

The mean and standard deviation was calculated for each question in the questionnaire for both Cohort 1 and Cohort 2 (Appendix I). The preliminary findings also reported the number of respondents to each question in the questionnaire.

4.3.2.1 Mean and Standard Deviation for Cohort 1

The number of respondents in Cohort 1 was 128 and there were 54 questions in the questionnaire. The number of respondents, means and standard deviations for each question is given in Appendix D. A 100% response rate was not received in all questions. Q2, Q42, Q46 and Q51 had the best response rate (Appendix I). The value for each question ranged between 1 and 5. A mean value above 2.5 would suggest agreement with the scale e.g. a value above 2.5 for a question in the *confidence* scale would mean the respondents were confident in that element of mathematics. Scores for negatively worded statements were reversed as is explained in detail in chapter 3.

In the findings below where mean values, are given the standard deviation value follows in brackets.

The *Confidence in Mathematics* scale contained 8 questions. The mean values per question for all questions on the *confidence* scale ranged from 3.29 (1.1) to 4.1 (0.7) with small standard deviation values which suggest strong *confidence* in mathematics. The *confidence* question with the highest mean value (4.1) was Q42 (*I get a great deal of satisfaction out of solving a Mathematics problem*).

The *Anxiety in Mathematics* scale which had six questions also had high mean values per question ranging from 3.02 (1.2) to 4.03 (0.1). This shows that students are anxious about mathematics.

The *Beliefs about Mathematics* had 7 questions. The mean values per question ranged between 3.03 (1.1) and 4.22 (0.1). These high values represent strong *beliefs* about mathematics as reported by the respondents.

The *Enjoyment in Mathematics* scale had 7 questions. The mean values per question ranged from 2.25 (1.0) to 3.84 (1.1). Statement 45 (*I am happier in mathematics class than in any other class)* was the only question with a mean below 2.5. This result suggests that the respondents do enjoy mathematics.

The *Self-concept* scale contained 8 questions. The mean values per question in this scale ranged from 3.23 (Q30) up to 3.92 (Q7) with small standard deviations. All mean values were above 2.5 which indicate positive *self-concept*ion in mathematics.

There were 12 questions in the *Value towards Mathematics* scale. The mean values per question ranged from 3.02 (Q16) up to 4.06 (Q39). As all mean values were above 2.5 this shows that the respondents valued mathematics highly and see the importance of it in everyday life.

There were 6 questions in the *Motivation in Mathematics* scale. The mean values per question for this scale ranged from 2.73 (1.2) to 4.1 (1.0) which implies that the respondents are motivated in mathematics. However, Q24 (*once I start working on a mathematics problem, I find it hard to stop*) only had a mean of 2.73 (1.2). This could be a factor in failing to persist at solving a mathematics problem presented to them by their mathematics teacher.

4.3.2.2 Mean and Standard Deviation for Cohort 2

The number of respondents in Cohort 2 was 138. The same questionnaire involving 54 questions was administered to this Cohort. The number of respondents, means and standard deviations for each question is given in Appendix I. A 100% response rate was not received in all questions. Q17, Q21 and Q24 had the best response rate (Appendix I). The value for each question again ranged between 1 and 5. Therefore, a mean value above 2.5 would suggest agreement with the scale.

The *Confidence in Mathematics* scale contained 8 questions. The mean values per question for all questions on the *confidence* scale ranged from 2.95 (1.2) to 4.09 (0.6) which suggest *confidence* in mathematics. The *confidence* question with the highest mean value (4.09) was Q22 (*I am always confused in my Mathematics class*).

The *Anxiety in Mathematics* scale also had very high mean values per question ranging from 3.32 (1.1) to 4.3 (0.7). This shows that students are anxious about mathematics.

The *Beliefs about Mathematics* had 7 questions. The mean values per question ranged between 3.16 (1.0) and 4.34 (0.6). These high mean values represent strong *beliefs* about mathematics as reported by the respondents.

The *Enjoyment in Mathematics* scale had 7 questions. The mean values per question ranged from 2.31 (1.2) to 4.17 (0.8). This result suggests that the respondents do enjoy mathematics. However, Q45 (*I am happier in mathematics class than in any other class)* had a very low mean (2.31), this indicates little *enjoyment* in mathematics compared to other subjects. This is the question which also had the lowest mean on the *enjoyment* scale.

There were 8 questions in the *Self-concept* scale. The mean values per question in this scale ranged from 3.01 (1.3) up to 4.04 (0.7). All mean values were above 2.5 which indicate positive *self-concept* in mathematics.

There were 12 questions in the *Value towards Mathematics* scale. The mean values per question ranged from 3.04 (0.9) up to 4.25 (0.7). As all mean values were above 2.5 this shows that the respondents valued mathematics highly and see the importance of it in everyday life.

There were 6 questions in the *Motivation in Mathematics* scale. The mean values per question for this scale ranged from 2.42 (1.2) to 3.83 (0.7) which implies that the respondents are motivated in mathematics but these values are not as strong as for Cohort 1. However, as was the case in Cohort 1, Q24 (*Once I start working on a mathematics problem, I find it hard to stop*) only had a mean of 2.42 (1.2). Again this could be a factor in failing to persist at solving a mathematics problem presented to them by their mathematics teacher.

Table 4.3 below summarises the range of scores in each scale for both Cohort 1 and Cohort 2. From the table it can be seen that the range of means for *confidence* and *motivation* were higher in Cohort 1 than in Cohort 2. However, all the other range of means were higher in Cohort 2 than in Cohort1.

Scale	Range of means Cohort 1 (Standard deviation)	Range of means Cohort 2 (Standard deviation)
Confidence	3.29 (1.1) to 4.10 (0.7)	2.95 (1.2) to 4.09 (0.6)
Anxiety	3.02 (1.2) to 4.03 (1.0)	3.32 (1.1) to 4.3 (0.7)
Beliefs	3.03 (1.1) to 4.22 (1.0)	3.16 (1.0) to 4.34 (0.6)
Enjoyment	2.25 (1.0) to 3.84 (1.1)	2.31 (1.2) to 4.17 (0.8)
Self-concept	3.23 (1.1) to 3.29 (1.1)	3.01 (1.3) to 4.04 (0.7)
Value	3.02 (1.2) to 4.06 (1.0)	3.04 (0.9) to 4.25 (0.7)
Motivation	2.73 (1.2) to 4.1 (1.0)	2.42 (1.2) to 3.83 (0.7)

Table 4.3 Range of mean scores for each scale in Cohort 1 and Cohort 2.

Each of the research questions in this study will be addressed in turn. These findings will be integrated and informed by relevant literature explored in Chapter 2.

4.4 Research question 1: *To what extent are the attitudes of students related to their understanding of mathematics?*

The scales used to answer this research question were *enjoyment* and *value* of mathematics. These scales were measured using the questionnaire (Appendix E). Student understanding was measured using the worksheet (Appendix F). The author sought to link the scales to the worksheet scores.

Attitude towards mathematics is broken down in this study into two subscales according to Aiken (1974); *enjoyment in mathematics* and *value of mathematics*. Student understanding of mathematics was examined under two headings; instrumental and relational. Instrumental understanding tests studentsô ability óto doô a task in mathematics, while, relational understanding tests if students óknow whyô they are doing a task in mathematics. Mathematical understanding incorporating both relational and instrumental understanding was tested using the worksheet (Appendix F).

The worksheet (Appendix F) contained ten questions. Questions number 1, 9 and 10 tested instrumental learning. The remaining questions tested relational understanding and three of these in particular contained a problem-solving element (Q 3, 7 and 8). The questions were PISA (Programme for International Student Assessment) like questions. All the questions were unseen and were based on topics which were common to both traditional and the new Project Maths syllabuses.

Pearson product-moment correlation coefficients were calculated to establish if the scales *enjoyment in mathematics* and *value towards mathematics* were correlated with worksheet score. The guidelines that were used to interpret the results were taken from Cohen (1988, P 79-81) cited in Pallant (2007) and are shown in table 4.4 below. The preliminary analyses were preformed to ensure that no violation of the assumptions of normality, linearity and homoscedasticity occurred. If a case was missing information for any of the variables it was excluded from the analysis.

Strength of correlation	**r *value* intervals**
Small	r = 0.1 ï 0.29
Medium	r = 0.3 ï 0.49
Large	r = 0.5 ï 1.0

Table 4.4 Guideline for interpretation of coefficient correlation.

The correlation finding for Cohort 1 revealed that there was no relationship between the *enjoyment* scale and student understanding using the worksheet scores (r = 0.01). However, in Cohort 1 the correlation coefficient between *value* and student understanding (r = 0.1) confirmed a small relationship.

In Cohort 2 the r values for *enjoyment* with student understanding (r = 0.3) displayed a medium correlation. The relationship between the attitudinal scale *value* and student understanding (r = 0.1) was small indicating that the correlation between the *value* scales and student understanding is small. Thus, there was a small to medium association between the two attitudinal scales and mathematical understanding for Cohort 2. However, it is important to note that for both scales in Cohort 2 there was a lot of data missing (*enjoyment* = 91 respondents and *value* = 58 respondents).

The author was keen to further explore student responses to the worksheets as this was the instrument used to assess their level of mathematical understanding. The semi-structured interviews conducted with both Cohorts, facilitated this exploration, allowing the author to probe and seek clarification on a number of issues.

Firstly, students were asked if they understood why (relational understanding) a particular topic was been undertaken in mathematics and whether they could make connections between topics in mathematics? This question was asked in the semi-structured interviews to check student understanding and these responses were then connected to the attitude of students towards mathematics in follow up questions.

No student in both Cohorts could provide a rationale for the inclusion of any mathematical topic. This is an indictment on the traditional mathematics syllabus and also on the new Project Maths syllabus (NCCA, 2010).

The picture was more encouraging when students were questioned on their ability to make connections themselves between mathematical topics. Students from both Cohorts made connections between topics as is evidenced from these responses; ñ*You need algebra to work out co-ordinate geometry” (*Cohort 1*)* and ñ*Yes, algebra is used in all topics”* (Cohort 2*).*

When asked if their teacher explains how topics are related to each other, there were different responses from Cohort 1 and Cohort 2 students. A student from Cohort 1 said *“No, don’t really think about it”* whereas a Cohort 2 student answered *“Yes, like we are just doing co-ordinate geometry now and we used simultaneous equations to find the intersection of two lines which explains why we did the same type of sum in algebra”*. However, this may have been something that their teacher always did and may not be attributed to the new Project Maths course per se.

The results from the worksheet were analysed and the results are illustrated in table 4.5 overleaf, first by school type and then by overall mean scores between both Cohorts. The worksheet was scored on correct answers only and no attempt marks were given, therefore stopping during a question resulted in no marks. Both Cohorts showed similar overall worksheet results. In both Cohorts the ordinary level students struggled with the worksheet and so their overall scores were low. Hence, the low scores reported in school 4 in Cohort 1 and in school 1 in Cohort 2.

School	1 Community College	2 Community school	3 All-girls school	4 All-boys school	5 Compreh-ensive school	Overall
Mean (S.D.) Worksheet score Cohort 1	47.81 (17.5)	66.08 (21.4)	55.81 (16.1)	43.45 (21.8)	49.76 (20.5)	52.02 (21.0)
Mean Worksheet score Cohort 2	44.5 (19.7)	47.96 (17.1)	39.10 (16.8)	59.18 (16.7)	44.68 (13.3)	47.29 (18.1)

Table 4.5 Mean worksheet score for Cohort 1 and 2.

When the worksheets were corrected it was noted that students from both Cohort 1 and 2 did not attempt some questions and stopped part of the way through other questions. In both Cohorts the students dealt better with questions which tested instrumental (Q1, 9 and 10) understanding rather than those that tested relational understanding and were problem-solving type questions (Q3, 7 and 8).

In both Cohorts the instrumental understanding type questions were well attempted (Cohort 1 = 82%, Cohort 2 = 84%). The ordinary level students (Cohort 1 = 68%, Cohort 2 = 74%) coped well with these questions when compared to higher level students (Cohort 1 = 88%, Cohort 2 = 90%). Overall the number of students that did not make any attempt at these questions was very small (Cohort 1 = 18%, Cohort 2 = 16%). The reason for the high success rate in these questions was investigated during the semi-structured interviews and will be discussed in the final section of this research question.

The relational understanding questions that were poorly attempted by students from both Cohorts were the problem-solving type questions (Q3, 7 and 8). In both Cohorts very few students were able to cope with Q8 (*Calculate the number of Emus and Elephants in the zoo given the number of eyes and legs that can be seen*). This question required students to transfer their knowledge of simultaneous equations to an out of context question. It is not surprising that Cohort 2 students did not cope well with this problem as they had not been exposed to Strand 3 (Algebra). The Strand 3 algebra content starts with new entrants to Junior Certificate in 2013 and will deal with problems of this nature.

In comparison to Cohort 2, Cohort 1 students got more of these three questions (Q3, 7 and 8) correct (Cohort 1 = 52%, Cohort 2 = 47%). However, more Cohort 2 students made an attempt at the question even if it was not correct (Cohort 1 = 17%, Cohort 2 = 23%). Cohort 1 students found the problem-solving questions (Q3, 7 and 8) difficult. There was a high number of students who did not attempt these questions (Cohort 1; higher level = 31%, ordinary level = 75%, Cohort 2; higher level 30%, ordinary level 48%). The ordinary level students for both Cohorts attempted these questions less often than the higher level students (Higher level = 18%, Ordinary level = 10%). Overall, Cohort 2 ordinary level students displayed better ability to attempt the question or complete it correctly compared to Cohort 1 (Cohort 1; 5.5% attempt, 19% correct, Cohort 2; 13% attempt, 38% correct).

The high incidence of text in the actual questions was clearly an issue for students in both Cohorts. When questioned about this during the semi-structured interviews, both Cohorts had similar responses. Students from Cohort 1 replied *"The wording puts me off", "Yeah some of them looked too hard because of the amount of words in it"* and *"I prefer questions with just numbers in it".* A Cohort 1 student also reported that the; ñ*wording mainly put me off it, I did not understand what I was being asked for".* These responses were echoed by Cohort 2 students as was observed by the following responses; ñ*It was too long and I could not do any more"* another student said;

"Unseen questions would not scare me it is just the wording I don't get". A Cohort 2 student also reflected ñ*I just did not know how to continue so I stopped",* another Cohort 2 student answered; *"Yeah, I did not know how to finish it off".* The students attributed this to the ñ*wording*ò used in the questions and were unable to attempt the question if it did not follow a pattern that they had previously experienced.

Cohort 2 students appeared better able to cope with the problem-solving questions of an unseen nature. From the worksheet results the percentage of students in Cohort 2 (18%) who attempted these questions was higher than those in Cohort 1 (11%). In the semi-structured interviews Cohort 1 students said that they followed a set of steps given to them by the teacher to do their homework, ñ*I just use my hardback"*. In contrast to this, Cohort 2 students said they ñ*Sometimes use the steps or the might do it their own way"*. Cohort 2 students were encouraged to discuss problems and to give a reason for their answer under the new Project Maths syllabus (NCCA, 2010).

4.5 Research question 2: *Are attitudes of students related to methods of teaching and learning of Mathematics?*

The attitudes (*enjoyment* and *value*) of students were tested using the questionnaire (Appendix E) and using the semi-structured interviews (Appendix G). Both the *enjoyment* and *value* in mathematics scores were higher in Cohort 2 than in Cohort 1. Cohort 1 had mean scores ranging from 2.25 (1.0) to 3.84 (1.1) on the *enjoyment* scale while Cohort 2 had mean scores between 2.31 (2.1) and 4.17 (0.8) for the same scale. The total mean (table 4.6 p 90) score for *enjoyment* in mathematics was 21.29 (6.6) for Cohort 1 and 22.39 (6.5) in Cohort 2. These scores are all quite high and illustrate that the students enjoy mathematics.

In Cohort 1 the mean value scores ranged from 3.02 (1.2) to 4.06 (1.0) while in Cohort 2 the range of scores were 3.04 (0.9) to 4.25 (0.7). The total mean (table 4.6 p 90) value score was very high for both Cohorts; 43.78 (6.8) in Cohort 1 and 46.9 (6.5) in Cohort 2. Again these high scores demonstrate that students have *value* in mathematics.

The author will seek to connect attitudinal scores (*enjoyment* and *value*) for both Cohorts as measured by the questionnaires, to student responses elicited from the semi-structured interviews (Appendix F). Cohort 1 students named *peers, teachers and parents* as those that influence their *enjoyment* in mathematics whereas Cohort 2 students named *teachers* and *parents* as having the greatest influence over them. When questioned further on this topic, a Cohort 1 student replied that their ñ*Parents see maths as very important"* and a Cohort 2 student believes *"Teachers and parents tell you how important it is"*. A Cohort 1 student revealed that their parents *"Make sure that I study but they don't check my homework every night".* However, a Cohort 2 student answered ñ*My parents check now and again but not every night".* This shows that students do not see the importance of mathematics for themselves.

When the students were questioned about the influence that their peers had on them in the class they gave varying responses; a Cohort 1 student believed that ñ*You want to be up there with the good ones and you want to get good results"* while a Cohort 2 student reported that the class ñ*did not influence how they do"*. Cohort 1 students affirmed that the more competitive the class the more they would like to do well.

When questioned about their homework, Cohort 1 and Cohort 2 students reported that they did their homework at a desk in their bedroom or at the kitchen table. Cohort 1 and Cohort 2 students said that their work area is free from distraction and only a small number of Cohort 1 students reported ñ*Sharing the work space with siblings"* and ñ*listening to music during study or homework".* The two Cohorts reported varying amounts of time spent on mathematics homework; a Cohort 1 student stated that ñ*I spend more time on maths homework if it is hard but usually less than other subjects"* but a Cohort 2 student revealed that ñ*I spend more time on my maths homework unless I had an English essay or something like that"*. These responses reflect the higher *anxiety* score reported by Cohort 2.

Statement 45 on the questionnaire; *I am happier in Mathematics class than in any other class,* reported that both Cohort 1 (mean = 2.25, S.D. = 0.1) and Cohort 2 (mean = 2.31, S.D. = 1.2) disagreed with this statement and so the students were asked why this was during the interviews. A Cohort 1 student conveyed that mathematics class ñ*was not fun”* and that ñ*you did not get to do or make things like in other subjects”*. A student from Cohort 2 claimed that mathematics was ñ*the hardest subject”*. These responses emphasise their high *anxiety* level and also the lack of active learning methodologies used in the classroom. The students appear to learn from activities in the classroom and from their peers during group work.

During the review of literature it was found that large proportions (96%) of the interactions that take place in the mathematics classroom are teacher led Lyons *et al* (2003). The semi-structured interviews were used to investigate this further and to explore the activities used in the classroom during the teaching of mathematics.

Cohort 1 and Cohort 2 students found that their teacher does most of the work in the classroom. Cohort 1 and Cohort 2 students only used group work on occasion. When questioned about group work students from both Cohorts agreed that they enjoy it and learn from their peers; ñ*you feel more comfortable asking a question from your friends and you understand it better”* a Cohort 1 student responded and ñ*I really enjoy it as I learn from my peers”* a Cohort 2 student answered. At the beginning of the interviews students from both Cohorts replied that *teachers* and *parents* influenced their *enjoyment* of mathematics. However, when probed students mentioned their peers as those who they enjoy learning from. Perhaps students do not use group work enough to see how much their peers can influence them in the classroom

Evidence from the student responses during the semi-structured interviews suggest that active teaching methodologies are being used in the classroom with both Cohorts. The students were questioned about these activities. A student from Cohort 1 answered ñ*I like using the small white boards that you write the answer on because it was not like a normal mathematics class"* and another student, this time from Cohort 2 replied ñ*I like it when we use playing cars or the dice because then you can see the answer in front of you".* A different Cohort 2 student also claimed that he had ñ*enjoyed using quizzes for revision like 'teams games tournament'*[ψ]*"*. The same response was given by another Cohort 1 student. The evidence from the interviews demonstrates that students enjoy learning when they are engaged in activities and interacting with their peers.

During the semi-structured interviews students were asked what they would change about their mathematics class. Cohort1 and Cohort 2 students conveyed that they would increase the amount of ñ*activities used in mathematics to help them learn"*. The students in both Cohorts in this study felt that these methodologies would improve their learning; *"group work and more activities would make it seem less like a maths class"* (response from a Cohort 1 student) and *"I feel more comfortable asking a question in a small group"* (a Cohort 2 student replied). This was confirmed by the optimistic responses given by students from both Cohorts towards group work.

The semi-structured interviews were also used to question students if they learn from their mistakes. A student from Cohort 1 said that their mistake is explained to them ñ*Only if they ask"*. However, a Cohort 2 student revealed that their mistakes were explained to them and that ñ*It helps you to correct your mistake"*. Studentsô mistakes were explained to Cohort 2 students more than to Cohort 1 students according to the responses during the semi-structured interviews. However, this may be connected to the mathematics teacher rather than the new Project Maths syllabus per se.

An analysis of the questionnaire responses indicated that students were unable to relate mathematics to the world around them, a theme which also emerged in the

[ψ] Teams, games, tournaments is an instructional intelligence revision tool used in the classroom. It is a quiz type revision tool where students have control of the quiz and all students are actively learning at all times. (Bennett, 2001).

literature review in chapter 2. The semi-structured interviews were used to examine this finding more closely. A number of students from both Cohort 1 and Cohort 2 were able to relate mathematics to other parts of their lives; a Cohort 1 student replied *"you need it for money to add up and figuring everything out"* a Cohort 2 student expressed ñ*it is used in Business and in science"*. Mathematics was reported to be the ñ*most important subject"* by both a Cohort 1 and a Cohort 2 student. One Cohort 1 student claimed ñ*it is used in other subjects and you need it to figure out the world",* while another student from the same Cohort replied *"if you fail it you will fail your leaving cert"* and a Cohort 2 student declared ñ*it is needed for everything in life"*. When asked if they would use mathematics in their future career students from both Cohorts answered *"no"* a Cohort 1 student added *"but maybe through another subject"*. While the students could see the imminent importance of mathematics in school they were not fully aware of the importance of mathematics and how it will impact on their lives. The students place importance on mathematics from an examination point of view only. These responses explain the high *value* scores from the questionnaire.

4.6 Research question 3: *Are attitudes of students related to student success in Mathematics examinations?*

The attitudes (*enjoyment* and *value*) of students were tested using the questionnaire (Appendix D). The relationship between the scales *enjoyment* and *value of mathematics* with semester examination results were investigated using Pearson product-moment correlation coefficient values.

Both Cohorts had high mean semester scores, Cohort1 had a mean of 71.53 (SD = 16.7) whilst Cohort 2 had a mean of 60.56 (SD = 19.1). The lower mean score in Cohort 2 could be related to the studentsô difficulty in expressing themselves mathematically in the new style of questioning associated with the Project Maths syllabus. The problem of inadequate understanding of mathematical concepts has been detailed in the Chief Examinerõs report (Chief Examinerõs Report, Leaving Certificate, 2005 and 2001).

In Cohort 1 there was no correlation (r = 0.08) between *enjoyment in mathematics* with semester examination results. This indicates that students who enjoy their mathematics do not tend to achieve high semester examinations results in mathematics. Similarly, no correlation (r = 0.04) existed between *value in mathematics* and semester examination results for Cohort 1. Thus, students who *value*d mathematics highly did not tend to achieve high semester examination scores in mathematics. Cohort 1 had a semester examination mean score of 71.53 (SD = 16.7). This is relatively high and shows that the students have a good understanding of mathematics.

In Cohort 2 the correlation between *enjoyment in mathematics* and semester examination result was small (r = 0.2). *Value in mathematics* and semester examination results in Cohort 2 showed no correlation (r = 0.07), a similar finding to their colleagues in Cohort 1. The overall mean semester score for Cohort 2 (60.56, SD = 19.08) was lower than for Cohort 1 (71.53, SD = 16.7).

4.7 Research question 4: *What level of confidence, anxiety, beliefs, enjoyment, self-concept, values of and motivation in the subject do students exhibit towards mathematics?*

Cohort 1 students were not exposed to the new mathematics syllabus (Project Maths strand 1 and 2). Cohort 2 students were exposed to Project Maths (strand 1 and 2). The total means and standard deviation scores were calculated for both Cohort 1 and Cohort 2 for each of the seven scales on the questionnaire. These scores are given in table 4.6 overleaf.

	Total *Confidence*	**Total *Anxiety***	**Total *Beliefs***	**Total *Enjoyment***	**Total *Self-concept***	**Total *Values***	**Total *Motivation***
Range of scores in each scale	8-40	6-30	7-35	7-35	8-40	12-60	6-30
Cohort 1 Mean (Standard deviation)	28.6 (5.5)	21.84 (4.1)	25.10 (3.2)	21.29 (6.6)	27.64 (4.5)	43.78 (6.8)	19.4 (4.9)
Cohort 2 Mean (Standard deviation)	29.19 (4.9)	24.72 (2.5)	27.46 (3.3)	22.39 (6.5)	29.26 (3.8)	46.9 (6.5)	21.22 (3.7)

Table 4.6 Mean and Standard deviation scores for all scales for Cohort 1 and Cohort 2

4.7.1 Cohort 1 and Cohort 2 students' *Confidence in Mathematics*

There were 8 questions in this scale, therefore the possible scores ranged from 8 to 40. The mean score for the scale in Cohort 1 was 28.6 (SD = 5.5). This indicates a high level of *confidence* in mathematics for the student sample. Figure 4.5 shows a histogram of the *confidence* scale Cohort 1. The distribution has a negative skewness *value* of -0.703 indicating some quite low scores on the *confidence* scale. Overall the histogram illustrates that the respondents were confident in mathematics.

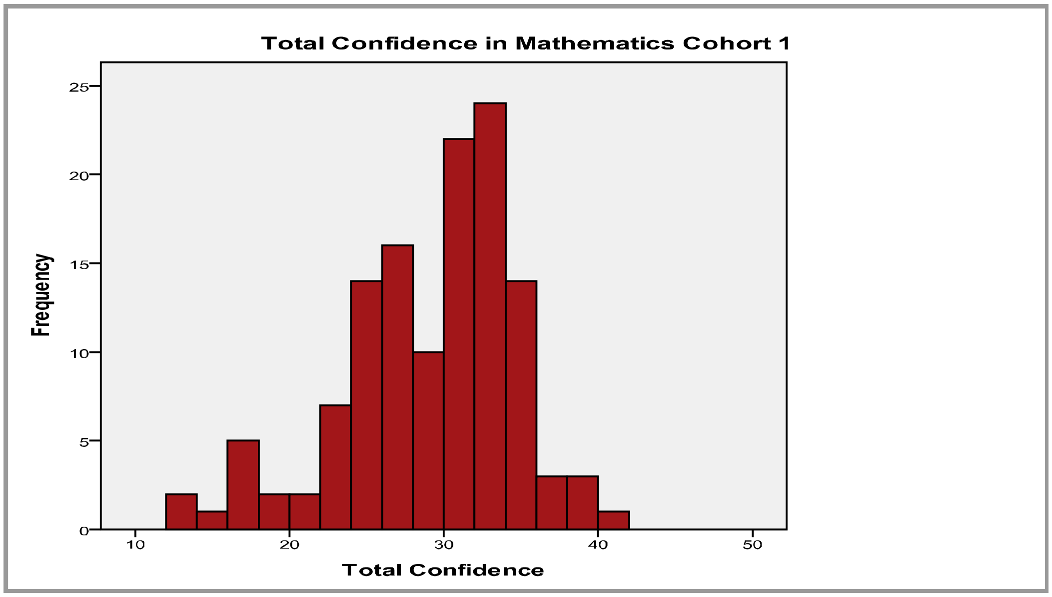

Figure 4.5 Total *Confidence* in mathematics for Cohort 1

In Cohort 2 the mean value for *confidence* was 29.19 (SD = 4.9). Therefore, the level of *confidence* in mathematics is also high in Cohort 2. This mean is slightly higher than Cohort 1. Figure 4.6 shows a histogram of the *confidence* scale in Cohort 2. The histogram emphasises the high level of *confidence* in mathematics among Cohort 2 students.

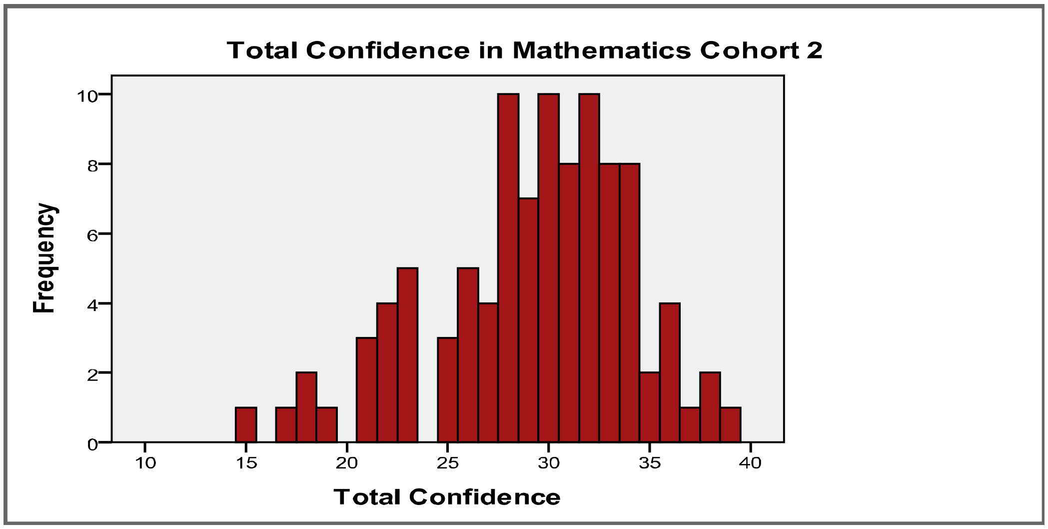

Figure 4.6 Total *Confidence* in mathematics for Cohort 2

4.7.2 Cohort 1 and Cohort 2 students *Anxiety towards Mathematics*

There were 6 questions in this scale therefore the possible scores were between 6 and 30. The mean value for Cohort 1 was 21.84 (SD = 4.1), therefore the Cohort reported a high level of *anxiety* towards mathematics. Figure 4.7 overleaf illustrates the results from this scale. The skewness value is -0.616 again indicating that some students had low levels of *anxiety* towards mathematics.

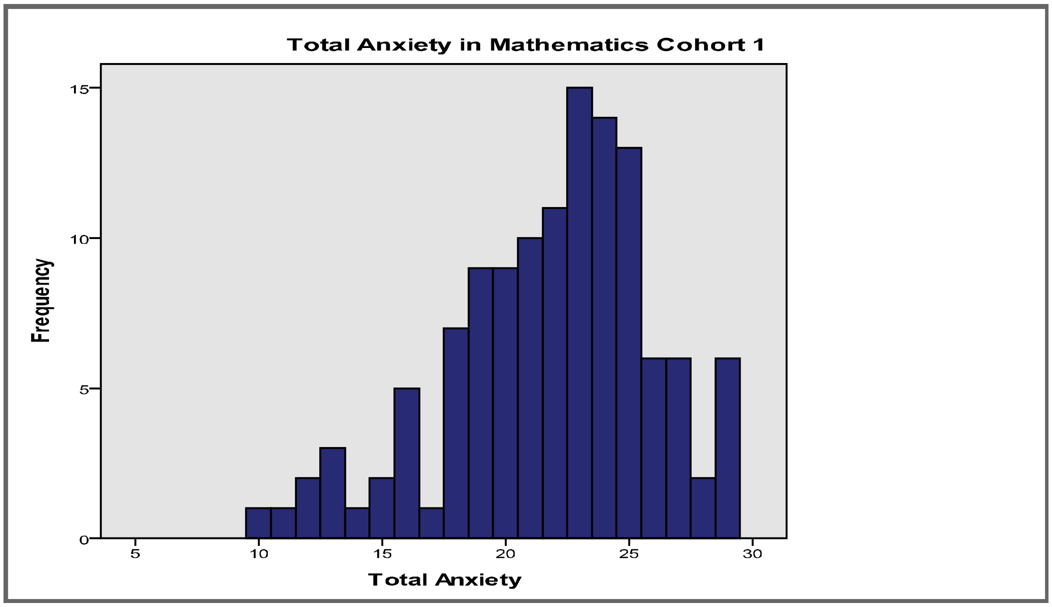

Figure 4.7 Total *Anxiety* towards mathematics for Cohort 1.

Cohort 2 had a mean value of 24.72 (SD = 2.5). This value indicates high levels of *anxiety* towards mathematics and is higher than the value for Cohort 1, however, it is interesting to note the Cohort 2 had a much smaller standard deviation value (2.5) than that of Cohort 1 (4.1). This establishes that Cohort 2 *anxiety* levels were all quite similar. Figure 4.8 below illustrates these high *anxiety* levels diagrammatically.

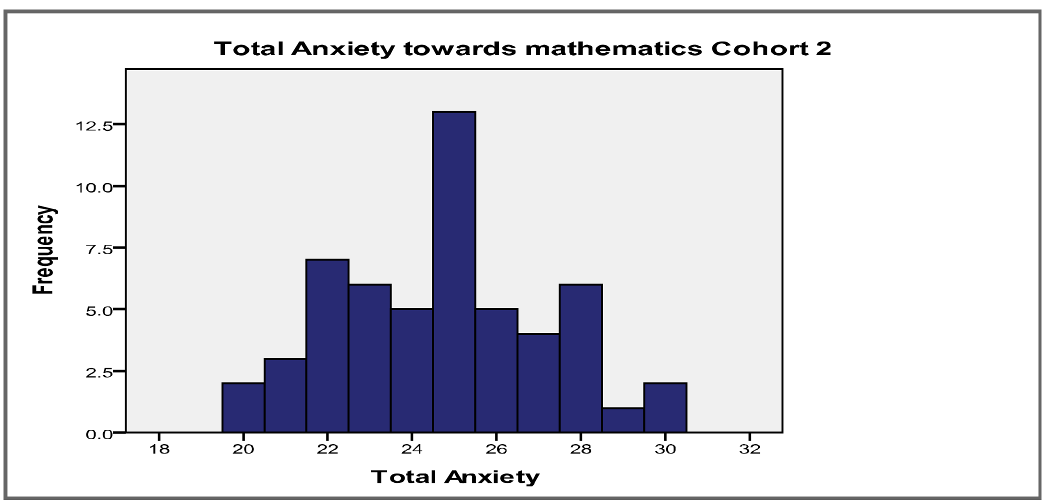

Figure 4.8 Total *Anxiety* towards mathematics for Cohort 2.

4.7.3 Cohort 1 and Cohort 2 students *Beliefs about Mathematics*

This scale consisted of 7 questions, therefore the possible scores ranged between 7 and 35. The mean score for this scale was 25.1 (SD = 3.2). This shows that students held strong *beliefs* about mathematics in Cohort 1. Figure 4.9 shows this result in graph form.

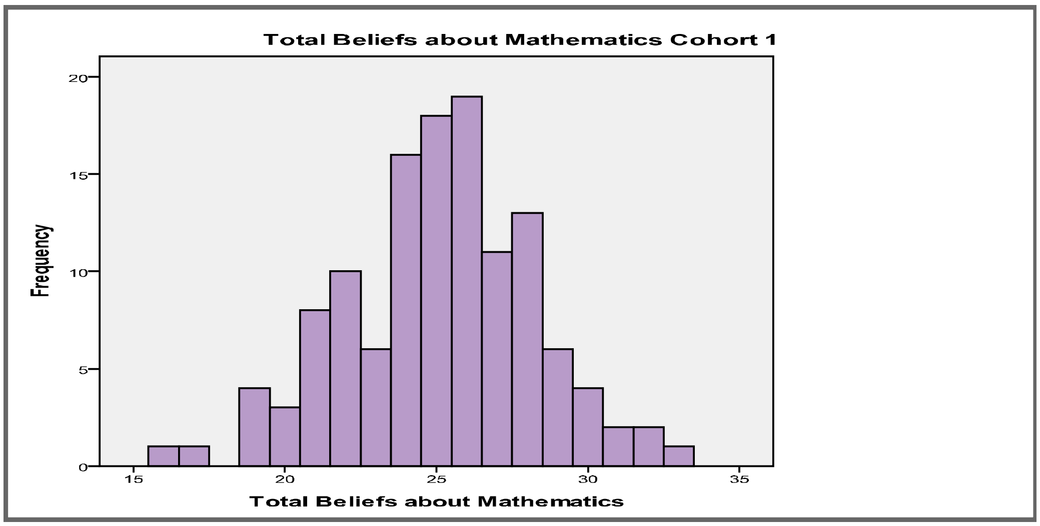

Figure 4.9 Total *Beliefs* about mathematics for Cohort 1.

In Cohort 2 the mean score was 27.46 (SD = 3.3). This is a very high mean suggesting that Cohort 2 students had strong *beliefs* about mathematics. Again this value is higher than Cohort 1. This is shown in the histogram overleaf (4.10).

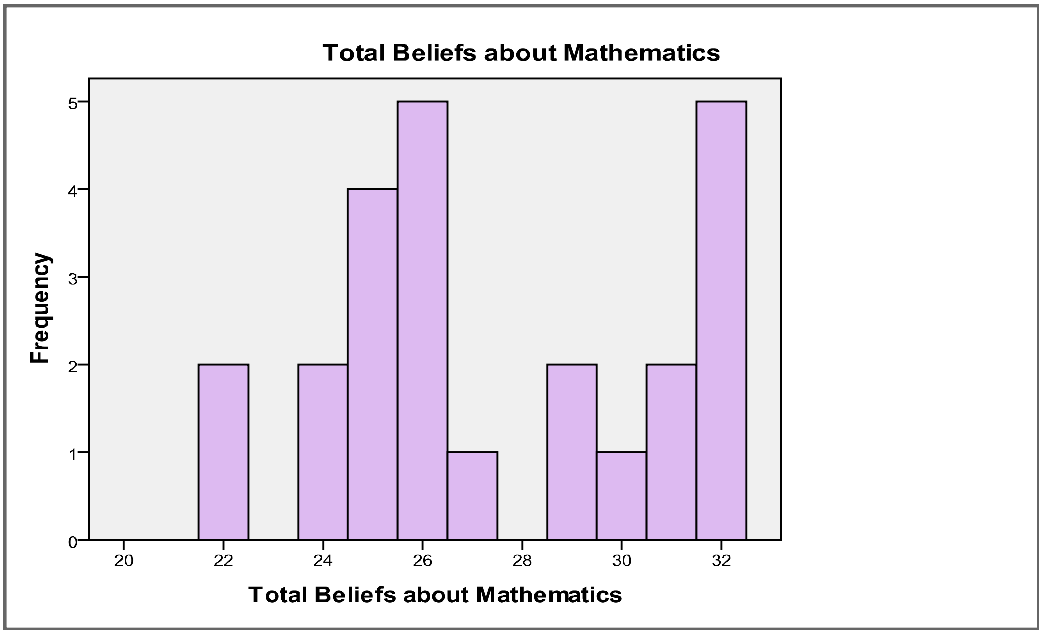

Figure 4.10 Total *Beliefs* about mathematics for Cohort 2.

4.7.4 Cohort 1 and Cohort 2 students *Enjoyment in Mathematics*

With 7 questions in this scale the possible scores were between 7 and 35. The mean score for *enjoyment* in mathematics (Cohort 1) was 21.29 (SD = 6.6). The mean in this scale is in the middle and the standard deviation is quite high showing that the responses varied in this scale. This is also illustrated in figure 4.11 overleaf. The highest bars are separated on either side of the median (the middle value) which was 21. The scores have indicated no strong trend in either direction with some very high and some very low *enjoyment* scores.

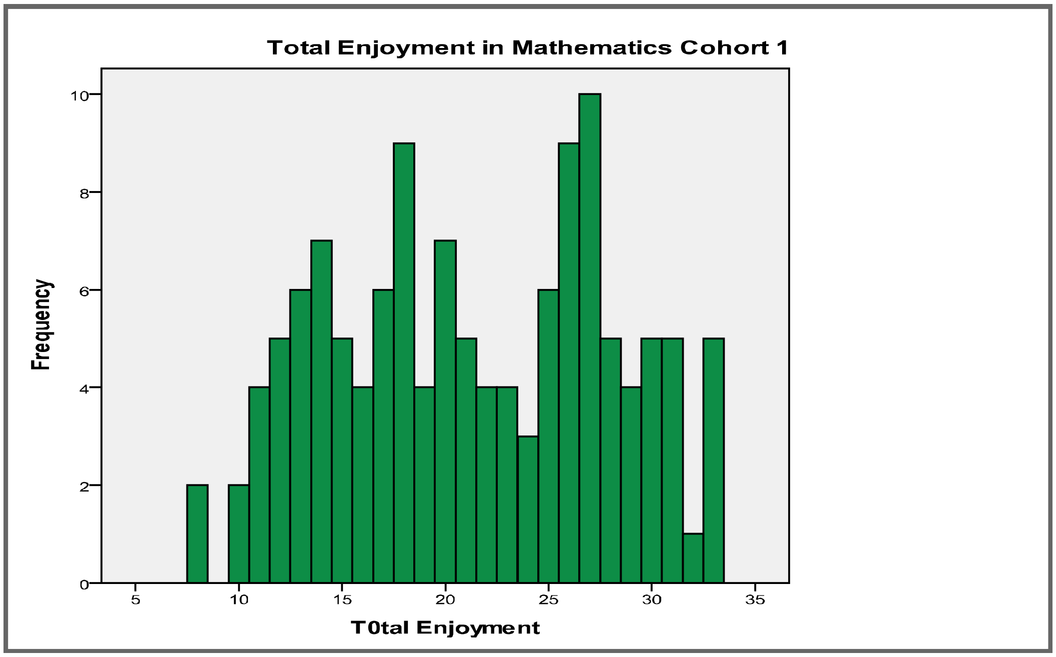

Figure 4.11 Total *Enjoyment* in mathematics for Cohort 1

Cohort 2 students had a mean of 22.39 (SD = 6.5) on the *enjoyment* in mathematics scale. This mean is slightly higher than in Cohort 1 students. Figure 4.12 shows *enjoyment* in mathematics for Cohort 2. As for Cohort 1 there is no significant trend in either direction the bars are slightly more clustered to the right side of the graph.

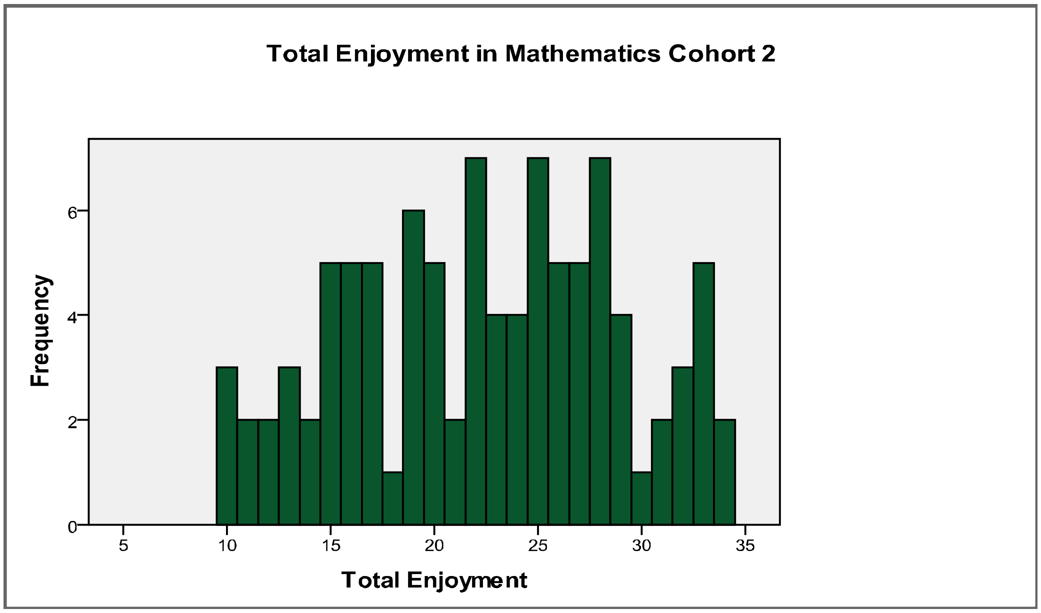

Figure 4.12 Total *Enjoyment* in mathematics for Cohort 2

4.7.5 Cohort 1 and Cohort 2 students *Self-concept*

There were 8 questions in this scale, the possible scores ranged from 8 to 40. The mean for this scale was 27.64 (SD = 4.5) which demonstrates positive findings for this scale in Cohort 1. The distribution was negatively skewed (-0.624) (Figure 4.13). This reflects high self- concept scores amongst Cohort 1 students but with a small number of worryingly low *self-concept* scores, the lowest score being 12.

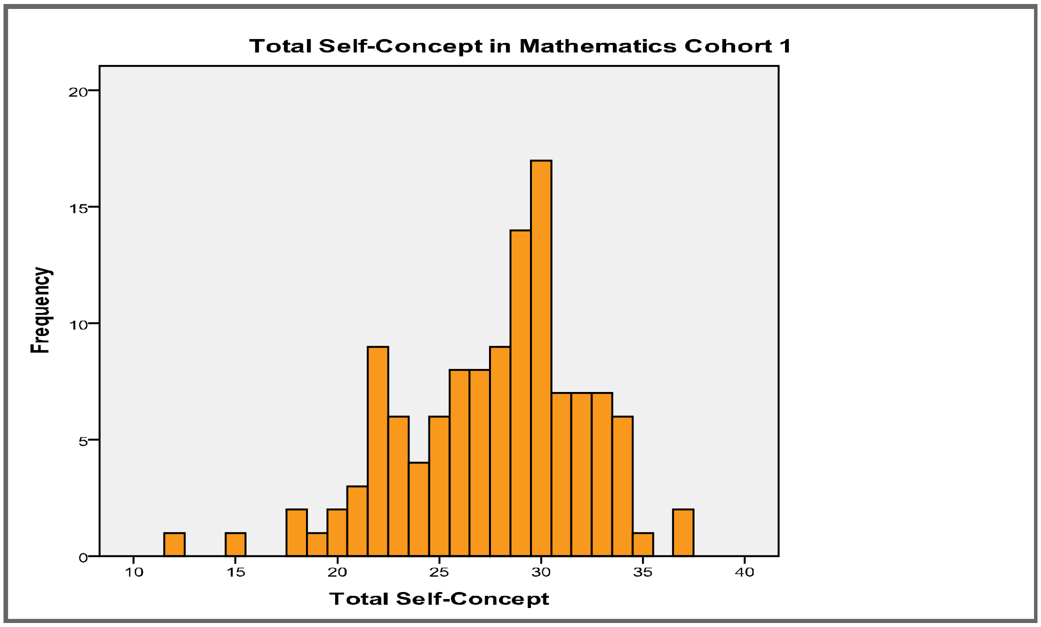

Figure 4.13 Total *Self-concept* for Cohort 1

The mean value for total *self-concept* in Cohort 2 was 29.26 (SD = 3.8). This mean is slightly higher than that of Cohort 1. Again Cohort 2 students have high *self-concept* values in mathematics. Figure 4.14 below shows the spread of these scores. Unlike Cohort 1, Cohort 2 does not show any significantly low scores. Therefore, Cohort 2 students have higher *self-concept* scores.

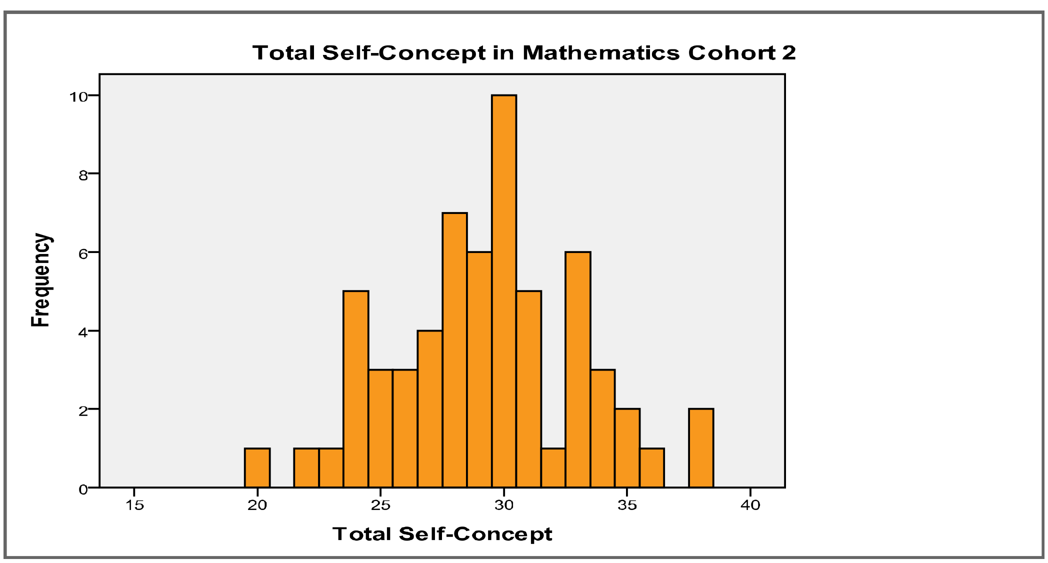

Figure 4.14 Total *Self-concept* for Cohort 2

4.7.6 Cohort 1 and Cohort 2 students *Value of Mathematics*

The range of scores in this scale was between 12 and 60 as there are 12 questions in the scale. The mean value for Cohort 1 was 43.78 (SD = 6.8). Figure 4.15 below shows the distribution for this scale. The distribution is skewed to the left. The histogram shows that the respondents *valued* mathematics highly.

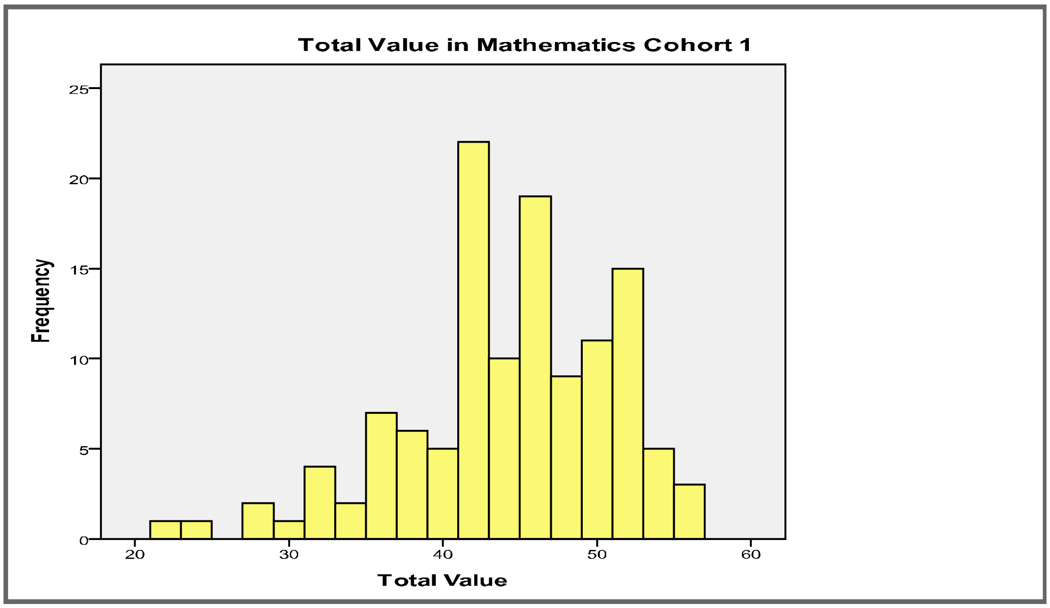

Figure 4.15 Total *Value* of Mathematics for Cohort 1

Value of Mathematics had again a higher mean than Cohort 2 (46.9, SD = 6.5). This high mean shows that students *value* mathematics. Figure 4.16 shows the distribution of the scores for this scale in Cohort 2.

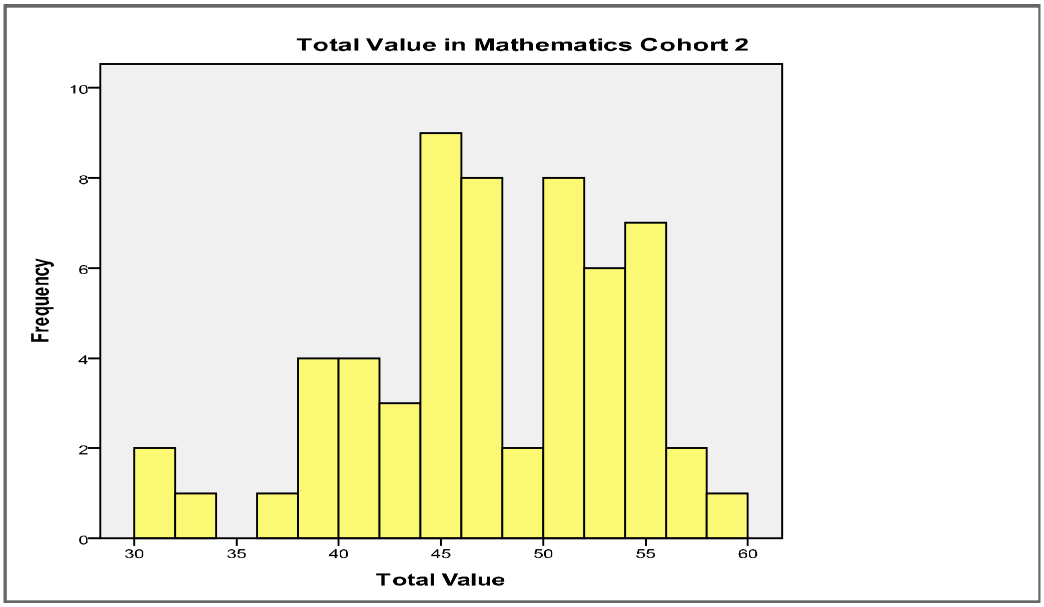

Figure 4.16 Total *Value* of Mathematics for Cohort 2

4.7.7 Cohort 1 and Cohort 2 students *Motivation in Mathematics*

There were 6 questions in this scale, therefore the range of scores were between 6 and 30. The mean value for Cohort 1 was 19.4 (SD = 4.9) indicating that there is a relatively even distribution of scores with the mean not being overly effected by either very high or very low scores. The distribution illustrated in figure 4.17 shows negative skewness (-0.309) which does indicate some low *motivation* scores.

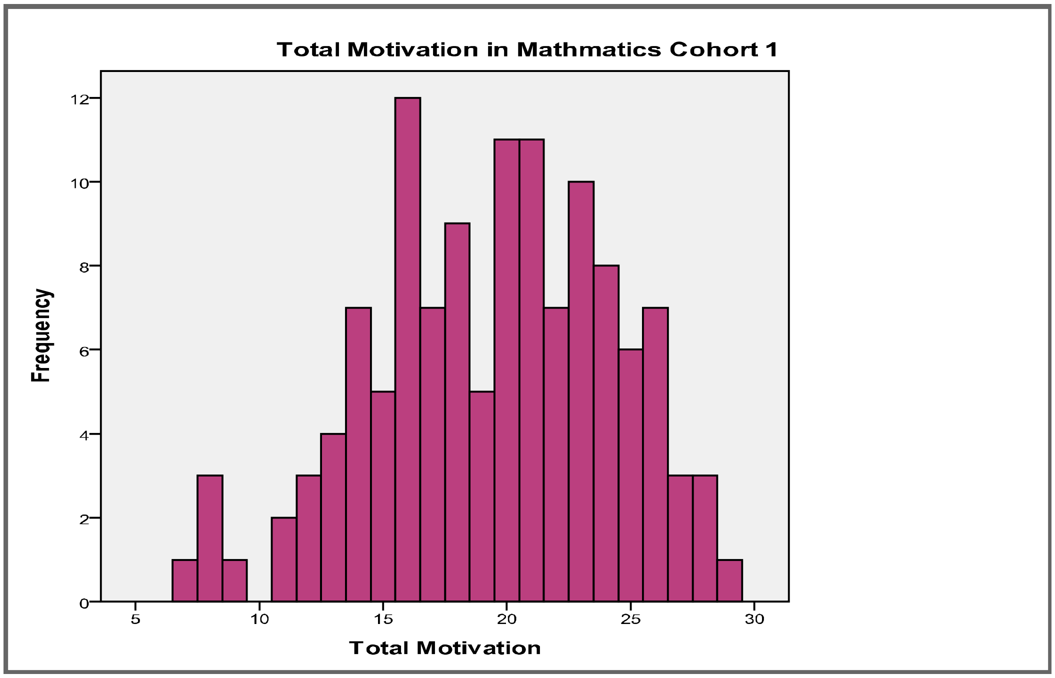

Figure 4.17 Total *Motivation* in Mathematics for Cohort 1

The mean value for *motivation* in mathematics for Cohort 2 was 21.22 (SD = 3.7). This was again slightly higher than the mean in Cohort 1. Figure 4.18 shows the results of the total scores for *motivation* in mathematics in Cohort 2.

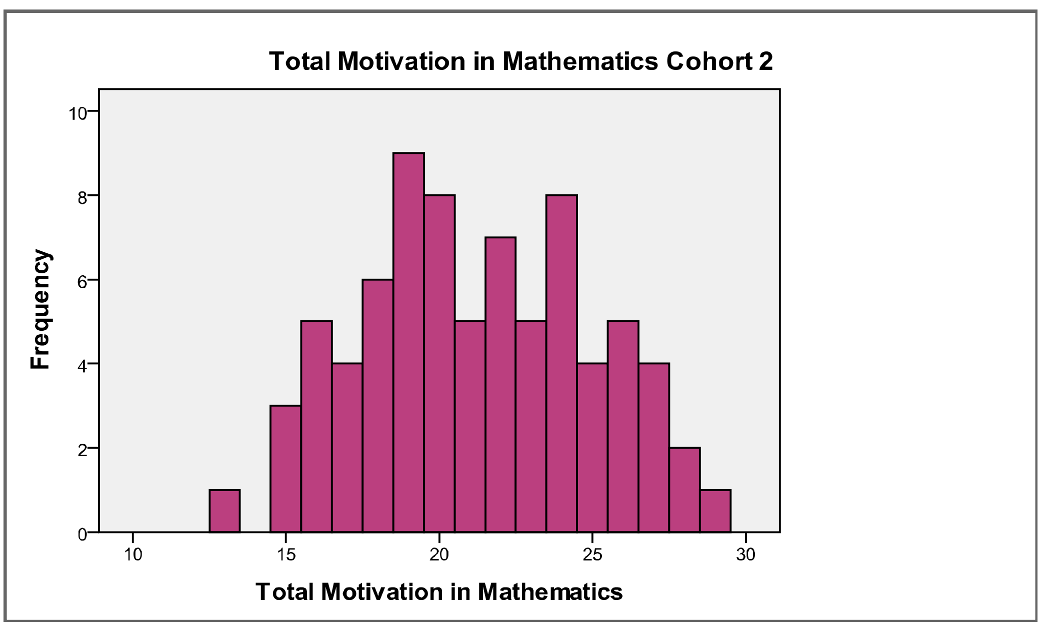

Figure 4.18 Total *Motivation* in Mathematics for Cohort 2

The following sections **4.7.8** to **4.7.10** report unexpected outcomes. These outcomes arose from preliminary analysis of each scale for both Cohort 1 and Cohort 2. High levels of *confidence* and *anxiety* were displayed by both Cohorts and so this investigated further. A correlation between the *confidence* and *anxiety* scales was explored to help illustrate these relationships. The mean for each scale was found in relation to each of the five schools for both Cohort 1 and Cohort 2. The relationship between each scale and school was also investigated and reported using boxplots.

4.7.8 *Confidence* and *Anxiety* for Cohort 1 and Cohort 2 students

The results from Cohort 1 students in both *confidence* and *anxiety* scales appear to relate to each other when a scatter diagram was constructed as shown in figure 4.19.

Figure 4.19 overleaf shows a positive relationship between the *confidence* and *anxiety* scales for Cohort 1 students. This relationship was further investigated using the Pearson product-moment correlation coefficient value. The outcome was a large positive correlation between the two variables, with an r value of 0.8 (n = 123). Thus high levels of *confidence* were associated with high levels of *anxiety* and vice versa. These results show that Cohort 1 students who reported high *confidence* levels also reported high levels of *anxiety*.

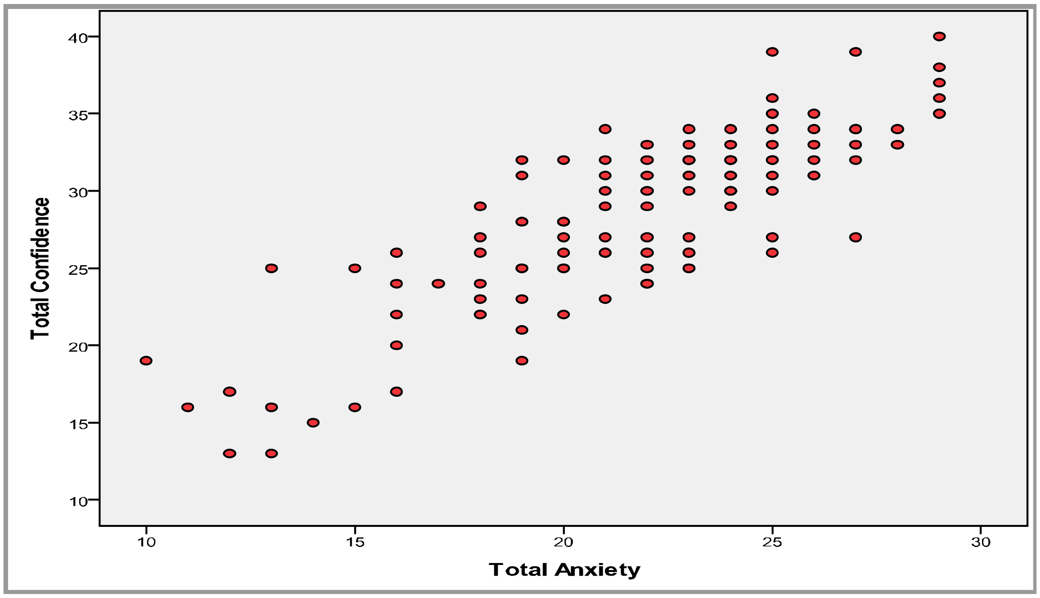

Figure 4.19 Correlation between Total *Confidence* and Total *Anxiety* for Cohort 1

Cohort 2 students (Figure 4.20) showed a positive relationship between the *Confidence* and *Anxiety* scales. Again this relationship was further investigated using the Pearson product-moment correlation coefficient. The outcome was a large positive correlation between the two variables ($r = 0.7$). Similar to the results from Cohort 1, high levels of *confidence* were associated with high levels of *anxiety* and vice versa. These results show that Cohort 2 students who reported high *confidence* levels also reported high levels of *anxiety*.

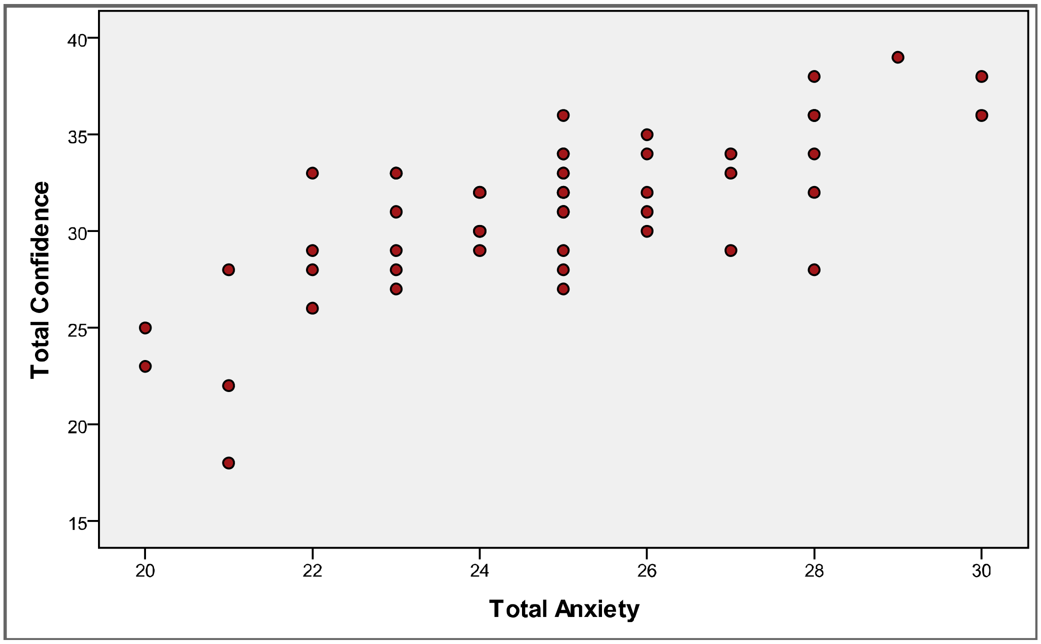

Figure 4.20 Correlation between Total *Confidence* and Total *Anxiety* for Cohort 2

Type of school was then correlated with each of the scales to determine if school type was a discriminating factor.

4.7.9 *Confidence* and *Anxiety* and type of school

A One-way between groups Anova with a post-hoc test was carried out to explore the impact of school attended by students on level of *confidence* (figure 4.21, page 97) and then on level of *anxiety* (figure 4.22, page 98).

4.7.9.1 *Confidence* and *Anxiety* and type of school Cohort 1 students

Table 4.7 overleaf illustrates the mean *anxiety* and *confidence* score for each school type. The lowest mean score for *confidence* (Cohort 1) was found in the school 2 (26.6) while the highest score was reported in school 3 (30.71). It is interesting to note that both schools 3 and 4 recorded the highest *confidence*. However, the difference between the means in schools 3 and 4 was very small.

Anxiety scores were also highest in schools 3 and 4 (Girls 23.52, Boys 22.93) and lowest in school 2 (20.76). These scores emphasise that there is a relationship between both scales as confirmed in figure 4.19 on page 92. It would have been expected to report perhaps that high levels of *anxiety* were associated with low *confidence* levels. The mathematics class in school 2 were reported by their teacher to be a very ñgoodò class. It is possible to be confident in mathematics but still be anxious and high *anxiety* exists even among high achieving students. Students who reported high *anxiety* with high *confidence* levels were identified and during the semi-structured interviews were questioned about this.

Cohort 1 and 2 students gave similar responses when questioned about their high *anxiety* scores. A Cohort1 student replied *"you are expected to do well in mathematics"* this was followed by agreement from the other students and another Cohort 1 student added *"you know that you are doing only a small section, not everything and you worry about the parts that you cannot do".* Cohort 2 students responded in a similar manner *"you are afraid of getting other parts wrong".* Another Cohort 2 student replied *"you know there are other questions or topics that you may not be good at"*. These comments are reinforced by the students not understanding why they do a particular topic and their inability to connect one topic with another.

School	1 Vocational school	2 Community school	3 All-girls school	4 All-boys school	5 Comprehensive school
Mean *Confidence*	27.08	26.60	30.71	30.45	28.24
Mean *Anxiety*	20.83	20.76	23.52	22.93	21.20

Table 4.7 Mean *Anxiety* and *Confidence* scores in each school type Cohort 1

4.7.9.2 *Confidence* and *Anxiety* and type of school Cohort 2 students

Table 4.8 shows the mean scores for *confidence* and *anxiety* in each school for Cohort 2. In all schools the *confidence* in mathematics is higher than the *anxiety* in mathematics. *Confidence* levels were reported to be highest in school 5 and lowest in school 3. This is in contrast to Cohort 1 when schools 3 and 4 reported the highest *confidence* levels. Following a similar pattern to Cohort 1, school 5 had the highest *anxiety* score while school 3 had the lowest. These are equivalent findings to Cohort 1. The students with high *confidence* in mathematics also have high *anxiety* levels.

School	1 Vocational school	2 Community school	3 All-girls school	4 All-boys school	5 Comprehensive school
Mean *Confidence*	30.38	30.80	29.67	31.31	32.08
Mean *Anxiety*	24.75	24.80	24.00	24.46	25.69

Table 4.8 Mean *Anxiety* and *Confidence* scores in each school type Cohort 2

As a result it can be assumed that school is not a discriminating factor in *confidence* or *anxiety*.

4.7.10. Correlation between *Enjoyment* and *Motivation*

Enjoyment and *motivation* are closely related to each other (Tapia *et al*, 2002). The relationship between *motivation* and *enjoyment* scales is shown in figure 4.21 overleaf. There is a large positive correlation (r = 0.9) between the two scales. Therefore, students who scored high in the *motivation* scale also scored high in the *enjoyment* scale and vice versa.

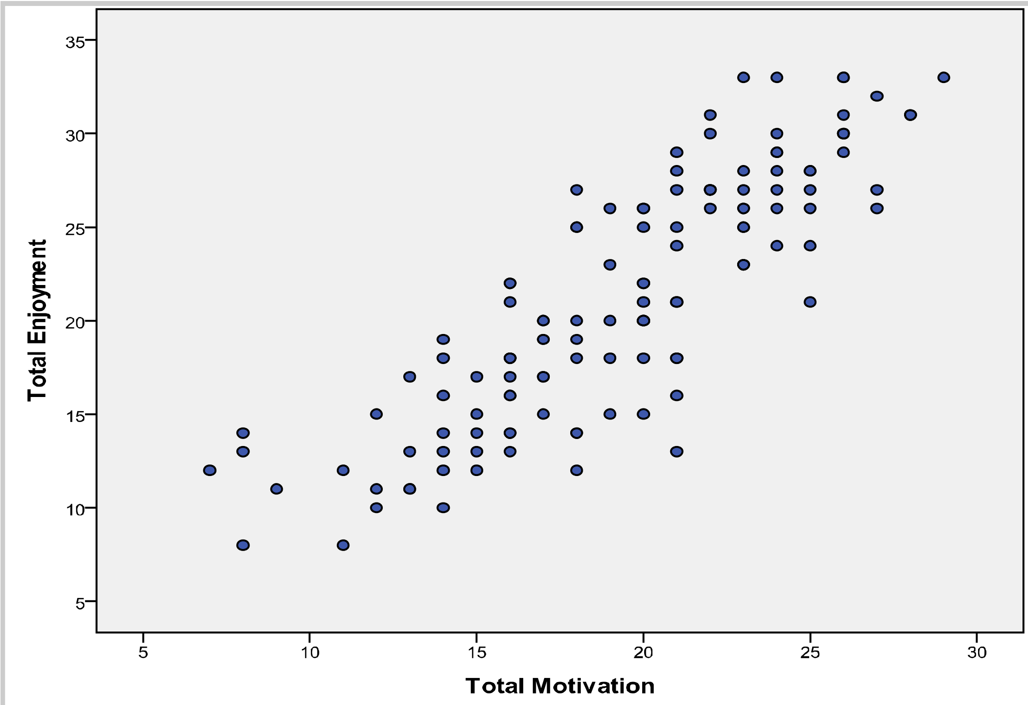

Figure 4.21 Correlation between Total *Motivation* and *Enjoyment* in Mathematics for Cohort 1

Figure 4.22 overleaf shows a scatter plot between total *motivation* and *enjoyment* in mathematics for Cohort 2. From the plot it can be seen that there is a large positive correlation (r = 0.8) between the two scales. This is a similar finding to Cohort 1. Therefore the students who enjoy mathematics are also motivated in the subject.

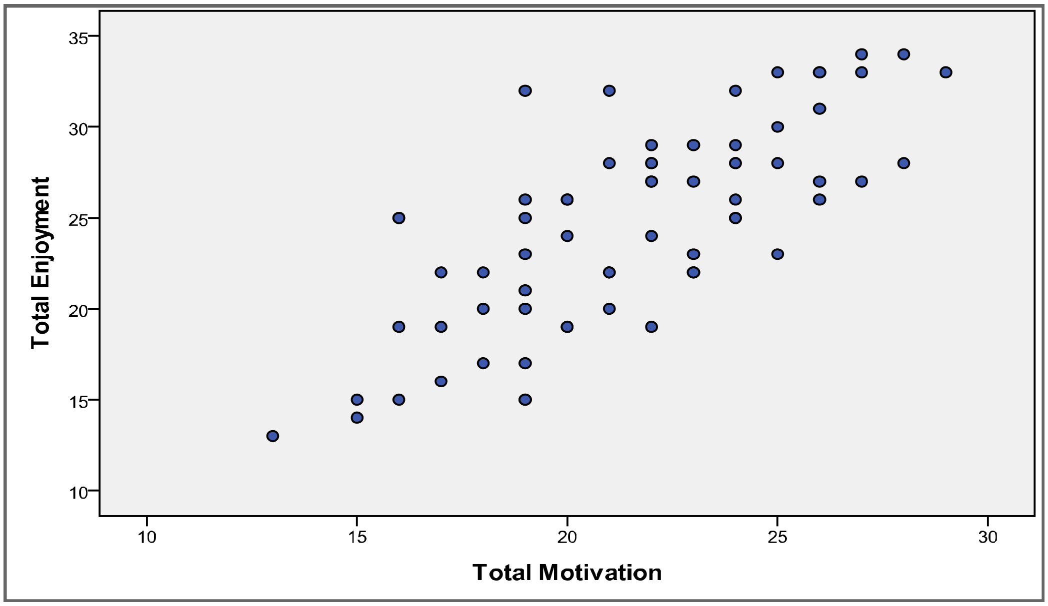

Figure 4.22 Correlation between Total *Motivation* and *Enjoyment* in mathematics for Cohort 2

The relationship between *motivation* and *enjoyment* scales in mathematics was investigated further using the semi-structured interviews. Students from both Cohorts were asked about the people that influence their *enjoyment* of the subject, their mathematics homework, their peers and how happy they are in mathematics class. The results of this were discussed in research question 2.

4.7.11. Relationship between each scale in each school

Boxplot graphs were used to exemplify a contrast between scores in a scale and a particular school. The rectangle represents the middle 50% of the scores while the tails mark the highest and lowest score. Dots represent outliers which are scores well above or well below the majority of scores, an asterisk represents an extreme outlier. The boxplot graphs for *beliefs* about mathematics, *self-concept* and *value* (Cohort 1 and 2) were omitted as their results did not illustrate a dramatic contrast between the five schools. The boxplots for these scales can be found in Appendix K.

4.7.11.1 Relationship between each scale in each school Cohort 1

Examining figure 4.23 below shows that the median *confidence* score for school 4 is lying on the lower quartile. Therefore, the students all scored *confidence* (Cohort 1) in a similar manner. There are a number of outliers in the same school which would have caused the mean to be lower than expected. It is also worth noting that the rectangles for both schools 3 and 4 are small in comparison to schools 1, 2 and 5. In schools 3 and 4 there are worryingly low outliers.

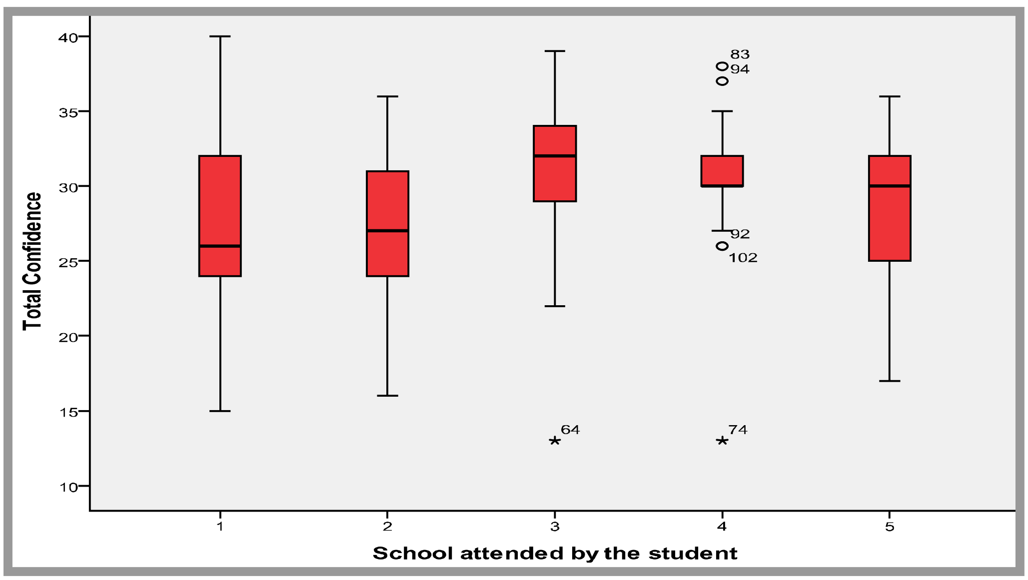

Figure 4.23 Total *Confidence* in each school for Cohort 1

Anxiety (Cohort 1) scored high in school 3 according to figure 4.24. The mean value for this school was the highest but was pulled down by the outliers. School 4 had the next highest mean. The school 2 had the largest spread of scores. The evidence here shows that in Cohort 1 *anxiety* was higher in single sex schools 3 and 4 than in schools 1, 2 and 5.

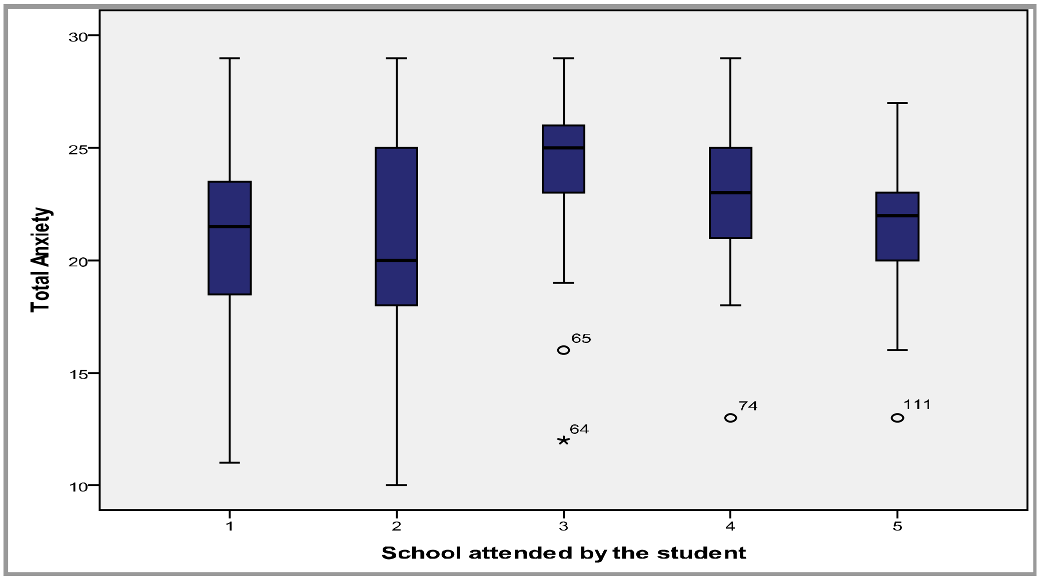

Figure 4.24 Total *Anxiety* in each school for Cohort 1

School 1 (Cohort 1) scored very low in the *enjoyment* scale. In contrast it can be seen in figure 4.25 that school 3 scored very high. The school 4 also scored quite high. This demonstrates that the students in schools 3 and 4 (single sex schools) enjoy mathematics more than in the other three types of schools.

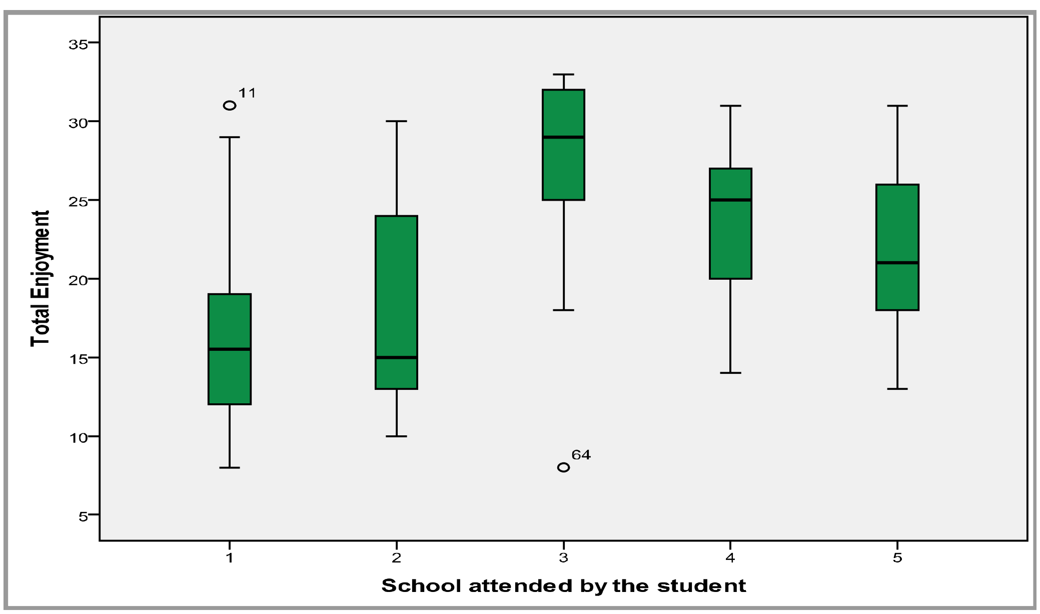

Figure 4.25 Total *Enjoyment* in each school for Cohort 1

Motivation in mathematics is related to *enjoyment* to mathematics. Figure 4.26 below reveals that school 3 displays the highest levels of *motivation* (Cohort 1). School 2 reported low scores for the same scale. These results are very similar to those of the *enjoyment* scale above. However, in this scale school 5 scored as high as school 4.

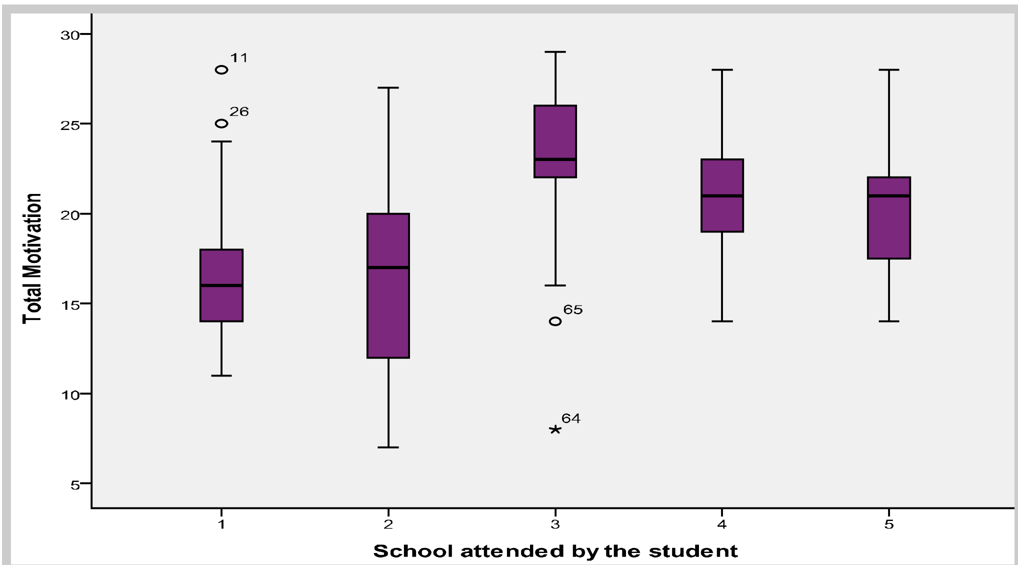

Figure 4.26 Total *Motivation* in each school for Cohort 1

4.7.11.2 Relationship between each scale in each school Cohort 2

Schools 1, 2 and 4 have similar spreads in their *confidence* values (Figure 4.27, overleaf). School 5 has the highest *confidence* levels. School 3 has a very small range of values showing that all students in that school rated *confidence* in the same way on the questionnaire. This school also had the lowest mean *confidence* score.

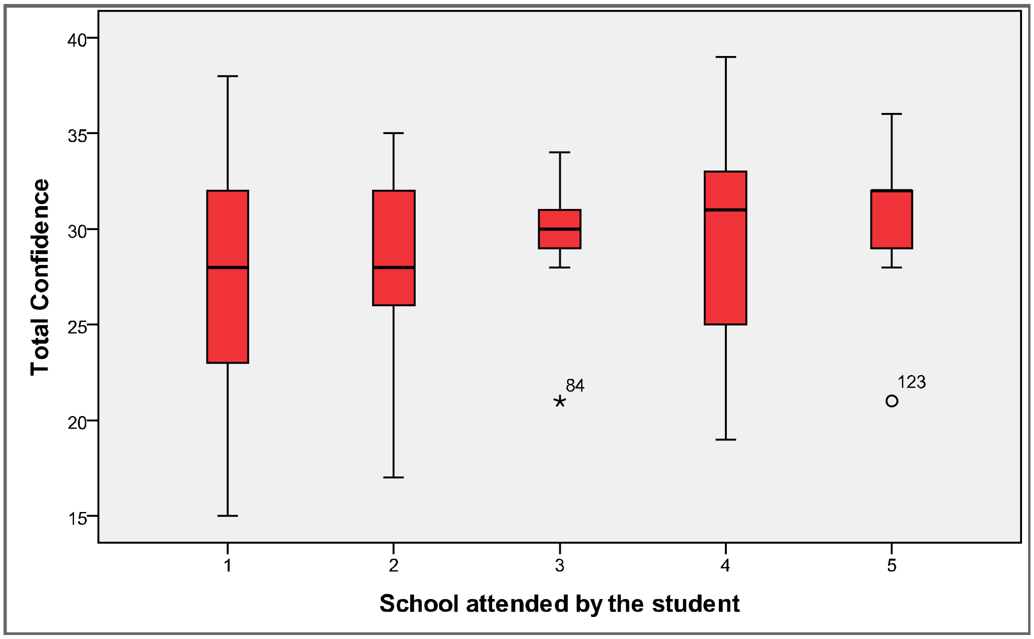

Figure 4.27 Total *Confidence* in each school for Cohort 2

Anxiety was reported by the students in school 1 over the largest range (Figure 4.28). School 3 had the smallest range of scores and also reported the lowest *anxiety* levels. School 5 which had the largest mean *anxiety* score has its median (middle value) on the bottom of the rectangle with only one outlier below. This illustrates that the students in school 5 reported similar high values for *anxiety*.

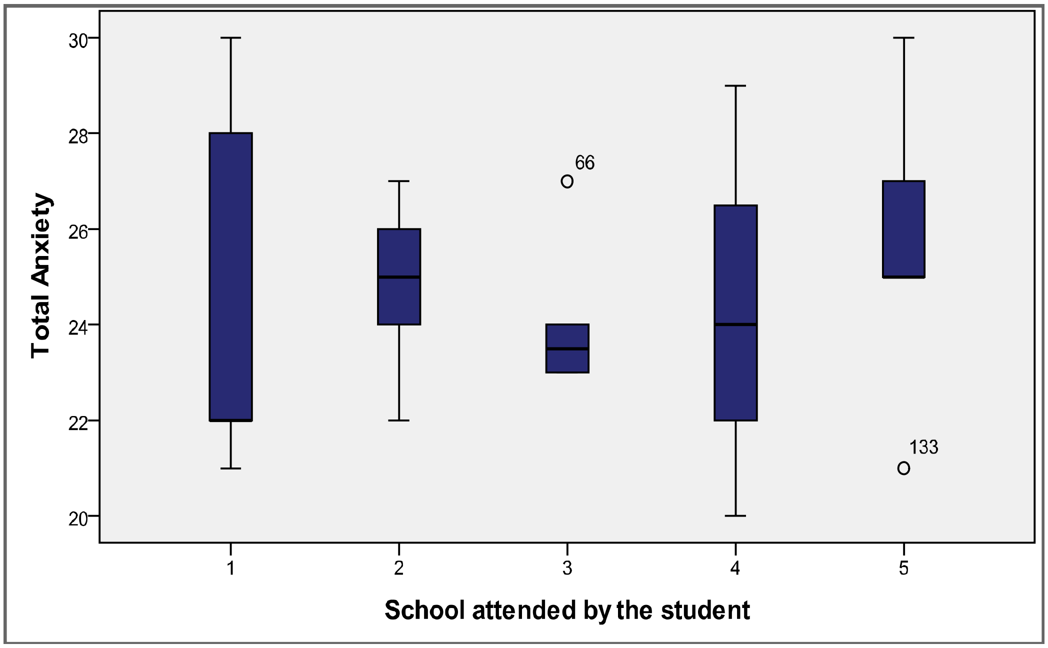

Figure 4.28 Total *Anxiety* in each school for Cohort 2

From figure 4.29 overleaf, school 1 showed worryingly low *enjoyment* levels while school 5 showed very high *enjoyment* levels. However, school 1 had a higher level and an ordinary level class in this Cohort. This finding reflects the responses given by the students during the semi-structured interviews which were discussed in section 4.7.10 above.

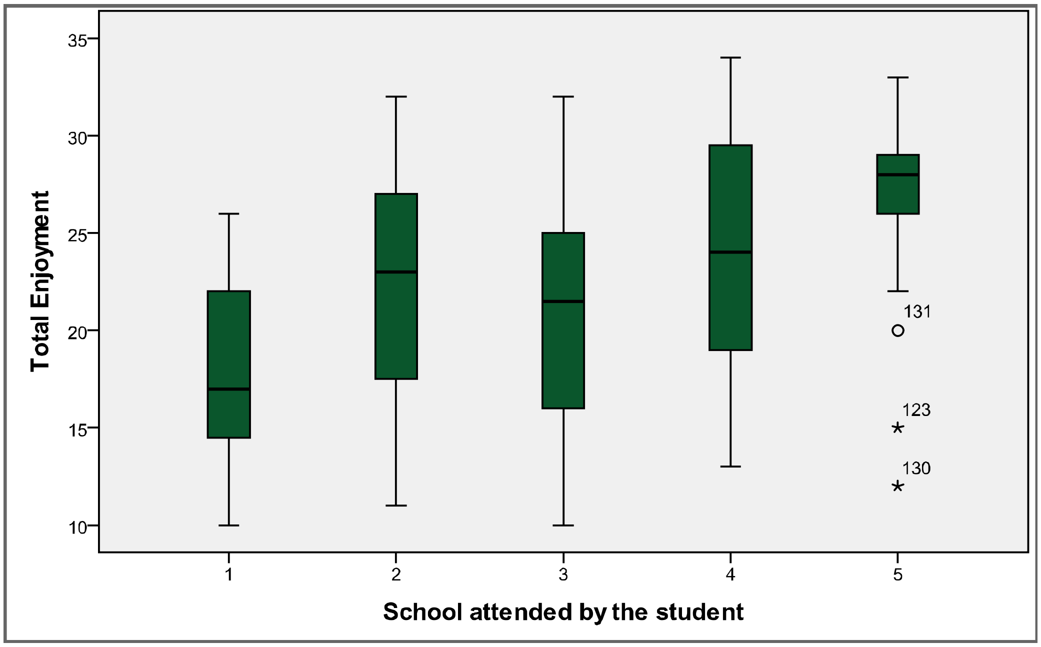

Figure 4.29 Total *Enjoyment* in each school for Cohort 2

School 4 showed the largest range of *motivation* scores (figure 4.30, page 105). In contrast school 2 had a very small range of scores. School 1 showed very low *motivation* scores which can be linked to the low *enjoyment* scores seen above in figure 4.27 (page 102). In contrast to the *enjoyment* scores school 2 had a very small range of *motivation* scores (figure 4.30, page 105).

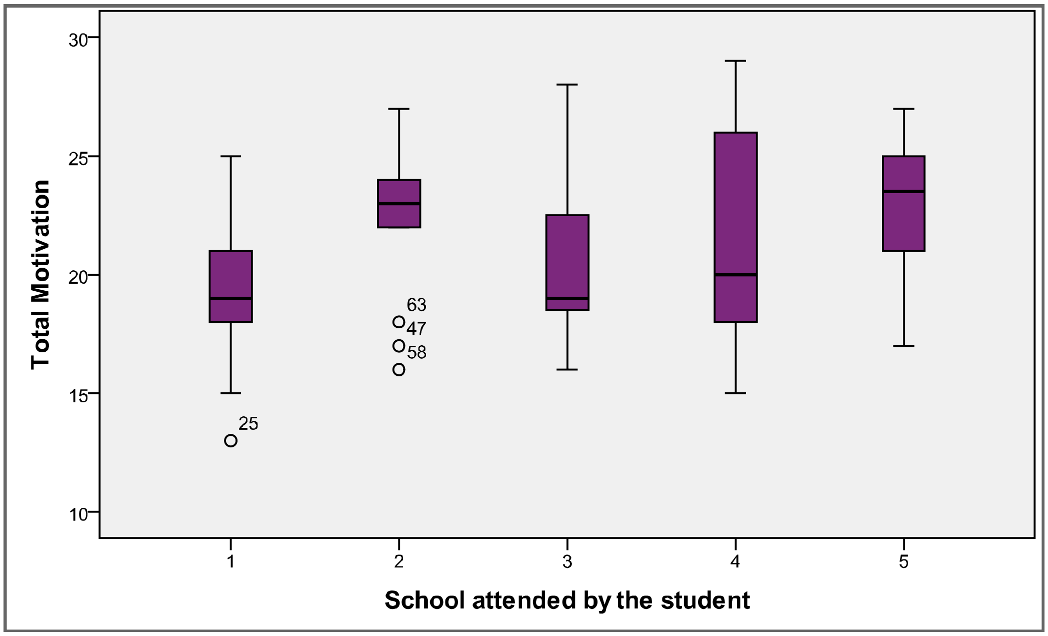

Figure 4.30 Total *Motivation* in each school for Cohort 2

Overall the scores for all scales in both Cohorts were high. Cohort 1 had slightly higher scores for all scales than Cohort 2. *Anxiety* and *confidence* were looked at together as was *enjoyment* and *motivation* scores. Correlation values were calculated for these relationships. *Anxiety* and *confidence* had large correlations for Cohort 1 (r = 0.8) and Cohort 2 (r = 0.7). *Enjoyment* and *motivation* also had large correlation values for Cohort 1 (r = 0.9) and Cohort 2 (r = 0.8). These results were supported by the student responses during the semi-structured interviews.

4.8 Research question 5: *Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?*

This question can be split into two parts:

Part 1. *Is there a significant difference between student understanding of mathematical problems pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?* and

Part 2. *Is there a significant difference between student attitudes to mathematics pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?*

Part 1 was investigated using the worksheet scores. Part 2 was answered using the questionnaire.

Part 1. *Is there a significant difference between student understanding of mathematical problems pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?*

The worksheet mean scores for each school in both Cohorts and the overall mean scores are shown in table 4.9 (page 108). The overall worksheet mean (47.29, S.D. = 18.1) score for Cohort 2 was lower than that of Cohort 1 (52.02, S.D. = 21.0). The result of an independent-sample t-test carried out on the two groups for worksheet scores showed there was a significant difference between the scores of Cohort 1 and Cohort 2 ($t(265) = 39.643$, $p<.0005$).

The mean worksheet score fell in all schools from Cohort 1 to Cohort 2 except in school 4 which had an increase from 43.45 (SD = 21.8) to 59.18 (SD = 16.7). School 4 had an ordinary level class in Cohort 1. School 2 had the largest fall in mean worksheet scores from 66.08 (SD = 21.4) to 47.96 (17.1). The teacher in school 2 described the Cohort 1 group as a very good class and this probably explains the high mean score for Cohort 1. There is a significant difference between the mean worksheet scores in Cohort 1 between schools 1 and 2 and between school 2 with schools 4 and 5 ($p<.0005$ level). In Cohort 2 there is a significant difference between school 1 and 4, 3 and 4 and between schools 4 and 5 ($p<.0005$ level).

A Pearson product-moment correlation coefficient was used to investigate the relationship between total *confidence* with the worksheet score and total *anxiety* with the worksheet score. It was found that in Cohort 1 *confidence* had no correlation with the worksheet score ($r = 0.02$). Also in Cohort 1, there was no correlation between *anxiety* and the worksheet score ($r = 0.01$).

In Cohort 2 the correlation between the two scales and the worksheet scores were found to be positive. Both scales had a medium correlation (*confidence*, $r = 0.3$ and *anxiety*, $r = 0.3$) with the worksheet scores. Therefore, students in Cohort 2 who are confident in mathematics did moderately well in the worksheet in general but these studentsô *anxiety* levels were also moderately high.

School	1 Community College	2 Community school	3 All-girls school	4 All-boys school	5 Compre-hensive school	Overall
Mean (S.D.) Worksheet score Cohort 1	47.81 (17.5)	66.08 (21.4)	55.81 (16.1)	43.45 (21.8)	49.76 (20.5)	52.02 (21.0)
Mean Worksheet score Cohort 2	44.5 (19.7)	47.96 (17.1)	39.10 (16.8)	59.18 (16.7)	44.68 (13.3)	47.29 (18.1)

Table 4.9 Mean Worksheet scores for Cohort 1 and Cohort 2

Part 2. *Is there a significant difference between student attitudes to mathematics pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?*

The attitudinal change from Cohort 1 to Cohort 2 was investigated using the questionnaire and the semi-structured interviews. The questionnaire results were reported in detail in response to research question 4 (*What level of confidence, anxiety, beliefs, enjoyment, self-concept, values of and motivation in the subject do students exhibit towards mathematics?*). Table 4.6 (page 79) illustrates the mean score for all the scales used in the questionnaire. While an increase in *anxiety* may be an increase in a negative variable, all other positive variables also increased.

To measure the attitudinal change from Cohort 1 to Cohort 2, independent-sample t-tests were carried out. The results of these tests are given in table 4.10 overleaf. There is no significant difference in *confidence* levels in scores for Cohort 1 (mean = 28.6, SD = 5.5) and Cohort 2 (mean = 29.19, SD = 4.9). The magnitude of the difference in means was very small (eta squared = 0.003). There was a significant difference in *anxiety* levels between Cohort 1 (mean = 21.84, SD = 4.4) and Cohort 2 (mean = 24.72, SD = 2.5). The magnitude of the difference between the means was large (eta squared = 0.16). This difference between the two means was investigated using the semi-structured interviews.

The students who reported high *anxiety* scores but also had high worksheet and semester scores were asked why they thought that they displayed high *anxiety* levels with high semester scores. A Cohort1 student explained that *"You may be able to do that topic but you know you are only doing a small section and you worry about the parts you cannot do"*. A Cohort 2 students remarked; ñ*You are always afraid of getting other questions or topics wrong, the ones you are not good at".* A Cohort 1 student also reported that they are ñ*Expected to do well"*. These comments are reinforcing the fact that students do not understand why they do a topic and their inability to connect one topic to another.

In the *beliefs* about mathematics scale there was a significant difference between the scores in Cohort 1 (mean = 25.1, SD = 3.2) and Cohort 2 (mean = 27.46, SD = 3.3) with a moderate magnitude between the two mean scores (eta squared = 0.07). However, this scale was found to have a low Cronbach alpha value in Cohort 1 (0.4) and so caution should be used when viewing the results.

When the independent-sample t-tests (table 4.10, page 110) were carried out on the *enjoyment* scale there was no significant difference between Cohort 1 (mean = 21.29, SD = 6.6) and Cohort 2 (mean = 22.39, SD = 6.5). There is a very small magnitude between the two Cohorts (eta squared = 0.007). The semi-structured interviews reported that students found mathematics to be *"Very hard and not fun* *at all"* (a Cohort1 student) and a Cohort 2 student responded that mathematics was ñ*The hardest subject"*. The students do seem to enjoy mathematics but prefer other subjects. This strengthens the case that students do not see the importance of mathematics in the world around them.

For the final three scales; *self-concept*, *value* and *motivation* there was a significant difference in each scale between the two Cohorts. In each case the magnitude of the difference between the means was small (eta squared < 0.05, for the three scales). The higher mean values for these affective variables in Cohort 2 could explain the higher number of attempts in the worksheet questions in Cohort 2 compared to Cohort1.

Scale	**Cohort 1 Mean (S.D.)**	**Cohort 2 Mean (S.D.)**	**P value**	**Eta squared (Magnitude)**
Total *Confidence*	28.60 (5.5)	29.19 (4.9)	0.4	0.003 (Small)
Total *Anxiety*	21.84 (4.1)	24.72 (2.5)	0.000*	0.16 (Large)
Total *Beliefs* about Mathematics	25.10 (3.2)	27.46 (3.3)	0.001*	0.07 (Moderate)
Total *Enjoyment*	21.29 (6.6)	22.39 (6.5)	0.216	0.007 (Small)
Total *Self-concept*	27.64 (4.5)	29.26(3.8)	0.017*	0.03 (Small)
Total *Value*	43.78 (6.8)	46.9 (6.5)	0.004*	0.05 (Small)
Motivation	19.4 (4.9)	21.22 (3.7)	0.003*	0.04 (Small)

Table 4.10 Results of the Independent-samples t-test *Significant at the 0.05 level

During the semi-structured interviews students were asked about the benefits of active learning methodologies and also about the new strands (1 and 2) in the Project Maths syllabus (Cohort 2 only). Cohort 1 and 2 students both felt that they could benefit from more active learning methodologies being used in the classroom. Cohort 1 suggested that they are ñ*easier to learn from and keep you interested"* whilst Cohort 2 liked the activities because ñ*you did not realise that you were doing a difficult maths problem"*. These responses tie in with student *motivation* and *enjoyment*. Perhaps this explains why the significant difference for each of these scales between the two Cohorts was so small (eta squared <0.04).

Cohort 2 had the opportunity to compare the Project Maths syllabus (strands 1 and 2) with the traditional syllabus. The students said that they liked the new strands (1 and 2) because ñ*there were activities involved"* however, when asked which syllabus they would prefer they said the old course. The reason that the students gave as their preference was as follows; one student replied ñ*the amount of words in the questions in the new book"* and another studentös response was *"when there are too many words and symbols in a question you cannot figure out what they are asking".* The students were then asked if the increase in text in the questions helped to relate the question to the world around them, a student replied ñ*No, not really"* and other students agreed with this reply. The students views would suggest that they are still being taught in a rote manner rather than using an approach based on teaching for understanding.

4.9 Summary

This chapter described the study sample. This chapter also detailed the findings of the questionnaire, worksheet and the semi-structured interviews for both Cohort 1 and Cohort 2 students. These results were related to each of the research questions which guided the study. Further analysis of the findings was carried out when the results showed interesting correlations between certain scales. The results reported will be discussed under each research question in chapter 5.

5. Discussion of findings

5.1 Introduction

This chapter will discuss the findings reported in chapter 4 for each research question in turn. An overall summary and conclusion will be offered at the end of the chapter.

5.2 Research questions and discussion

Each of the research questions in this study will be addressed in turn. These findings will be integrated with relevant literature explored in chapter 2.

5.2.1 Research Question 1: *To what extent are attitudes of students related to their understanding of mathematics?*

Attitude towards mathematics in this study is broken down into two subscales; *enjoyment in mathematics* and *value of mathematics* (Aiken, 1974). The attitude of students towards mathematics was tested using the questionnaire and the semi-structured interviews. Mathematical understanding was examined under two headings in this study. The first was instrumental, which is linked to a traditional didactic style of teaching as it tests the ability óto doô a task in mathematics. The second is relational, which tests a higher order of thinking or to óknow whyô you are carrying out a task. Both types of understanding were tested using the worksheet. The worksheet (Appendix F) contained questions that tested both studentsô instrumental and relational mathematical understanding. Question numbers 1, 9 and 10 tested instrumental learning. The remaining questions tested relational understanding and questions 3, 7 and 8 contained a problem-solving element.

A small or no correlation existed between the worksheet scores and the two scales. Cohort 1 showed no correlation between *enjoyment* and student understanding using the worksheet scores. Cohort 2 showed a medium correlation (r = 0.3) between *enjoyment* and understanding. The IMTA survey (B. OøSullivan, personal communication, October 2011 Appendix L) of the pilot schools reported that students were enjoying the new methods of teaching and learning used in the new syllabus.

There was a small correlation (r = 0.1) between *value* and student understanding in both Cohort 1 and 2. Carroll and OøDonoghue (2009) reported that students were unable to link topics in mathematics to real-life situations. Boaler (2002) believes that the use of a variety of learning styles in the classroom encourage students to hold on to and in turn use their knowledge. The new project-maths syllabus encourages the use of a variety of teaching methodologies including the relating of mathematics to everyday life.

Despite it being an aim of the Project Maths syllabus (NCCA, 2010) no student in either Cohort could provide rationale for the inclusion of any mathematical topic. However, mathematics teachers are only getting used to the new syllabus and this may well improve with time. Students from both Cohorts were able to connect mathematical topics to each other. Boaler (2002) found that many people were unable to connect topics in mathematics and so perhaps progress has been made recently in the mathematics classroom to help students connect topics together. Emphasising this point further, Cohort 1 students said their teacher did not point out connections between topics for them, while Cohort 2 students said that this did happen for them in their mathematics classroom. Perhaps in the mathematics classrooms of Cohort 1 students the lessons were teacher led and emphasis was placed on traditional drill and rote learning (Lyons *et al,* 2003).

In both Cohorts the students dealt better with questions which tested instrumental understanding. The ordinary level students coped as well with these questions as the higher level students. This confirms the findings of Brosnanôs (2008) study which discovered that post-primary students were unable to discuss mathematics and saw it as a series of notes that should be learned off. Boaler (2002) had similar findings when he reported that mathematics is seen by many people as a collection of disconnected procedures and formulae which must be memorised. The wording of the question or in this case the lack of heavy text in the questions may have attributed to the high number of attempts. Klinger (2006) highlighted this issue and tied anxiety in mathematics to mathematical language. The questions testing instrumental learning appeared to trigger greater interest in a higher number of students. This emphasises the work of Hidi and Renninger (2006) who believes that a situation can trigger interest in a student and focus the student on the task. This finding is also supported by Lubienskiôs (2011) who found that there was too much teacher lecturing happening in the mathematics classroom and that a trend towards a more problem-centred instruction would help to improve understanding.

Students from both Cohorts found the problem-solving questions (Q3, 7 and 8) difficult in the worksheet (Appendix F). In both Cohorts very few students were able to cope with Q8 (*Calculate the number of Emus and Elephants in the zoo given the number of eyes and legs that can be seen*). This question required students to transfer their knowledge of simultaneous equations to an out of context question. It is not surprising that Cohort 2 students did not cope better with this problem as they had not been exposed to strand 3 (Algebra). The strand 3 algebra content starts with new entrants to Junior cycle in 2013 and will deal with problems of this nature.

This lack of ability to cope with the problem-solving questions on the worksheet is worrying as Kuapri (2007) attributed Finlandôs high score in the PISA 2006 study to the emphasis on problem-solving in mathematics. Problem-solving is also a stated aim of the Project Maths syllabus (NCCA, 2010). PISA type problems test studentsô knowledge and the skills required for life after full time education. This type of knowledge and skills has not been prioritised in the traditional mathematics syllabus. Post-primary students in Ireland have not always participated well in the PISA study for this reason. However, the new Project Maths syllabus aims to concentrate more on óreal-lifeô situations and so post-primary students may then be more familiar with PISA like questions.

When questioned during the semi-structured interviews the students, attributed this issue to the ñ*wording*ò used in the questions. These responses emphasise the work of Boaler (2002) who found that many people see mathematics as a collection of disconnected procedures and formulae which must be memorised. Cohort 2 students were encouraged to discuss problems and to give a reason for their answer under the new Project Maths syllabus (NCCA, 2010). This emphasis was missing from Irish mathematics classrooms pre Project Maths (Brosnan, 2008). Cohort 2 students appear to have higher interest in completing a question which holds resonance with Boekaerts and Boscoloôs (2002) study. This study found that students with individual interest possess an inner drive to learn more and find the answer to a question. Del Favero, Boscolo, Vidotto, and Vicentini, (2007) found that problem-solving can maintain interest by encouraging a student to further explore ideas. This may have led to Cohort 2 students thinking about the question for longer and to make a logical attempt. It is reasonable therefore to suggest that this new approach in Project Maths helped contribute to higher worksheet scores in comparison to Cohort 1 students.

Hence, Cohort 2 the Project Maths students have greater ability to cope with the unseen problems compared to Cohort 1 students. However, the worksheet cannot disclose whether either Cohort were able to relate the problems to óreal-lifeô situations. It can only be hypothesised that if students are better able to problem-solve they are also better able to relate mathematics to the world around them. This links to the work of Boaler (2002) who argued that students must make connections between mathematics problems and everyday life.

5.2.2 Research Question 2: *To what extent are student attitudes related to the methods of teaching mathematics?*

The attitudes (*enjoyment* and *value)* of students were tested using the questionnaire (Appendix E). The methods of teaching mathematics were elicited from student responses during semi-structured interviews. The author wished to investigate if attitudinal scores for *enjoyment* and *value* were related to methods of teaching used in the classroom.

The scores for both scales were high in Cohort 1 (*enjoyment* = 21.29, *value* = 43.78) and in Cohort 2 (*enjoyment* = 22.39, *value* = 46.9), which reflects that the students *enjoy* mathematics and also have *value* in it. Cohort 2 had slightly higher scores for both scales than Cohort 1. Cohort 1 students felt that *teachers, parents* and *students* all had a role to play in influencing their *enjoyment* in mathematics. Cohort 2 felt that their *enjoyment* was influenced by *teachers* and *parents.* These comments reflect the findings of English *et al* (1992) who reported that parents recognise the importance in the subject but were unable to help the students. This emphasises the importance of the initiative put in place to support parents that wish to help with their childôs numeracy (Department of Education and Skills, 2011). Students in Cohort 1 claimed that they were influenced by their peers in the class. Cohort 1 students appeared more competitive towards the other students in their mathematics class than Cohort 2 students. This validates the work of Sullivan (2007) who reported that higher ability groups tend to have higher expectations than ólow-abilityô groups. However, Cohort 2 implied that their classes had no influence on how competitive they are. Kang (2006) discovered that high achieving students relate better to other high achieving students. Cohort 1 students were conscious of this fact whilst the findings from Cohort 2 students contrast with those of Kang (2006). However, Cohort 2 students were younger and also less focused on their Junior Certificate examination at this stage.

When the students in both cohorts were questioned about their homework or study environment, they all replied that they did their homework at a desk in their room or at the kitchen table. The students also reported to listening to music while doing their homework but going to a quieter place to study. These comments suggest that positive learning environments are used by the students. A positive learning environment decreases student *anxiety* (Brosnan, 2008). Situational interest can be triggered by a favourable environment situation (Boekaerts and Boscolo, 2002).

Response to statement 45 on the questionnaire; *I am happier in Mathematics class than in any other class,* revealed that students in both Cohorts disagreed with this statement and so the students were asked why this was the case during the interviews. Their responses emphasise their high *anxiety* level and also the lack of active learning methodologies used in the classroom. The students appear to learn from activities in the classroom and from their peers during group work. Studies by Auster and Wylie (2006), Petty (2004), House (2006), Hidi and Renninger (2006) and McKinney *et al* (2009) have all shown that the use of active learning methodologies increase mathematical understanding. Felder and Brent (2009) found that the use of active learning methodologies made the mathematics class more enjoyable and the quality of learning improved. The Project Maths syllabus has encouraged the use of active learning methodologies in the classroom. However, teachers are slow to change therefore it will take time to see this improvement. This was reported by the IMTA survey of the 24 pilot schools which found that it took time but understanding did improve (B. OøSullivan, personal communication, October 2011, Appendix L).

The semi-structured interviews were used to determine if the variety of teaching methods used by teachers in the mathematics classroom had an impact on the scores. The teacher does most of the work in the classroom according to students from both Cohorts. This mirrors the findings of Lyons *et al* (2003). When questioned about this further, students from both Cohorts reported that they enjoy learning from their peers. Hidi and Harackiewicz (2000) and Arnold and Lawler (2012) support the use of group work as it results in increased interest and self-confidence in some students.

There was evidence of active teaching methodologies being used in the mathematics classroom with both Cohorts. Cohort 1 and Cohort 2 students responded positively to the use of these methodologies. However, most of the activities used were restricted to a revision based emphasis. The students had said that they enjoyed group work and so it is worth noting that both group work and active teaching methodologies could be used to improve student understanding in mathematics. The studentsô responses from the interviews echo the findings of Auster and Wylie (2006) and Hidi and Renninger (2006) where the students with various learning styles were engaged in the learning process and interest was increased. Arnold and Lawler (2012) found that project based-learning helped students to make connections between mathematics and the óreal-worldô. This study also revealed that students preferred to work in small groups as they depended on their peers and felt more comfortable asking their peers a question (Arnold and Lawler, 2012). The use of a variety of teaching methods also challenges students to think and learn in new ways. These results relate to the findings of Orhun (2007) who carried out a detailed study on the manner in which males and females learn. Females were found to be ñConverger Learnersò which are active learners and like to learn by discovery. Males were found to be ñAssimilator Learnersò, those who learn by observation. These results also find resonance with the work of Biggs *et al* (2001) which showed that students have various learning styles; they could be deep or surface learners. This supports the findings from the questionnaire. Both Cohorts enjoy mathematics but Cohort 2 had slightly higher scores for *enjoyment* which perhaps reflects the use of more active learning and teaching tools in the classroom following continued professional development for all mathematics teachers in the Project Maths syllabus (NCCA, 2010).

The students were subsequently asked what they would change about their mathematics class. Students from both Cohorts suggested an increase in the amount of activities used in the mathematics class. The students implied that they would learn more from group work and from activity based learning. This echoes studies by McKinney *et al* (2009) and House (2006) who both found that active learning helped to develop conceptual understanding and increase test scores. Stassen (2003) also found group work resulted in more positive results than individual work.

Studentsô mathematical mistakes were explained to Cohort 2 students more than to Cohort 1 students according to the responses during the semi-structured interviews. However, this may be connected to the mathematics teacher rather than the Cohort. Hodgen and William (2006) emphasise the importance of feedback between student and teacher for effective learning. Stigler *et al* (1996) found that mistakes were a natural learning process. Perhaps more discussion involving the studentsô mistakes would help students to understand the mathematics behind the questions. In fact this has already been verified by Corcoran (2009) who confirmed that student discussion in the classroom had improved both teaching and learning outcomes. The Project Maths syllabus encourages discussion of student approaches to their solutions and perhaps when the teachers have become more comfortable with the syllabus there will be more emphasis on discussion as an integral part of teaching.

The semi-structured interviews were used to explore how students relate mathematics to the world around them. Cohort 1 and Cohort 2 students were able to see the importance of mathematics. However, the students were unable to relate it to anything other than money and other subjects in school. The students in both Cohorts said that mathematics was the ñ*most important subject"* yet this importance is only placed on mathematics from an examination point of view. Perhaps the students in the study were young and had not yet focused on their future career or the world outside the classroom. These responses echo the findings of Carroll and OôDonoghue (2009) who found that students were unable to link topics in mathematics to óreal-lifeô situations. However, the new Project Maths course has begun to use questions relating to óreal-lifeô situations. This may help to improve the link between the classroom and the world around them. Also, the increased use of problem-solving questions may increase individual interest in mathematics which may over time improve not only their knowledge, but also their value and positive feelings towards mathematics (Hidi and Harackiewicz 2000). However, Lubienski (2011) warns of the over use of óreal-lifeô problems as some mathematical problems used in the classroom are not practical but should be used in the classroom as they may help students to understand mathematical concepts.

5.2.3 Research Question 3: *To what extent are student attitudes related to their success in mathematics examinations?*

To investigate this research question the semester scores were used. The attitudes (*enjoyment* and *value)* of students were examined using the questionnaire (Appendix E). The relationship between the semester scores and the attitudes was explored using Pearson product-moment correlation coefficient values. The most recent semester examination results for all students that took part in the study were recorded and mean scores were calculated.

Both Cohorts had high mean semester scores, Cohort1 had a mean of 71.53 (SD = 16.7) whilst Cohort 2 had a mean of 60.56 (SD = 19.1). The lower mean score in Cohort 2 could be related to the studentsô difficulty in expressing themselves mathematically in the new style of questioning associated with the Project Maths syllabus. The short exposure to strands 1 and 2 of the new Project Maths syllabus has not impacted on the problem. Perhaps with time this may improve. The attitudinal scales showed a small or no correlation with the semester score results. While, the students appeared to do well in mathematics, this was not linked to their *enjoyment* or *value* in mathematics. This would suggest that students can learn off formulae and sequences but do not understand the concept involved, hence scoring well in tests but not having any deep understanding of the content being tested. This was highlighted in a study by Boaler (2002) and Brosnan (2008) who remarked that mathematics was seen as a series of procedures and formulae that can be learned off.

The lower semester examination scores for Cohort 2 may be linked back to the introduction of the new Project Maths syllabus. In the traditional syllabus the studentsô instrumental understanding was heavily tested but in contrast, a lack of understanding of mathematical concepts was reported by the Chief Examiner (Chief Examinerõs Report Leaving Certificate, 2005 and 2001). The new Project Maths syllabus has attempted to improve this by encouraging students to give justifications for their answers and to explain their reasoning (NCCA, 2010). Brosnan (2008) found that there was little or no higher form of cognitive thinking in the mathematics classroom (pre-Project Maths era). This is an opinion supported by Lyons *et al* (2003) who found that 96% of all interaction that takes place in the post-primary mathematics classroom is teacher led. Perhaps not enough practice of discussing answers has occurred in the classroom for students to feel comfortable with this new emphasis on understanding mathematics. It is possible to explain this, in part at least, by mathematics teachers only getting accustomed to the new rationale at this early stage of the implementation of the Project Maths syllabus. The IMTA survey (B. OõSullivan, personal communication, October 2011, Appendix L) of the 24 pilot schools in autumn of 2011, reported that mathematics teachers found the new methodologies for teaching mathematics difficult to implement in the beginning. However, in the same study, the mathematics teachers in the pilot schools reported that their students were enjoying these and that student understanding of mathematics was improving.

The lower semester examinations scores for Cohort 2 could also be attributed to less time being available for Project Maths teachers to focus on some of the more traditional mathematical topics. Lack of time is a common complaint from mathematics teachers engaged in Projcet Maths (IMTA survey, B. OõSullivan, personal communication, October 2011, Appendix L) since its introduction. It was never the intention of Project Maths to reduce time allocation for key competencies on mathematical procedures and instrumental learning. In due course, pacing by mathematics teachers may also improve. In addition, Cohort 2 students did report higher mean scores (23.29 compared to 21.29) on the *enjoyment* scale than Cohort 1 students. If *enjoyment* continues to improve in time with Project Maths it is possible this will lead to increased scores in examinations in mathematics. Ma and Kishor (1997) investigated the relationship between attitude towards mathematics and achievement in mathematics. Their study found that this relationship was dependant on the age of the student and their ethnic background. While Schreiber (2002) carried out a similar study and reported that the more a student believed that success was caused by natural ability, the higher the grade achieved by them in mathematical examinations. Similarly, Barkatsas, Kasimatis and Gialamas (2009) confirmed that high achievement was associated with high levels of confidence in mathematics. Therefore, it is important to encourage students to have confidence in their own ability to help improve their examination grade. However, Wu, Barth, Amin, Malcarne and Menon (2012) showed evidence in their study that math anxiety has a detrimental impact on achievement in the subject regardless of the studentös social experience or situation. Moses, Bjork and Goldenberg (1990) contrasted with these studies when they found that student attitude towards mathematics and achievement were not correlated.

5.2.4 Research Question 4: *What level of confidence, anxiety, beliefs, enjoyment, self-concept, values of and motivation in the subject do students exhibit towards mathematics?*

This question was investigated using the questionnaire made up of the seven affective variable scales and the semi-structured interviews. Both Cohorts displayed high mean scores for all affective variables. Cohort 2 had slightly higher means for all variables compared to Cohort 1. The scale that had the largest increase from Cohort 1 to Cohort 2 was *value* in mathematics while the smallest increase was in *confidence*. The large increase in *anxiety* in Cohort 2 led the author to investigate this scale further.

When the preliminary analysis had been carried out, the high level of *anxiety* and *confidence* were then investigated using a correlation coefficient test. Both Cohorts showed a strong positive correlation between the two scales. Cohort 1 ($r = 0.8$) showed a slightly higher correlation than Cohort 2 ($r = 0.7$).

This relationship was then investigated further within each school to determine if school type was a discriminating factor. The results from Cohort 1 conveyed that the highest *confidence* scores were in school 3 and 4. These are both single-sex schools. However, both these schools had the highest mean *anxiety* scores also. Girls in single-sex schools have higher motivation to achieve and confidence than those in coeducational schools according to Cherney and Campbell (2011). It would be hypothesised that as confidence increases anxiety would decrease. However, Cohort 1 results did not support this and so high anxiety levels deserve more attention.

Cohort 2 scores contradict these results. School 3 had both the lowest mean *confidence* and *anxiety* scores in Cohort 2. School 4 had the second highest mean *confidence* score but the second lowest mean *anxiety* score. School 4 had a higher level and an ordinary level class in Cohort 1. Consequently, it would have been predicted that *confidence* levels would be dramatically lower in Cohort 1 than in Cohort 2. As a result it can be assumed that school is not a discriminating factor in *confidence* or *anxiety*. This may contradict slightly the report by Eivers *et al* (2006) which found that children with higher socioeconomic status out performed students with a lower socioeconomic status. This was also expressed by Boaler (1997). However, this study was carried out in the Northwest area of Ireland and therefore the choice of school may for the most part have more to do with location and convenience sampling than a socioeconomic status.

The semi-structured interviews were used to investigate the reasons why students illustrated high *confidence* and *anxiety* scores. Students from both Cohorts conveyed that mathematics was the most important subject in school. Cohort 1 and 2 students both expressed that knowing one topic did not ensure that you were confident with another topic. This emphasises the NCCA (2007) study which found that there needs to be an increased importance placed on connections between different topics in the syllabus. This is an aim of the Project Maths syllabus and will perhaps foster interested students who will in turn be able to calm negative thoughts and reduce *anxiety* levels (Hidi and Harackiewicz, 2000). Mathematical *anxiety* is recognised as an impediment to performance (Gourgey, 1982). Studies have found that students express strong feelings of fear towards mathematics which results in avoidance of the subject (Aiken, 1974). This may explain why so many students were unable to attempt or complete a question on the worksheet.

Enjoyment and *motivation* were also looked at in this manner as they are closely related to each other (Tapia *et al*, 2002). The findings (chapter 4) illustrated that in both Cohort 1 and Cohort 2, school 1 (community college) had worryingly low *enjoyment* and *motivation* scores. This issue was further addressed in the semi-structured interviews. When students were questioned on this they reported that ñ*parents and teachers”* (Cohort 1 and 2) and *“peers”* (Cohort 2) influenced their *enjoyment* in mathematics. When further probed on this they reported that ñ*parents and teachers tell you how important it is”*. This shows that students do not see the importance of mathematics for themselves. Boaler (2002) alluded to this issue in her study which highlighted that a large number of students who give up the study of mathematics as soon as possible regardless of their ability in the subject. Singh *et al*, (2002) concluded that parents and teachers influence studentsô attitudes towards mathematics. The aim of both the traditional and the new Project Maths syllabuses is to emphasise the importance of mathematics in everyday life (Department of Education, 2006 and NCCA, 2010). This aim must now be fulfilled by mathematical educationalists in Ireland.

Both Cohorts reported spending more time on mathematics homework than other subjects but this was because it ñ*is harder than”* the other subjects. The students also remarked that their parents were interested in the study they do but ñ*don't always check”* their homework. Perhaps this reflects the findings of English *et al* (1992) which reported that parents recognise the importance in the subject but were unable to help the students.

Schools 3, 4 and 5 reported very high *enjoyment* and *motivation* scores in both Cohorts. When a correlation test between these two scales was performed for both Cohorts it was shown that there were large correlations between *motivation* and *enjoyment* (Cohort 1, r = 0.9 and Cohort 2, r = 0.8). This conveys that students who are motivated towards mathematics also enjoy mathematics. Eynde and Hannula (2006) listed *enjoyment* and *motivation* as two of the emotions that a student will go through while attempting to solve a mathematical problem.

However, both Cohort 1(mean = 2.25, S.D. = 0.1) and Cohort 2 (mean = 2.31, S.D. = 1.2) disagreed with statement 45 (*I am happier in mathematics class than in any other class)* in the questionnaire (Appendix E). When probed about this in the semi-structured interviews students related this to a lack of active learning methodologies used in the mathematics classroom and also to high *anxiety* levels. In this connection, Eynde and Hannulaôs (2006) study listed *anxiety* as another emotion that students exhibit while attempting a mathematical problem. This finding is also supported in the work of Klinger (2006) who found a connection between mathematical language and math-anxiety.

Overall the scores for all scales in both Cohorts were high. Cohort 1 had slightly higher scores for all scales than Cohort 2. *Anxiety* and *confidence* were looked at together as was *enjoyment* and *motivation* scores. Correlation values were calculated for these relationships. These strong correlations were supported by the student responses during the semi-structured interviews. Both Cohorts found that students had high levels of *anxiety* so the introduction of the new Project Maths syllabus has not affected this emotion. This will be discussed further in part 2 of research question five (5.2.5). *Enjoyment* and *motivation* scores were higher in Cohort 2 than in Cohort 1. This may be linked to the increase in the discussion required in the new Project Maths syllabus (NCCA, 2010) and to the increase in the amount of active learning methodologies in the mathematics classroom. Gal, Ginsburg and Schau (1997) encouraged the assessment of student attitudes on a continuous basis to identify areas of frustration for the students and then learning could be guided by these findings to help improve attitudes. However, the high number of students that were unable to link mathematics to óreal-lifeô situations was worrying, this was reported in the semi-structured interviews by students from both Cohorts. The linking of mathematics to óreal-lifeô situations is an explicit aim of the new Project Maths syllabus (NCCA, 2010).

Felder and Brent (2009) encourage the use of active learning methodologies with specific emphasis on group work. Through these activities they believe that student interest will be heightened and mathematical concepts can be explained to students by teachers and peers. The use of active learning methodologies in the mathematics classroom is also encouraged by Auster and Wylie (2006) who believe that active learning methodologies challenge students to think and learn in new ways. The use of active learning methodologies in the classroom develops studentsô analytical and problem-solving skills according to Petty (2004). Active learning methodologies can increase enjoyment and motivation in mathematics (Singh, 2002). The student responses from the semi-structured interviews illustrate the importance placed by students on the use of active learning in the classroom. Perhaps the increase in the use of active learning methodologies may help to improve student attitudes towards mathematics.

5.2.5 Research Question 5: *Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre and post Project Maths (Strands 1 and 2)?*

This research question addressed two issues:

Part 1. *Is there a significant difference between student understanding of mathematical problems pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?* and

Part 2. *Is there a significant difference between student attitudes to mathematics pre Project Maths and strands 1 and 2 of the new Project Maths syllabus?*

Part 1 of this question was answered using the worksheet (Appendix F) scores for both Cohorts to assess student understanding.

There was a significant ($p < .0005$) difference in the worksheet mean scores for Cohort 1 (52.02) and Cohort 2 (47.29). As was reported in section 5.2.1 above there was an improvement in studentsô ability to attempt the problem-solving questions from Cohort 1 to Cohort 2. Attempting questions on the worksheet is linked to studentsô *confidence* and *anxiety* levels (Fennema and Sherman, 1976). It was important to investigate this further. The positive correlation between the *anxiety* scores and the worksheet scores conveys that those who scored well on the worksheet were also anxious. There was no correlation in Cohort 1 ($r = 0.01$) and in Cohort 2 this correlation was medium ($r = 0.3$).

The high *anxiety* and *confidence* levels conveyed by the students hold resonance with the work of Zan *et al* (2006). Zan *et al* (2006) linked *confidence* and *anxiety* to decision-making. It also confirms Eynde and Hannulaôs (2006) study who listed these emotions as sentiments expressed by students while problem-solving in mathematics. However, it is important to note that the much earlier work of

Gourgey (1982) recognised *anxiety* as an impediment to performance in mathematics. This hindrance is evident from the number of students who were unable to attempt or complete questions on the worksheet. These results were investigated further using the semi-structured interviews and will be discussed in the next part of this research question.

Although a significant fall in mean worksheet scores were obtained from Cohort 1 to Cohort 2, it cannot be concluded that this fall was caused by the introduction of the Project Maths syllabus. Teachers have had difficulty with the content of strands 1 and 2 of the new Project Maths syllabus and have required help from other teachers and Project Maths leaders (Lubienski, 2011). Perhaps when all five strands of the Project Maths syllabus have been introduced into schools and mathematics teachers have been given time to adjust to the new methodologies involved in the new course, improvements in understanding will be observed. The IMTA survey of the 24 pilot schools has already reported this finding. It will take time to see the full results nationally (B. OöSullivan, personal communication, October 2011, Appendix L).

Part **2.** *Is there a significant difference between student attitudes to mathematics pre Project Maths and strand 1 and 2 new Project Maths syllabus?*

Part 2 of this research question, relating to, attitudinal change, was answered using the questionnaire and the semi-structured interviews. Attitude has been broken down in this study into two subscales; *enjoyment* and *value* (Aiken, 1974) in research questions 1, 2 and 3. However, when comparing the attitudes of the two Cohorts it is important to take in all the scales that were measured using the questionnaire.

Overall there was an increase in the mean score for all affective variables from Cohort 1 to Cohort 2. There was no significant difference in the total *confidence* mean score from Cohort 1 to Cohort 2. It can be concluded that both Cohorts had high *confidence* levels in mathematics. *Anxiety* showed a significant difference from Cohort 1 to Cohort 2 (eta squared = 0.16). Therefore, students in Cohort 2 were more anxious than those in Cohort 1.

Cohort 2 had significantly different scores in *beliefs* about mathematics than Cohort 1 (eta squared = 0.07). This shows that Cohort 2 students had stronger *beliefs* about mathematics. *Enjoyment* showed no significant difference between the two Cohorts. Both Cohorts seem to enjoy mathematics yet they do not fully understand the concepts involved. This strengthens the case that students do not see the importance of mathematics in the world around them. English *et al* (1992) reported that if the students find purpose in their learning their attitude towards the topic would improve. A study by Mitchell (1993) echoes similar findings. If students hold meaningful perceptions of the mathematics to their own lives then their interest will improve (Mitchell, 1993).

Self-concept (eta squared = 0.03), *value* in mathematics (eta squared = 0.05) and *motivation* (eta squared = 0.04) all had significant difference between the Cohorts. These three scales are connected according to Klinger (2006). Also, Eynde and Hannula (2006) named these as a number of emotions that a student will go through while solving a mathematical problem. Alexander (1997) found that if the studentsô interest increases their *motivation* to do well will also increase. Therefore, it is important to recognise the link between these affective variables. The higher mean values for these affective variables in Cohort 2 could explain the higher number of attempts in the worksheet questions.

Students were asked during the semi-structured interviews why they reported high *anxiety* scores with high worksheet and semester scores. Cohort 1 and 2 students reported that they were anxious about the *"parts that they could not do"*. This comment is reinforced by the students not understanding why they do a particular topic and their inability to connect one topic with another. This emphasises the

NCCA (2007) report which conveyed the need for an increase in the importance placed on connections between topics. This is an aim of the Project Maths syllabus and when all five strands are introduced nationally perhaps it will be addressed further.

Both Cohorts felt that their learning could improve with the use of more active learning methodologies in the mathematics classroom. Perhaps this is why there was a small significant difference between the two Cohorts for the *value* and *motivation* scales (eta squared < 0.04). The studentsô view reflects the findings of Auster and Wylie (2006) who proposed that the use of a variety of learning methodologies engages a variety of learning types and also challenges students to think in new ways.

Cohort 2 students compared the Project Maths (strands 1 and 2) with the traditional syllabus. While the students welcomed the use of more active learning in the classroom they were put off by text heavy questions used in the new Project Maths syllabus (strands 1 and 2). The students were unable to relate the questions to real-life situations and felt the increase in text only confused them further. This view would suggest that students are still being taught in a rote manner rather than for understanding. Perhaps when all five strands have been introduced teaching for understanding will be prioritised in the classroom. If this were to happen, students may be able to cope with the wording of questions and also relate the questions to óreal-lifeô situations. This would fulfil an aim of the Project Maths syllabus (NCCA, 2010).

There was no significant difference in the semester examination scores between Cohort 1 and Cohort 2. Therefore the introduction of the Project Maths syllabus has not made an immediate improvement on studentsô semester examination scores. It is perhaps too early to judge the effect of the Project Maths syllabus. Student mathematical understanding may appear to improve after all five strands of the Project Maths syllabus have been introduced.

5.3 Summary

This chapter discussed the findings reported in chapter 4. The findings were discussed with respect to each of the research questions and then in turn were related to appropriate literature reviewed in chapter 2. Recommendations that arose from this study together with suggested avenues for future research will be explored in chapter 6.

6. Conclusions, Contributions, Recommendations and Future Research

6.1 Introduction

This chapter will give a conclusion to the findings reported in chapter 4 and discussed in chapter 5. The contribution that this piece of research makes to Irish education will then be discussed. Recommendations that arose from the research will also be considered in this chapter along with areas of future research that may lead from this study.

6.2 Conclusion to preliminary results

The range of mean scores was 2.31 to 4.34 which reflects a positive result for all scales. However, both Cohorts reported a low score for one item on the enjoyment scale (*I am happier in mathematics class than in any other class*) and one item on the motivation scale (*Once I start working on a mathematics problem, I find it hard to stop*).

The low score on the enjoyment scale reflected studentsô opinions that they did not enjoy mathematics class as much as other subjects. This result was confirmed by the semi-structured interviews. The low score for the item on the motivation score was reflected in the poor attempt by both Cohorts at problem-solving questions on the worksheet.

6.3 Conclusion to research questions

The main conclusion for each research question will now be outlined.

6.3.1 Research Question 1: *To what extent are attitudes of students related to their understanding of mathematics?*

Cohort 2 students are only beginning to make connections between topics in mathematics. Teachers also appear to be pointing out these connections more to students in Cohort 2 than in Cohort 1. The students from both Cohorts dealt better with questions which tested instrumental understanding compared to relational understanding. The studentsô lack of ability to cope with problem-solving type questions on the worksheet reflected this. Studentsô were óput-offô by ótext heavyô questions. This is worrying considering the *text-heavy* questions that are used in the Project Maths syllabus (NCCA, 2010). This issue was raised by Klinger (2006) who connected maths-anxiety to mathematical language.

However, Cohort 2 students were slightly better at attempting and completing the problem-solving questions so perhaps with time as the students adjust to the new style of questioning their skills for problem-solving will improve. This emphasises the study of Boekaerts and Boscolo (2002) which found that students were driven to learn more and seek the answer to a question. When all five stands of the Project Maths syllabus have been introduced into schools students will be more familiar with the new style of questioning and so their analytical and problem-solving skills may improve.

6.3.2 Research Question 2: *To what extent are student attitudes related to the methods of teaching mathematics?*

It was found that parents, teachers and peers all influence studentsô *enjoyment* of mathematics. Students learn from their peers which emphasises the work of Hidi and Harackiewicz (2000). The students learn from their peers without realising it (Hidi and Harackiewicz 2000). This occurs when active learning methodologies are being used in the classroom (Auster and Wylie, 2006). The increase in the use of active learning methodologies is an aim of the Project Maths syllabus (NCCA, 2010). Therefore, teachers are encouraged to use active methodologies in the classroom.

Students from both Cohorts appeared to connect the importance of mathematics to examinations rather than to the world around them. Carroll and OôDonoghue (2009) found similar results. This will conceivably change when both students and teachers adjust to the new type of questioning and reasoning required by the Project Maths syllabus (NCCA, 2010).

6.3.3 Research Question 3: *To what extent are student attitudes related to their success in mathematics examinations?*

Semester examination scores in mathematics were high for both Cohorts. However, no correlation was found between these semester scores and student attitudes for Cohort 1. Similarly, no correlation was found between semester scores and *value* but a small correlation did exist between *enjoyment* and semester scores. It is possible to conclude therefore, in general, that success in mathematics examinations is not influenced by student attitudes.

Cohort 2 had a slightly higher mean score than Cohort 1. This could be attributed to the new style of questioning and reasoning required in the answers on the Project Maths syllabus (NCCA, 2010). Brosnan (2008) and Lyons *et al* (2003) highlighted the lack of higher form of thinking in the mathematics classroom pre-Project Maths. Perhaps this may influence the inability of some students to cope with unseen questions and problem-solving questions. With time students and teachers will adjust to the new style of questioning and the enjoyment in mathematics will hopefully increase. This, optimistically, will in turn help to improve semester score results.

6.3.4 Research Question 4: *What level of confidence, anxiety, beliefs, enjoyment, self-concept, values of and motivation in the subject do students exhibit towards mathematics?*

Cohort 2 students reported higher mean scores for all scales compared to Cohort 1. While this is a negative finding for the anxiety scale it is positive for the other scales. The high anxiety levels in students may be connected to the fact that mathematics in the classroom is often examination driven (Lubienski, 2011). The Project Maths syllabus hopes to change this by placing an emphasis on the use of mathematics in the óreal-worldô (NCCA, 2010).

Motivation was slightly higher in Cohort 2 compared to Cohort 1. This is encouraging as high motivation levels will hopefully help to improve studentsô ability to attempt and complete a question. Eynde and Hannula (2006) linked enjoyment and motivation. Therefore, if a studentsô enjoyment in mathematics improves, then their motivation will also improve. This has begun to occur according to the IMTA survey carried out in the pilot schools (B. OôSullivan, personal communication, October 2011, Appendix L).

A worrying outcome from this research question was the high anxiety levels that remain to exist in post-primary students even after the introduction of strands 1 and 2 of the new Project Maths syllabus. It can be concluded from the findings reported in chapter 4 that students are anxious about mathematics due to the importance placed on the subject by teachers, parents and peers. This was also a finding of the NCCA (2007) report.

6.3.5 Research Question 5: *Is there a significant difference between student understanding of mathematical problems and attitudes to mathematics pre-Project Maths and strands 1and 2 of the new Project Maths?*

Part 1. *Is there a significant difference between student understanding of mathematical problems pre-Project Maths and strands 1 and 2 of the new Project Maths syllabus?*

There was a significant difference in the worksheet scores between Cohort 1 (52.02) and Cohort 2 (47.29). The drop in worksheet scores reflects a drop in understanding. However, this overall result does not tell the entire story. Cohort 2 students were better able to cope with problem-solving questions on the worksheet compared to Cohort 1 students. This is promising as these students were only exposed to strands 1 and 2 of the new Project Maths syllabus. Fennema and Sherman (1976) linked confidence with anxiety. Confidence they found, is related to what a student will attempt while anxiety is the factor which will prevent a student from attempting the question.

Part 2. *Is there a significant difference between student attitudes to mathematics pre-Project Maths and strand 1 and 2 of the new Project Maths syllabus?*

There was a significant difference in five out of the seven scales used in the questionnaire between Cohort 1 and Cohort 2. *Enjoyment* and *confidence* did not show a significant difference. The attitudes of the students were higher in Cohort 2. While this is a positive reflection on the introduction of strands 1 and 2 of the new Project Maths syllabus, the increase in anxiety levels may be viewed as negative. Therefore, more intervention to reduce mathematical anxiety in post-primary students is required.

Cohort 1 and Cohort 2 students all agreed that their enjoyment of mathematics could improve with an increase in the use of active learning methodologies in the classroom. This would help to reduce anxiety as the students would be involved in group work more often and would feel more comfortable asking their peers for help. The increased use of the active learning methodologies would hopefully help to improve mathematical interest in the students. This is an aim of the new Project Maths syllabus (2010) and Orhun (2007) encourages the use of a variety of learning methodologies as it helps to cater for the diverse student learning styles.

When all five strands of the Project Maths syllabus have been introduced into schools, both teachers and students will feel more comfortable with the new style of questioning, the reasoning required when answering a question and the relation of mathematics to the óreal worldô. With time hopefully confidence levels in both teachers and students will improve and the aims of the Project Maths syllabus will be fulfilled.

6.4 Contribution

This study makes a unique contribution to Irish mathematics education on the study of change in attitude and mathematical understanding of Junior Certificate students pre Project Maths and after the implementation of the new Project Maths syllabus (strands 1 and 2). It adds to our knowledge and understanding of the importance of affective variables in mathematics teaching. There has been no research carried out on the impact of Project Maths since its introduction. This is the first classroom based study based on Project Maths and its impact on student attitudes towards mathematics. The study contributes to our understanding of the likely effects the new syllabus will have on post-primary mathematics students. The insights gained can by utilised in the future to compare results when all five strands of the Project Maths have been introduced.

It is a comparative study between students who have been exposed to the new Project Maths syllabus (strands 1 and 2) and those taught using the traditional syllabus. This opportunity will not be available again as from September 2012 all students entering post-primary schools will be taught the new Project Maths syllabus.

The seven scales that were used in this study (*confidence, anxiety, beliefs, enjoyment, self-concept, value and motivation)* have all been shown to be important emotions for students in mathematics. These scales or affective variables overlapped with one another (Eynde and Hannuala, 2006) and caused positive and negative reactions in the students. This holds resonance with the work of Eagly and Chaiken (2007) that provided the definition on which the theoretical framework of the study hung.

This study showed that the students who were exposed to strands 1 and 2 of the new Project Maths (Cohort 2) appeared to *enjoy* and *value* mathematics more than students who were not exposed to the new syllabus (Cohort 1). Cohort 2 students also displayed greater levels of *confidence*, *motivation*, *beliefs* and *self-concept* in mathematics than their counterparts in Cohort 1. However, the study also reported that student *anxiety* levels remained high in both Cohorts. The findings of this study have demonstrated that mathematical understanding has not improved with the implementation of the new Project Maths syllabus (strands 1 and 2). Therefore, further attention to improve mathematical understanding and lower anxiety levels, is required if the new Project Maths syllabus is to fulfil its aims.

6.5 Recommendations

A number of recommendations arose from this research study.

1. To help improve student mathematical understanding effective questioning techniques should be developed by mathematic teachers to probe and clarify learning in the classroom. An emphasis ought to be placed on the method and process students use while completing a mathematical task rather than focusing on getting the correct answer. The NCCA (2012) has listed a number of key skills that students should develop during Junior cycle. Being creative is one of theses key skills, students should be encouraged to find a variety of methods to solve a problem. Expanding from this, mistakes and misconceptions that arise in mathematics need to be explained to students to ensure that repeated mistakes do not become habit e.g. solving 2x = 8 does not become x = 8 ï 2 or 2.3 hours does not become 2 hours and 30 minutes. An explicit NCCA (2012) key skill for Junior certificate students is that of communication. Students should be able to explain there answers and communicate any mistakes. This is not a passive exercise. One of the explicit aims of the Project Maths syllabus is to relate mathematics to the óreal-worldô. To facilitate the implementation of this aim, teachers must make connections between topics in mathematics. The use of óreal-lifeô and cross-curricular mathematical examples could also aid student understanding and help them to relate mathematics to the world around them.

An example of this would be the deployment of opinion polls in statistics which are often utilised through the use of surveys in CSPE (Civic, Social and Political Education) classes.

2. One of the findings from this study is that students prefer active learning methodologies to passive methodologies. Group work is listed as a key skill by the NCCA (2012), emphasising the importance of students being able to work with one another. Collaborative group work, when it is well planned and executed can help students to learn in a contained and safe environment. This can be intertwined with the questioning or prompting and with the ‘real-life’ examples mentioned in the first recommendation. *Maths Week* each October offers post primary mathematics teachers further opportunitities to promote active learning through the creative use of treasure-hunts, quizzes, guest speakers and a variety of mathematical games. ICTs that students are familiar with can also be used in the classroom, ‘Youtube’ videos contain many appropriate examples and Geo-Gebra can be used to improve understanding of many coordinate geometry and algebra problems in an active fashion. The use of digital pens could also be explored. Teachers can make use of moodle or i-cloud space to store additional resources and examples for use by students.

3. Another finding of this study through the semi-structured interviews was that students found mathematics classes moved fast and at times they found it hard to ‘keep up’. Teachers must give some time to planning the pace of their classes and topics. Less teacher led examples, more group-work or activity based problems will lead to better understanding of concepts. This again is something that teachers may well discuss and again pool resources as discussed in the fifth recommendation below.

4. A link exists between success in examination and anxiety. To aid this, a variety of assessment types can be employed by teachers. Assessment for learning should be focused on in order to help students recognise their mistakes. For example, comment only marking can be used when you correct work and reply

with ótwo wishes and a starô i.e. two things the student is doing well and one area where improvement could be made. The use of a variety of assessment methods may reduce anxiety levels that students experience around semester examination periods. Continuous assessment could be used with non-exam classes.

5. The study found that the attitudes of students towards mathematics improved after exposure to strands 1 and 2 of the new Project Maths syllabus. The use of active learning methodologies has helped this. Further use of problem-based questions, less emphasis on semester examinations, varied teaching methodologies and listening to student feedback will help to improve student attitude towards mathematics further.

6. The author would like to make a recommendation for those delivering support services to post primary mathematics teachers. Advice and guidance given at Continuing Professional Development (CPD) courses could be used by mathematics teachers along with the teaching and learning plans supplied by the Project Maths support team. These plans are given to teachers to help them to think about the subject matter, plan and guide them through topics and develop knowledge in the area. Teachers may feel the benefit of pooling these resources along with their own resources for particular topics and helping one another with parts of the course that some teachers may be coming in contact with for the first time or after a long break. Another approach which will complement the teaching and leaning plans is the CLEAR approach (Lynch, 2011). This approach hopes to involve five skills which will help students develop and strengthen their own understanding of mathematics. The five skills are; **C**onnecting the learning, **L**eading the learning through rich tasks, **E**xtending the learning, **A**ssessing the learning and **R**eflecting on the learning.

6.6 Future research

This study could be replicated in a number of years time when the new Project Maths syllabus has been fully implemented into schools. The study could also be broadened to investigate further if school type is a discriminating factor for the affective variables. The study could be expanded to investigate the issue of gender and its impact on teaching and learning methodologies used under the new Project Maths syllabus.

The findings of this study will be of interest to teachers of mathematics and members of the IMTA (Irish Mathematics Teachers Association). Due to the lack of research in this area it is hoped that it will be of interest to the NCCA and in particular to the Project Maths team. The findings may also be of interest to teachers of other subjects, students and parents.

6.7 Conclusion

This study only reflects on the introduction of a small part (strands 1 and 2) of the new Project Maths syllabus. Therefore, it is too early to say what effect the complete new syllabus will have on student mathematical understanding and attitude towards mathematics. However, it offers a unique comparison between the traditional syllabus and the new syllabus (strands 1 and 2) at one point in this major curriculum change in post primary mathematics in Ireland.

The research has shown that for the students involved in this study there was an improvement in all affective variables since the introduction of the new syllabus (strands 1 and 2). Cohort 2 students, however, expressed worryingly high anxiety levels similar to those in Cohort 1 students. Mathematical understanding did not improve dramatically for Cohort 2 students but the willingness of the students in this cohort to attempt and óstick atô a question augurs well for Project Maths.

These results should be approached with caution as the study only concentrated on a small number of students that were exposed to merely strands 1 and 2 of the new Project Maths syllabus. However, there appears to be bright signs in the findings and these are encouraging as the roll out of the new Project Maths syllabus continues.

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Appendix A

Information Sheet (Cohort 1)

The attitudes of students to mathematics is a popular topic at the moment. The Irish economy and workforce, in itôs current climate, requires students to be good problem solvers and have a good understanding of mathematics.

The new mathematics syllabus (Project Maths) which has been introduced to all secondary level schools in September 2010 will change the way mathematics is taught. Project Maths will encouage teaching for understanding and not just teaching for learning of maths. Teachers will be encouraged to use active learning methodologies in the delivery of maths.

Action research will be carried out in the classroom in order to investigate the result on learning of active teaching methodologies. This active research will consist of a questionnaire being distributed to second year students in March/April 2011. These students will not have been exposed to Project Maths. The questionnaire will be repeated with second year students in March/April 2012. These students will have been exposed to Project Maths. Participation in this questionnaire is voluntary and pupils may opt out at any stage of the process.

It is hoped that this research will find an improvement in the learning and understanding of maths when active teaching methodologies are used. This study will be of interest to many groups such as the ñProject Mathsò team, Irish Maths Teachers Association, current post-primary mathematics teachers and to other researchers in the field of Mathematics Education.

All participants will be issued with a summary of the key findings emerging from the study.

Thank you for your co-operation in this research study.

Brigid Moohan

Research Masters Student, Lyit.

Information Sheet (Cohort 2)

The attitudes of students to mathematics is a popular topic at the moment. The Irish economy and workforce, in itôs current climate, requires students to be good problem solvers and have a good understanding of mathematics.

The new mathematics syllabus *(Project Maths*) was introduced to all secondary level schools in September 2010 and is changing the way mathematics is taught. *Project Maths* aims to encourage teaching for understanding and not just teaching for rote learning. Teachers will be encouraged to use active learning methodologies in the delivery of mathematics.

This research study aims to investigate the impact which active teaching methodologies have on studentsô learning and understanding of mathematics. The first phase of the research consisted of a questionnaire being distributed to second year students in March/April 2011. These students had not been exposed to *Project Maths*. In this second phase, the questionnaire will be administered to second year students in March/April 2012. These students will have been exposed to *Project Maths*. The responses from both groups will then be compared. Participation in this questionnaire is voluntary and pupils may opt out at any stage of the process.

It is hoped that this research will provide insights into the teaching and understanding of mathematicss when active teaching methodologies are used. This study will be of interest to groups such as the *Project Maths* implementation team, the Irish Mathematics Teachersô Association, practising post-primary mathematics teachers and to other researchers in the field of Mathematics Education.

All participants will be issued with a summary of the key findings emerging from the study.

Thank you for your co-operation in this research study.

Brigid Moohan,

Research Masters Student at Letterkenny Institute of Technology.

Appendix B

Letter to School Principal (Cohort 1)

Dear Principal,

My name is Brigid Moohan, I am a secondary level teacher in Moville Community College. I am presently undertaking a research Masters of Education in Letterkenny Institute of Technology with Dr. Joseph English. As part of my research, I will be analysing the effects of active teaching methodologies on the learning and understanding of mathematics. This will tie in with the introduction of Project Maths in all secondary level schools next year.

I would be grateful if you would consent to your schools participation in the research project. This project will be carried out over two years.

Year 1 (March/April) - First year students will fill out a questionnaire to establish their attitudes towards the learning and their understanding of maths.

Year 2 (March/April) - First year students will fill out the same questionnaire. These students will have been exposed to the new maths syllabus which will be taught using active learning methodologies.

All information will be coded and your school will not be identified in this project. Participation in this questionnaire is voluntary and pupils may opt out at any stage of the process.

I would be grateful if you would agree to participate in this project as I really feel that pupilsô mathematical learning and understanding will be enhanced by active teaching methodologies. Perhaps you could suggest a mathematics teacher who would be willing to carry out these questionnaires for me. I would appreciate it, if you could let me know at 0868249061 or 074- 9385988. I would like to thank you for your help in this research project and I look forward to working with you and your school.

Yours sincerely,

____

Brigid Moohan

Letter to School Principal (Cohort 2)

Dear

My name is Brigid Moohan and I am a secondary school mathematics teacher in Moville Community College. I am undertaking a research Masters in Letterkenny Institute of Technology. Dr. Joseph English is my primary supervisor. As part of my research, I am investigating the attitudes of Junior Certificate post-primary students to mathematics. I am also interested in the impact which active teaching methodologies have on studentsô learning and understanding of mathematics.

I would be grateful if you would consent to your schoolôs participation in the research project. This project will be carried out over two years.

The Project will involve two phases:

Phase 1 will be carried out in March/April 2011 and for this I require one group of 25-30 **Year 2** students who have not been exposed to *Project Maths.*

Phase 2 will be carried out in March/April 2012 and for this I will require again one group of 25-30 **Year 2** students who have been exposed to *Project Maths*.

All information will be coded and your school and mathematics will not be identified in this project to preserve anonymity. All data collected during the Project will be stored securely. Participation in this questionnaire is voluntary and pupils may opt out at any stage of the process. Utmost care will be taken of storage and backup of data held in statistical software and access to this data will be restricted to the researcher. Principals, teachers and students will have access to a summary of the key findings if they so request. The research will involve access to one higher level mathematics class with **Year 2** students to administer a questionnaire and worksheet. Follow up group interviews with a smaller number of students will also be required.

I would be grateful if you would agree to participate in this project as I really feel that studentsô mathematical learning and understanding will be enhanced by active teaching methodologies. If you have any further queries, I can be contacted at 086-8249061, 0749385988 (work) or via email; brigidmoohan@donegalvec.ie. I would like to thank you for your help in this research project and I look forward to working with your school.

Yours sincerely,

Brigid Moohan

Appendix C

Letter to participating mathematics teacher (Cohort 1)

Dear

My name is Brigid Moohan and I am a secondary school mathematics teacher in Moville Community College. I am undertaking a research Masters in Letterkenny Institute of Technology. Dr. Joseph English is my primary supervisor. As part of my research, I am investigating the attitudes of Junior Certificate post-primary students to mathematics. I am also interested in the impact which active teaching methodologies have on studentsô learning and understanding of mathematics.

My sample needs to be representative of all types of post-primary schools. As your school is an all-boys post-primary school, I would be grateful if you would consent to your mathematics class participation in the research project.

The Project will involve two phases. Phase 1 will be carried out in March/April 2011 and for this I require one group of 25-30 **Year 2** students who have not been exposed to Project Mathematics. Phase 2 will be carried out in March/April 2012 and for this I will require again one group of 25-30 **Year 2** students who have been exposed to Project Mathematics.

Each Phase will require students to complete a questionnaire to assess their attitudes to mathematics and also to complete a worksheet to test their problem-solving ability and understanding.

All information will be coded and your school and class will not be identified in this project to preserve anonymity. All data collected during the Project will be stored securely. Participation in this questionnaire is voluntary and pupils may opt out at any stage of the process. Utmost care will be taken of storage and backup of data held in statistical software and access to this data will be restricted to the researcher. Teachers and students will have access to summary of the key findings if they so request.

I would be delighted if your school would agree to participate with your mathematics class in this project. I can meet briefly with you at a suitable time to discuss this project and to answer any queries that you might have. I can be contacted on 086 8249061 or 074 9385988 (school) or brigidmoohan@donegalvec.ie. Thank you for your time in relation to this matter and I look forward to hearing from you at your convenience.

Yours sincerely,

Brigid Moohan

Letter to participating mathematics teacher (Cohort 2)

Dear

My name is Brigid Moohan and I am a secondary school mathematics teacher in Moville Community College. I am undertaking a research Masters in Letterkenny Institute of Technology. Dr. Joseph English is my primary supervisor. As part of my research, I am investigating the attitudes of Junior Certificate post-primary students to mathematics. I am also interested in the impact which active teaching methodologies have on studentsô learning and understanding of mathematics.

My sample needs to be representative of all types of post-primary schools. As your school is an all-boys post-primary school, I would be grateful if you would consent to your mathematics class participating in the research project.

The Project involves two phases. Phase 1 was carried out in March/April 2011 which required one group of 25-30 **Year 2** students who have not been exposed to *Project Maths*. Phase 2 will be carried out in March/April 2012 and for this I will require again one group of 25-30 **Year 2** students who have been exposed to *Project Maths*.

Students will be required to complete a questionnaire to assess their attitudes to mathematics and also to complete a worksheet to test their problem-solving ability and understanding. Some students will be required to participate in a follow up interview.

All information will be coded and your school and your class will not be identified in this project to preserve anonymity. All data collected during the Project will be stored securely. Participation in this questionnaire is voluntary and pupils may opt out at any stage of the process. Utmost care will be taken of storage and backup of data held in statistical software and access to this data will be restricted to the researcher. Principals, teachers and students will have access to a summary of the key findings if they so request.

I would be delighted if your school would agree to participate with your mathematics class in this project. I can meet briefly with you at a suitable time to discuss this project and to answer any queries that you might have. I can be contacted on 086 8249061 or 074 9385988 (school) or brigidmoohan@donegalvec.ie. Thank you for your time in relation to this matter and I look forward to hearing from you at your convenience.

Yours sincerely,

Brigid Moohan

Appendix D

Parental consent form (Cohort 1 and 2)

Dear Parent /Guardian,

My name is Brigid Moohan and I am a secondary school mathematics teacher in Moville Community College. I am undertaking a research Masters in Letterkenny Institute of Technology. Dr. Joseph English is my primary supervisor. As part of my research, I am investigating the attitudes of Junior Certificate post-primary students to mathematics. I am also interested in the impact which active teaching methodologies have on studentsô learning and understanding of mathematics.

I would be grateful if you would consent to your son/daughterös participation in the study. This will involve your son/daughter filling out a questionnaire and worksheet during a maths class and your son/daughter taking part in group interviews.

All information will be coded and your son/daughter will not be identified in this project to preserve anonymity. All data collected during the Project will be stored securely. Participation in this questionnaire is voluntary and your son/daughter may opt out at any stage of the process. Utmost care will be taken of storage and backup of data held in statistical software and access to this data will be restricted to the researcher. Parents, Principals, mathematics teachers and students will have access to a summary of the key findings if they so request.

Should you consent your son/daughterös participation, I would be grateful if you would sign the form below and return it to your son/daughterös maths teacher. I would like to thank you for taking the time to read this letter and your help in my research project.

Yours sincerely,

Brigid Moohan

Please circle your choice and fill in the name of your son/daughter

I agree/ disagree to ________________________________ participating in this research project.

Signed: ____

Appendix E

Student Questionnaire

Please answer all questions truthfully and to the fullest extent. All information will be kept confidential and only used for the purpose of this study.

Student Profile

Please indicate your answer clearly

School: ____

Gender: Male ☐ Female ☐

Instructions:

For each statement, **circle** the response that best describes what you think or feel. As you read the sentence, you will know whether you agree or disagree. If you strongly disagree, circle 1 under SD. If you disagree but not strongly, circle 2 under D. If you are unsure, circle 3 under U. If you agree with the statement, circle 4 under A, but if you agree with the statement a lot, circle 5 under SA for strongly agree.

	Question	**SD**	**D**	**U**	**A**	**SA**
1.	If I understand a mathematics problem, then it must be an easy one.	1	2	3	4	5
2.	I donĝt ask questions in mathematics classes because mine sound stupid	1	2	3	4	5
3.	Mathematics problems can be done correctly in one way.	1	2	3	4	5

	Question	SD	D	U	A	SA
4.	When I have difficulty with mathematics, I know I can handle them if I try	1	2	3	4	5
5.	I have always enjoyed studying mathematics	1	2	3	4	5
6.	Mathematics is needed in designing practically everything	1	2	3	4	5
7.	I donꞌt have a good enough memory to learn mathematics	1	2	3	4	5
8.	I like to solve new problems in Mathematics	1	2	3	4	5
9.	When I do mathematics, I feel confident that I have done it correctly	1	2	3	4	5
10.	My mind goes blank and I am unable to think clearly when working with Mathematics.	1	2	3	4	5
11.	Whenever I do a mathematics problem, I am sure that I have made a mistake	1	2	3	4	5
12.	Mathematics is needed in order to keep the world running.	1	2	3	4	5
13.	Mathematics does not scare me at all	1	2	3	4	5
14.	Real mathematics problems can be solved by commonsense instead of the mathematics rules you learn at school.	1	2	3	4	5
15.	Mathematics is very interesting, and I have usually enjoyed classes in this subject	1	2	3	4	5
16.	There is nothing creative about mathematics, itꞌs just memorising formulas and things	1	2	3	4	5

	Question	SD	D	U	A	SA
17.	The challenge of Mathematics appeals to me	1	2	3	4	5
18.	To solve mathematics problems you have to be taught the right procedure, or you cannot do anything.	1	2	3	4	5
19.	I feel a sense of insecurity when attempting Mathematics.	1	2	3	4	5
20.	Mathematics is not important in everyday life	1	2	3	4	5
21.	I have a good mind for mathematics.	1	2	3	4	5
22.	I am always confused in my Mathematics class	1	2	3	4	5
23.	Mathematics uses logical structures to solve and explain real life problems.	1	2	3	4	5
24.	Once I start trying to work on a mathematics problem, I find it hard to stop	1	2	3	4	5
25.	Mathematics makes me feel uncomfortable and nervous	1	2	3	4	5
26.	Mathematics helps develop the mind and teaches a person to think	1	2	3	4	5
27.	I learn Mathematics easily	1	2	3	4	5
28.	Knowing why an answer is correct is as important as getting the right answer	1	2	3	4	5
29.	I can think of many ways that I use Mathematics outside school.	1	2	3	4	5
30.	I have no more trouble understanding mathematics than any other subject.	1	2	3	4	5
31.	I am comfortable answering questions in mathematics class	1	2	3	4	5

	Question	SD	D	U	A	SA
32.	You can only find out that the answer to a mathematics problem is wrong when the answer is different to the back of the book	1	2	3	4	5
33.	I do as little work in mathematics as possible	1	2	3	4	5
34.	Mathematics is one of the most important subjects for people to study	1	2	3	4	5
35.	I try to understand the solutions of my classmates in mathematics class	1	2	3	4	5
36.	I believe that I am good at solving mathematics problems	1	2	3	4	5
37.	I would be uneasy about going to the board during mathematics class	1	2	3	4	5
38.	I have never liked mathematics and it is my most dreaded subject	1	2	3	4	5
39.	A strong mathematics background could help me in my professional life.	1	2	3	4	5
40.	I get a great deal of satisfaction out of solving a Mathematics problem	1	2	3	4	5
41.	I usually have been at ease in Mathematics classes	1	2	3	4	5
42.	I am sure that I can learn mathematics	1	2	3	4	5
43.	Mathematics develops understanding and logical thinking.	1	2	3	4	5
44.	If you cannot solve a mathematics problem quickly, then spending more time on it will not help.	1	2	3	4	5

	Question	SD	D	U	A	SA
45.	I am happier in Mathematics class than in any other class	1	2	3	4	5
46.	I am willing to share my insights about solving mathematics problems.	1	2	3	4	5
47.	It would be useful in mathematics class to have discussions on our answers and methods	1	2	3	4	5
48.	Mathematics is a very interesting subject.	1	2	3	4	5
49.	What mathematics is about is formulae and applying them to everyday life and situations	1	2	3	4	5
50.	Mathematics problems are boring	1	2	3	4	5
51.	I will use methods learnt in mathematics class in other school subjects.	1	2	3	4	5
52.	I am usually patient when I do mathematics and I usually persevere until I get the right answer.	1	2	3	4	5
53.	I ask for help whenever I have a problem in mathematics.	1	2	3	4	5
54.	I find mathematics enjoyable and interesting	1	2	3	4	5

Thank you very much for taking the time to fill out this questionnaire.

Appendix F

Problem Sheet

Instructions: Answer all questions to the best of your ability.

Q1.

Sarah found out that the exchange rate between Canadian dollars and English pounds was:

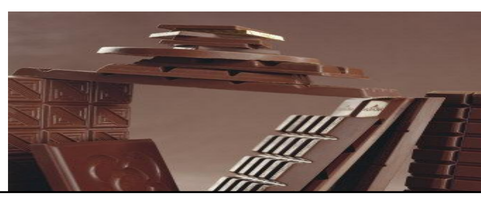
$1 =£ 4.2.

Sarah changed 3000 Canadian dollars to English pounds at this exchange rate.

How much money in English Pounds did Sarah get?

Q2.

How many snaps does it take to break a 20 square bar of chocolate into single squares?

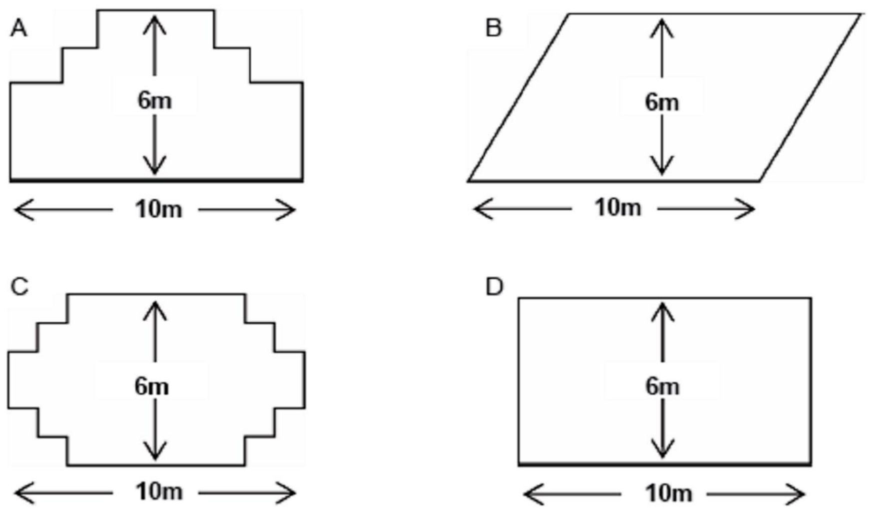


Q3.

Billy bought a bag of oranges on Monday and ate a third of them. On Tuesday he ate half of the oranges he had left. On Wednesday he found he had two left. How many did he start with?

Q4.

A carpenter has 32 metres of timber and wants to make a border around a vegetable patch. He is considering the following designs for the vegetable patch.

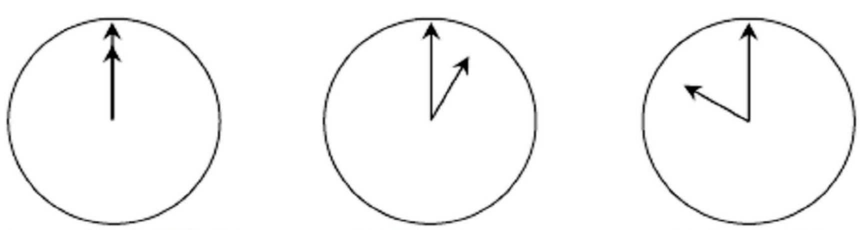


Vegetable Patch Design	Can this design be made using 32m of timber (circle the correct answer)
Design A	Yes/No
Design B	Yes/No
Design C	Yes/No
Design D	Yes/No

Q5.

Mark (from Sydney, Australia) and Hans (from Berlin, Germany) often communicate with each other using "chat" on the Internet. They have to log on to the Internet at the same time to be able to chat.

To find a suitable time to chat, Mark looked up a chart of world times and found the following:



Greenwich 12 Midnight   Berlin 1:00 am   Sydney 10:00 am

(i)

At 7:00 pm in Sydney, what time is it in Berlin?

Answer: __________.

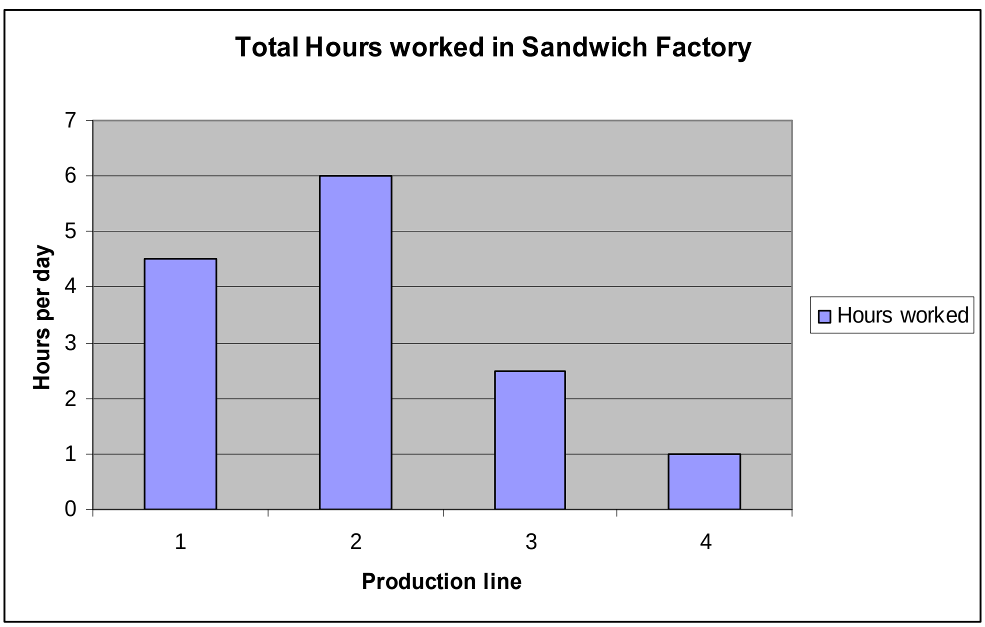
(ii)

Mark and Hans are not able to chat between 9:00 am and 4:30 pm their local time, as they have to go to school. Between 11:00 pm and 7:00 am (local time) both Mark and Hans will not be able to chat because they will be sleeping.

When would be a good time for Mark and Hans to chat? Write the local times in the table.

Place	Time
Sydney (Mark)	
Berlin (Hans)	

Q6.



This chart shows the number of hours worked on various production lines in a Sandwich factory.

Anne works in production line 2 and earns €8.27 per hour. Her husband Barry works in production line 1 and earns €7.89 per hour. They both work Monday – Friday only.

What is the average household income in any given week?

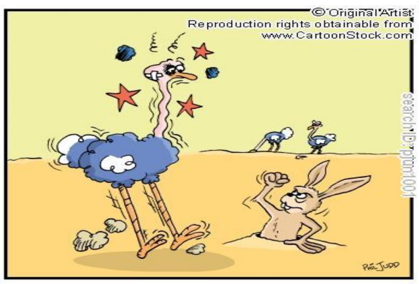
Q7.

Replace the question marks with mathematical symbols (+, −, x or ÷) to end up with 8 as the answer.

21 ? 3 ? 7 ? 1 = 8

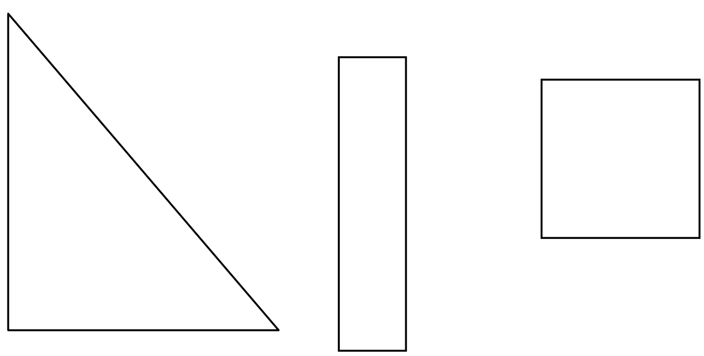
Q8.

An enclosure at the zoo contains both elephants and emus. If there are a total of 44 feet and 30 eyes, can you work out how many of each animal there is?



Q9.

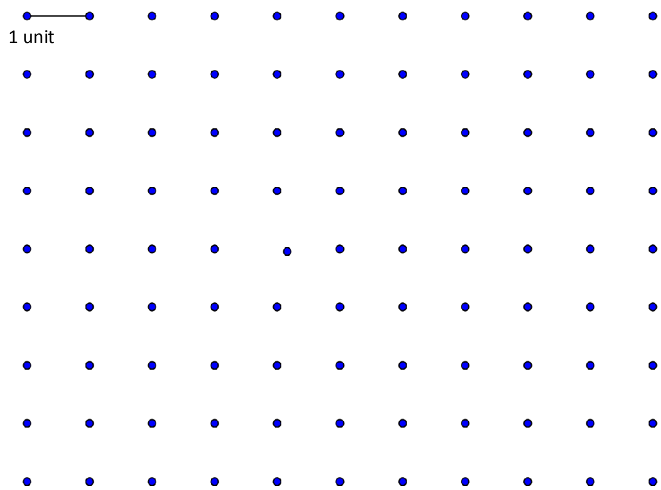
When you add up the degrees inside each of the following shapes, what total do you get?



(a) ___________________ (b) ____________ (c) _______________

Q10.

Using the dots, draw a rectangle that has an area of area of 16 units^2.



Appendix G

Semi-Structured Interview Questions

***Anxiety* in mathematics:**

Q1. Your worksheet score and semester exam result are high and yet you reported high *anxiety*, why was this?

Q2. What changes in class or syllabus would you make that may help to ease your *anxiety*?

***Motivation* and *enjoyment*:**

Q1. Does your *enjoyment* influence your *motivation*?

Q2. Who most influences your *enjoyment* or *motivation* of the subject- peers, parents or teachers?

Q3. Do you spend a lot of time on your mathematics homework every night in comparison to other subjects?

Q4. Do you find that your homework questions are worked out using problem solving skills or do you use a set of steps given to you by your teacher?

Q5. Does the class that you are in influence how competitive you are about your mathematics?

Attempts at worksheet:

Q1. What prevents you from starting a question- layout, length, wording, unseen questions, etc?

Q2. Why do you stop part of the way through a question?

Relating mathematics to the outside world and the importance of mathematics

Q1. Can you link any part of mathematics to the world around you?

Q2. How important is mathematics to you compared to other subjects for example Science or Geography?

Q3. Do you see yourself using mathematics in your future career?

Understanding of mathematics

Q1. Do you understand why you are doing a particular topic in mathematics?

Q2. Do you use your knowledge of one topic to help you in another topic?

Q3. Does your teacher explain how a topic is linked to other topics in mathematics?

Variety and effectiveness of teaching methodologies

Q1. Who does most of the work in the classroom during mathematics class- you or your teacher?

Q1. Do you use group work in class? If so how often? Do you enjoy it?

Q2. Do you use a variety of activities during mathematics class? Which do you enjoy most and why?

Q4. If you have a wrong answer is it explained to you why it is wrong and where you made your mistake?

Q5. What would you change about the way mathematics is taught?

Home environment or parental input:

Q1. Do your parents take an interest in your homework and study, if so, how much i.e. do they ask how you are getting on?

Q2. Do you have a comfortable environment in which you can study free of distractions?

Project Maths vs Old syllabus:

Cohort 1

Q1. Do you feel you could benefit from more active learning activities used in mathematics class and why?

Q2. Look at your typical statistics question and now one from Project Maths syllabus, how do you feel about the amount of words in a typical question?

Cohort 2

Q1. You have studied part of a new course, this was statistics and probability, how did you enjoy it- did you enjoy the content/teaching/active learning?

Q2. Look at your statistics question from your Project Maths syllabus and now one from the old syllabus, how do you feel about the amount of words in each question?

Q3. Does the increase in the amount of text in a question help you to relate the topic to the world around you?

Q4. Which do you prefer the new parts of the course or the traditional parts?

Appendix H

Question Number	Question	Scale	Source	+ve or -ve
9.	When I do mathematics, I feel confident that I have done it correctly	*Confidence*	Gourgey	+
13.	Mathematics does not scare me at all		Tapia	+
22.	I am always confused in my Mathematics class		Tapia	_
27.	I learn Mathematics easily		Tapia	+
31.	I am comfortable answering questions in Mathematics class		Tapia	+
36.	I believe that I am good at solving Mathematics problems		Tapia	+
42.	I am sure that I can learn mathematics		Fennema-Sherman	+
53.	I ask for help whenever I have a problem in mathematics.		Klinger	+
2.	I donǿt ask questions in mathematics classes because mine sound stupid	*Anxiety*	Klinger	_
10.	My mind goes blank and I am unable to think clearly when working with Mathematics.		Tapia	_
19.	I feel a sense of insecurity when attempting Mathematics.		Tapia	_
25.	Mathematics makes me feel uncomfortable and nervous		Fennema-Sherman	_
37.	I would be uneasy about going to the board during mathematics class		Klinger	_
41.	I usually have been at ease in Maths classes		Fennema-Sherman	+
3.	Mathematics problems can be done correctly in one way.	*Beliefs* about Mathematics	Schoenfeld	_
14.	Real mathematics problems can be solved by commonsense instead of the mathematics rules you learn at school.		Schoenfeld	_
18.	To solve mathematics problems you have to be taught the right procedure, or you cannot do anything.		Schoenfeld	_
28.	Knowing why an answer is correct is as important as getting the right answer		Klinger	+
32.	You can only find out that the answer to a mathematics problem is wrong when the answer is different to the back of the book		Schoenfeld	_
44.	If you cannot solve a mathematics problem quickly, then spending more time on it will not help.		Grouws	_

49.	What mathematics is about is formulae and applying them to everyday life and situations	*Beliefs* about Mathematics	Klinger	+
5.	I have always enjoyed studying mathematics	*Enjoyment*	Aiken	+
15.	Mathematics is very interesting, and I have usually enjoyed classes in this subject		Aiken	+
38.	I have never liked mathematics and it is my most dreaded subject		Aiken	_
40.	I get a great deal of satisfaction out of solving a Mathematics problem		Klinger	+
45.	I am happier in Mathematics class than in any other class		Tapia	+
48.	Mathematics is a very interesting subject.		Tapia	+
54.	I find mathematics enjoyable and interesting		Klinger	+
1.	If I understand a mathematics problem, then it must be an easy one.	*Self-concept*	Klinger	_
4.	When I have difficulty with mathematics, I know I can handle them if I try		Klinger	+
7.	I donḉt have a good enough memory to learn mathematics		Grouws	_
11.	Whenever I do a mathematics problem, I am sure that I have made a mistake		Klinger	_
21.	I have a good mind for mathematics.		Schoenfeld	+
30.	I have no more trouble understanding mathematics than any other subject.		Klinger	+
35.	I try to understand the solutions of my classmates in mathematics class		Klinger	+
46.	I am willing to share my insights about solving mathematics problems.		Grouws	+
6.	Mathematics is needed in designing practically everything	*Value*	Aiken	+
12.	Mathematics is needed in order to keep the world running.		Aiken	+
16.	There is nothing creative about mathematics, itḉs just memorising formulas and things		Aiken	_
20.	Mathematics is not important in everyday life		Aiken	_
23.	Mathematics uses logical structures to solve and explain real life problems.		Crawford	+

26.	Mathematics helps develop the mind and teaches a person to think	*Value*	Klinger	+
29.	I can think of many ways that I use Mathematics outside school.		Grouws	+
34.	Mathematics is one of the most important subjects for people to study		Schoenfeld	+
39.	A strong mathematics background could help me in my professional life.		Klinger	+
43.	Mathematics develops understanding and logical thinking		Schoenfeld	+
47.	It would be useful in mathematics class to have discussions on our answers and methods		Grouws	+
51.	I will use methods learnt in mathematics class in other school subjects.		Klinger	+
8.	I like to solve new problems in Mathematics	*Motivation*	Tapia	+
17.	The challenge of Mathematics appeals to me		Tapia	+
24.	Once I start trying to work on a mathematics problem, I find it hard to stop		Fennema-Sherman	+
33.	I do as little work in mathematics as possible		Fennema-Sherman	_
50.	Mathematics problems are boring		Fennema-Sherman	_
52.	I am usually patient when I do mathematics and I usually persevere until I get the right answer.		Fennema-Sherman	+

Appendix I

Question Number	Scale	Number of respondents for Cohort 1	Mean (S.D.) for Cohort 1		Number of respondents for Cohort 2	Mean (S.D.) for Cohort 2
9.	*Confidence*	128	3.29 (1.1)		137	3.02 (1.1)
13.		128	3.71 (1.1)		137	3.63 (1.2)
22.		128	3.68 (1.0)		108	4.09 (0.6)
27.		128	3.41 (1.0)		137	2.95 (1.2)
31.		128	3.43 (1.1)		136	3.34 (1.2)
36.		128	3.37 (1.0)		135	3.09 (1.2)
42.		126	4.1 (0.7)		131	3.84 (1.0)
53.		127	3.65 (1.1)		136	3.57 (1.2)
2.	*Anxiety*	126	4.03 (1.0)		109	4.26 (0.7)
10.		128	3.66 (1.1)		110	4.12 (0.7)

19.		127	3.67 (1.0)		108	3.86 (0.7)
25.		128	3.93 (1.1)		111	4.3 (0.7)
37.		128	3.02 (1.2)		74	3.89 (0.7)
41.		127	3.48 (1.0)		136	3.32 (1.1)
3.	*Beliefs* about Mathematics	127	3.99 (1.0)		124	3.92 (0.8)
14.		127	3.03 (1.1)		104	3.87 (0.7)
18.		128	2.88 (1.1)		61	3.64 (0.7)
28.		128	4.22 (1.0)		137	4.06 (1.0)
32.		128	3.68 (1.1)		100	4.1 (0.6)
44.		127	4.02 (1.0)		112	4.34 (0.6)
49.		127	3.22 (1.0)		136	3.16 (1.0)

11.

5.	*Enjoyment*	128	2.73 (1.3)		137	2.47 (1.3)
15.		128	2.99 (1.3)		137	2.92 (1.3)
38.		128	3.84 (1.1)		99	4.17 (0.8)
40.		127	3.27 (1.1)		136	3.18 (1.2)
45.		127	2.25 (1.0)		137	2.31 (1.2)
48.		127	3.22 (1.2)		136	2.93 (1.3)
54.		127	3.04 (1.2)		136	2.72 (1.4)
1.	*Self-concept*	127	3.4 (1.1)		77	4.00 (0.5)
4.		128	3.55 (1.0)		136	3.44 (1.0)
7.		127	3.92 (1.1)		114	4.04 (0.7)
11.		127	3.53 (1.1)		98	3.74 (0.7)

21.		128	3.55 (1.0)		138	3.11 (1.2)
30.		128	3.23 (1.1)		136	3.01 (1.3)
35.		127	3.24 (1.0)		136	3.24 (0.9)
46.		125	3.26(0.9)		137	3.16 (1.1)
6.	*Value*	128	3.44 (1.1)		135	3.32 (1.2)
12.		127	3.57 (1.1)		137	3.39 (1.1)
16.		128	3.02 (1.2)		71	4 (0.7)
20.		128	3.9 (1.0)		110	4.25 (0.7)
23.		128	3.28 (1.0)		137	3.04 (1.0)
26.		127	4.05 (1.0)		136	3.8 (1.0)
29.		127	3.53 (1.0)		136	3.26 (1.3)
34.		128	3.91 (1.0)		133	3.8 (1.1)

39.	*Value*	128	4.06 (1.0)	135	3.83 (1.1)
43.		127	3.98 (1.0)	136	3.82 (1.0)
47.		127	3.72 (1.1)	137	3.69 (1.0)
51.		125	3.43 (1.1)	136	3.18 (1.1)
8.	*Motivation*	128	3.32 (1.1)	137	3.09 (1.1)
17.		128	3.07 (1.1)	138	2.93 (1.2)
24.		128	2.73 (1.2)	138	2.42 (1.2)
33.		127	4.1 (1.0)	124	4.29 (0.7)
50.		127	3.01 (1.3)	84	3.83 (0.7)
52.		127	3.21 (1.1)	136	3.57 (1.2)

Appendix J

Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2011

MATHEMATICS – HIGHER LEVEL

PAPER 2 (300 marks)

MONDAY, 13 JUNE – MORNING, 9:30 to 12:00

Attempt **FIVE** questions from **Section A** and **ONE** question from **Section B**.
Each question carries 50 marks.

WARNING: Marks will be lost if all necessary work is not clearly shown.

Answers should include the appropriate units of measurement, where relevant.

SECTION A

Answer FIVE questions from this section.

1. **(a)** The following parametric equations define a circle:

$$x = 2 + 3\sin\theta,\quad y = 3\cos\theta, \text{ where } \theta \in \mathbb{R}.$$

What is the Cartesian equation of the circle?

(b) Find the equation of the circle that passes through the points (0, 3), (2, 1) and (6, 5).

(c) The circle $c_1 : x^2 + y^2 - 8x + 2y - 23 = 0$ has centre A and radius r_1.
The circle $c_2 : x^2 + y^2 + 6x + 4y + 3 = 0$ has centre B and radius r_2.

(i) Show that c_1 and c_2 intersect at two points.

(ii) Show that the tangents to c_1 at these points of intersection pass through the centre of c_2.

2. **(a)** Find the value of s and the value of t that satisfy the equation

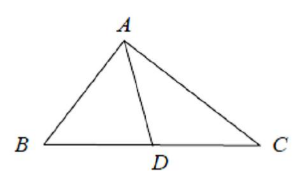
$$s\left(\vec{i} - 4\vec{j}\right) + t\left(2\vec{i} + 3\vec{j}\right) = 4\vec{i} - 27\vec{j}.$$

(b) $\overrightarrow{OP} = 3\vec{i} - 4\vec{j}$ and $\overrightarrow{OQ} = 5\left(\overrightarrow{OP}^{\perp}\right)$, where O is the origin.

(i) Find $\overrightarrow{OQ}$ in terms of $\vec{i}$ and $\vec{j}$.

(ii) Find $\cos|\angle OQP|$, in surd form.

(c) ABC is a triangle and D is the mid-point of $[BC]$.



(i) Express $\overrightarrow{AB}$ in terms of $\overrightarrow{AD}$ and $\overrightarrow{BC}$ and express $\overrightarrow{AC}$ in terms of $\overrightarrow{AD}$ and $\overrightarrow{BC}$.

(ii) Hence, prove that $|AB|^2 + |AC|^2 = 2|AD|^2 + \frac{1}{2}|BC|^2$.

3. **(a)** P and Q are the points $(-1, 4)$ and $(3, 7)$ respectively.
Find the co-ordinates of the point that divides $[PQ]$ internally in the ratio $3 : 1$.

(b) f is the transformation $(x, y) \rightarrow (x', y')$, where $x' = x - y$ and $y' = 2x + 3y$.
l_1 is the line $2x - y - 1 = 0$.

(i) Find the equation of $f(l_1)$, the image of l_1 under f.

(ii) Prove that f maps every pair of parallel lines to a pair of parallel lines.
You may assume that f maps every line to a line.

(iii) The line l_2 is parallel to the line l_1.
$f(l_2)$ intersects the x-axis at A' and the y-axis at B'.
The area of the triangle $A'OB'$ is 9 square units, where O is the origin.
Find the two possible equations of l_2.

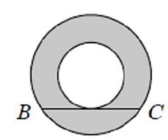
(iv) Given that $A' = f(A)$ and $B' = f(B)$, show that $|\angle AOB| \neq |\angle A'OB'|$.

4. **(a)** Evaluate $\lim_{x \to 0} \left(\frac{\sin 2x + \sin x}{3x} \right)$.

(b) Find all the solutions of the equation

$$\sin 2x + \cos x = 0, \text{ where } 0^\circ \leq x \leq 360^\circ.$$

(c) The diagram shows two concentric circles.
A tangent to the inner circle cuts the outer circle at B and C, where $|BC| = 2x$.



(i) Express the area of the shaded region in terms of x.

(ii) In the case where the radius of the outer circle is $2x$, show that the portion of the shaded region that lies below BC has area $\left(\frac{2\pi}{3} - \sqrt{3} \right) x^2$.

5. **(a)** Find the values of x for which $3\tan x = \sqrt{3}$, where $0° \leq x \leq 360°$.

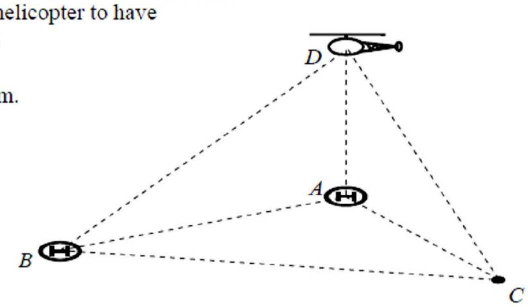
(b) **(i)** Prove that $\tan(A + B) = \dfrac{\tan A + \tan B}{1 - \tan A \tan B}$.

(ii) Show that if $\alpha + \beta = 90°$, then $\dfrac{\tan 2\alpha}{\tan 2\beta} = -1$.

(c) A and B are two helicopter landing pads on level ground. C is another point on the same level ground. $|BC| = 800$ metres, $|AC| = 900$ metres, and $|\angle BCA| = 60°$.
A helicopter at point D is hovering vertically above A.
A person at C observes the helicopter to have an angle of elevation of 30°.

(i) Find $|AD|$, in surd form.

(ii) Find $|BD|$.



6. **(a)** Two adults and four children stand in a row for a photograph. How many different arrangements are possible if the four children are between the two adults?

(b) **(i)** Solve the difference equation $u_{n+2} - 6u_{n+1} + 8u_n = 0$, where $n \geq 0$, given that $u_0 = 0$ and $u_1 = 4$.

(ii) For what value of n is $u_n = 30(2^n)$?

(c) Five cards are drawn together at random from a standard pack of 52 playing cards. Find, in decimal form, correct to two significant figures, the probability that:

(i) all five cards are diamonds

(ii) all five cards are of the same suit

(iii) the five cards are the ace, two, three, four and five of diamonds

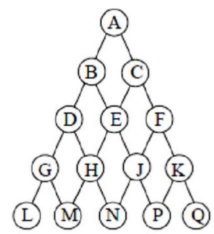
(iv) the five cards include the four aces.

7. **(a)** A team of four is selected from a group of seven girls and five boys.

(i) How many different selections are possible?

(ii) How many of these selections include at least one girl?

(b) A marble falls down from A and must follow one of the paths indicated on the diagram. All paths from A to the bottom row are equally likely to be followed.



(i) One of the paths from A to H is A-B-D-H.
List the other two possible paths from A to H.

(ii) Find the probability that the marble passes through H or J.

(iii) Find the probability that the marble lands at N.

(iv) Two marbles fall from A, one after the other, without affecting each other.
Find the probability that they both land at P.

(c) The real numbers a, b and c have mean μ and standard deviation σ.

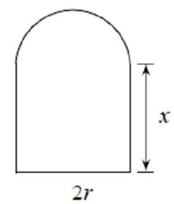
(i) Show that the mean of the numbers $\frac{a-\mu}{\sigma}$, $\frac{b-\mu}{\sigma}$ and $\frac{c-\mu}{\sigma}$ is 0.

(ii) Find, with justification, the standard deviation of the numbers $\frac{a-\mu}{\sigma}$, $\frac{b-\mu}{\sigma}$ and $\frac{c-\mu}{\sigma}$.

SECTION B

Answer one question from this section

8. **(a)** Use integration by parts to find $\int x \sin x \, dx$.



(b) A window is in the shape of a rectangle with a semicircle on top. The radius of the semicircle is r metres and the height of the rectangular part is x metres. The perimeter of the window is 20 metres.

(i) Use the perimeter to express x in terms of r and π.

(ii) Find, in terms of π, the value of r for which the area of the window is a maximum.

(c) The Maclaurin series for $\tan^{-1}x$ is $x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \ldots$

(i) Write down the general term of the series.

(ii) Use the Ratio Test to show that the series converges for $|x| < 1$.

(iii) Using the fact that $\frac{\pi}{4} = 4\tan^{-1}\frac{1}{5} - \tan^{-1}\frac{1}{239}$, and taking the first three terms in the Maclaurin series for $\tan^{-1}x$, find an approximation for π.
Give your answer correct to five decimal places.

9. **(a)** Z is a random variable with standard normal distribution.
Use the tables to find the value of z_1 for which $P(Z \geq z_1) = 0{\cdot}0778$.

(b) A die is biased in such a way that the probability of rolling a six is p.
The other five numbers are all equally likely. This biased die and a fair die are rolled simultaneously. Show that the probability of rolling a total of 7 is independent of p.

(c) The mean percentage mark for candidates in the 2010 Leaving Certificate Higher Level Mathematics examination was 67·0%, with a standard deviation of 10·4%. The suggestion that candidates who appealed their results have, on average, similar results to all other candidates, is being investigated. A random sample of candidates who appealed is taken. The mean percentage mark of this sample is 69·3%.

(i) Show that if the sample size was 25, then this result *is not* significant at the 5% level.

(ii) Show that if the sample size was 100, then this result *is* significant at the 5% level.

(iii) What is the smallest sample size for which this result could be regarded as significant at the 5% level?

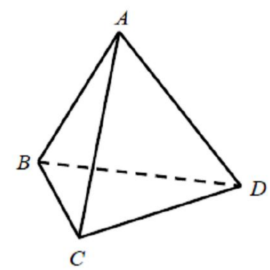
10. **(a)** A Cayley table for the group $(\{a, b, c\}, *)$ is shown.

$*$	a	b	c
a	c	a	b
b	a	b	c
c	b	c	a

(i) Write down the identity element.

(ii) Write down the inverse of each element.

(b) A regular tetrahedron has twelve rotational symmetries.
These form a group G under composition, $\circ$.
The symmetries can be represented as permutations of the vertices A, B, C and D.



(i) Write down in permutation form, one element x of order 3, and describe this symmetry geometrically.

(ii) Write down in permutation form, one element y of order 2, and describe this symmetry geometrically

(iii) Show that $x \circ y \neq y \circ x$.

(iv) Let S be the set $\{e,\ x,\ y,\ x \circ y,\ y \circ x,\ x \circ x\}$, where e is the identity transformation. Show that S is **not** closed under $\circ$.

(v) Let H be a subgroup of G. Let $x \in H$ and $y \in H$. Show that $H = G$.

11. **(a)** An ellipse has centre $(0, 0)$ and eccentricity $\frac{1}{2}$. One focus is at (2, 0).
Find the equation of the ellipse.

(b) **(i)** $P(x_1, y_1)$ and $Q(x_2, y_2)$ are two points such that $x_1 < x_2$.
If the slope of PQ is $\tan\theta$, and the length of $[PQ]$ is d, express $(x_2 - x_1)$ and $(y_2 - y_1)$ in terms of d and θ.

(ii) Let f be the transformation $(x, y) \to (x', y')$, where $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 2 & 5 \\ 3 & 4 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} 6 \\ 1 \end{pmatrix}$.

Show that $\dfrac{|f(P)f(Q)|}{|PQ|} = \sqrt{(2\cos\theta + 5\sin\theta)^2 + (3\cos\theta + 4\sin\theta)^2}$.

(iii) Deduce that the ratio of lengths on parallel lines is invariant under f.

2011. M230

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination, 2011

Mathematics
(Project Maths – Phase 2)

Paper 2

Higher Level

Monday 13 June Morning 9:30 – 12:00

300 marks

Examination number

Centre stamp

Running total	

For examiner	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Grade

Instructions

There are **two** sections in this examination paper.

Section A	Concepts and Skills	150 marks	6 questions
Section B	Contexts and Applications	150 marks	2 questions

Answer **all eight** questions, as follows:

In Section A, answer:

Questions 1 to 5 and

either Question 6A **or** Question 6B.

In Section B, answer Question 7 and Question 8.

Write your answers in the spaces provided in this booklet. There is space for extra work at the back of the booklet. You may also ask the superintendent for more paper. Label any extra work clearly with the question number and part.

The superintendent will give you a copy of the booklet of *Formulae and Tables*. You must return it at the end of the examination. You are not allowed to bring your own copy into the examination.

Marks will be lost if all necessary work is not clearly shown.

Answers should include the appropriate units of measurement, where relevant.

Answers should be given in simplest form, where relevant.

Write the make and model of your calculator(s) here:

Section A	Concepts and Skills	150 marks

Answer **all six** questions from this section.

Question 1 **(25 marks)**

(a) A random variable X follows a normal distribution with mean 20 and standard deviation 5. Find $P(14 \le X \le 26)$.

(b) There are 16 girls and 8 boys in a class. Half of these 24 students study French. The probability that a randomly selected girl studies French is 1·5 times the probability that a randomly selected boy studies French. How many of the boys in the class study French?

page	running

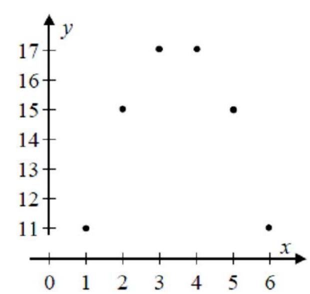
Question 2 **(25 marks)**

(a) Explain, with the aid of an example, what is meant by the statement:

"Correlation does not imply causality."

(b) The data given in the table below and represented in the scatter diagram are pairs of observations of the variables x and y.

x	1	2	3	4	5	6
y	11	15	17	17	15	11



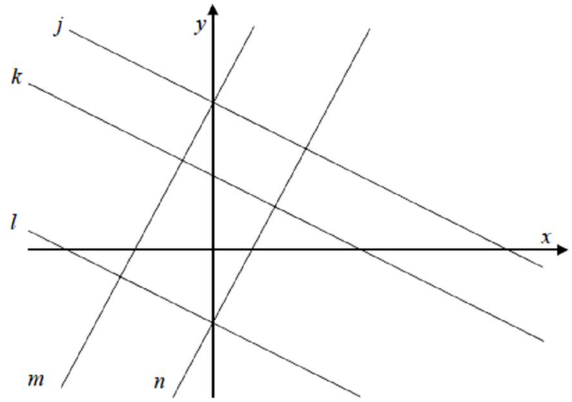
(i) Calculate the correlation coefficient.

Answer: ____________________

(ii) What kind of relationship, if any, do the observed data suggest exists between x and y?

Question 3 **(25 marks)**

In the co-ordinate diagram shown, the lines j, k, and l are parallel, and so are the lines m and n. The equations of four of the five lines are given in the table below.



Equation	Line
$x+2y=-4$	
$2x-y=-4$	
$x+2y=8$	
$2x-y=2$	

(a) Complete the table, by matching four of the lines to their equations.

(b) Hence, insert scales on the x-axis and y-axis.

(c) Hence, find the equation of the remaining line, given that its x-intercept and y-intercept are both integers.

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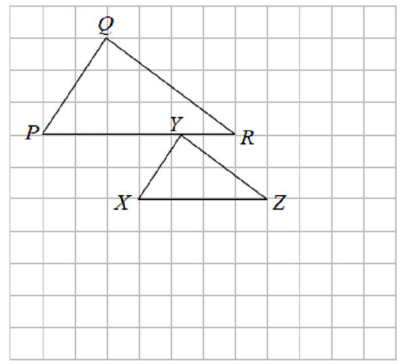
Question 4 **(25 marks)**

Two triangles are drawn on a square grid as shown. The points P, Q, R, X, and Z are on vertices of the grid, and the point Y lies on $[PR]$. The triangle PQR is an enlargement of the triangle XYZ.



(a) Calculate the scale factor of the enlargement, showing your work.

(b) By construction or otherwise, locate the centre of enlargement on the diagram above.

(c) Calculate $|YR|$ in grid units.

Question 5 **(25 marks)**

The line $x+3y=20$ intersects the circle $x^2+y^2-6x-8y=0$ at the points P and Q.
Find the equation of the circle that has $[PQ]$ as diameter.

page	running

Question 6 **(25 marks)**

Answer **either** 6A **or** 6B.

Question 6A

Prove that if three parallel lines cut off equal segments on some transversal line, then they will cut off equal segments on any other transversal line.

Diagram:

Given:

To prove:

Construction:

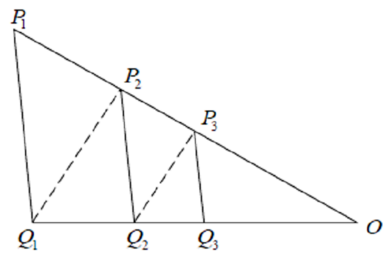
Proof:

OR

Question 6B

In the diagram, P_1Q_1, P_2Q_2, and P_3Q_3 are parallel and so also are Q_1P_2 and Q_2P_3.

Prove that $|P_1Q_1| \times |P_3Q_3| = |P_2Q_2|^2$.



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Section B	Contexts and Applications	150 marks

Answer Question 7 and Question 8.

Question 7 **(75 marks)**

(a) Some students are using a database of earthquakes to investigate the times between the occurrences of serious earthquakes around the world. They extract information about all of the earthquakes in the 20th century that caused at least 1000 deaths. There are 115 of these.

The students wonder whether there are patterns in the timing of these earthquakes, so they look at the number of days between each successive pair of these earthquakes.

They make the following table, showing the number of earthquakes for which the time interval from the previous earthquake is as shown.

Time in days from previous earthquake	0 – 100	100 – 200	200 – 300	300 – 400	400 – 500	500 – 600	600 – 700	700 – 800	800 – 1000	1000 – 1300
Number of earthquakes	31	24	12	14	8	7	5	6	5	3

[Source: National geophysical data center, significant earthquake database: www.ngdc.noaa.gov]

(i) Create a suitable graphical representation of the distribution.

(ii) Describe the distribution. Your description should refer to the shape of the distribution and should include an estimate of the median.

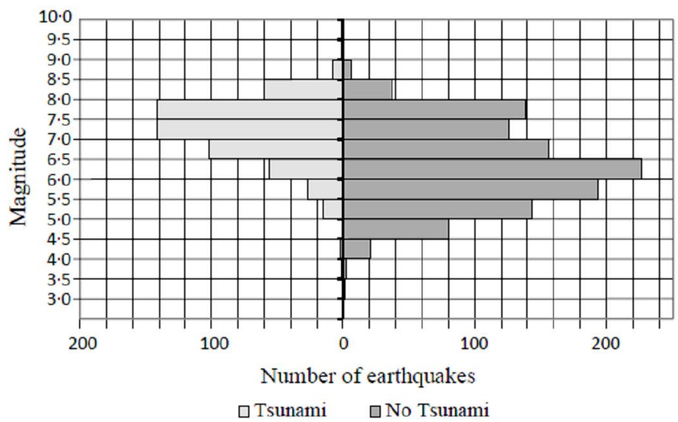
(iii) The mean time between these earthquakes is 309 days and the standard deviation is 277 days. Suppose that such an earthquake has just occurred and that we want to find the probability that the time to the next one will be between 100 and 200 days. Explain why it would **not** be correct to use standard normal distribution tables (z-tables) to do this.

(iv) Based on the information presented in this question so far, what is the best estimate for the probability described in part **(iii)** above? Explain your reasoning.

(v) As stated at the beginning, the students chose to analyse earthquake timings by looking at the time intervals between the occurrences of a particular type of earthquake. Suggest a different way that they could have looked at the data in the database in order to try to find patterns in the timing of earthquakes.

page	running

(b) The students heard a reporter saying that "strong earthquakes will cause large destructive ocean waves called tsunamis, while weaker ones will not". They decide to check this. They draw two histograms back to back, one showing the magnitudes of the earthquakes that caused tsunamis, and the other showing the magnitudes of those that did not. They use all of the suitable data from the 20th century that were recorded in this particular database.



(i) Comment on the reporter's statement, using information from the diagram to support your answer, and suggest a more accurate statement.

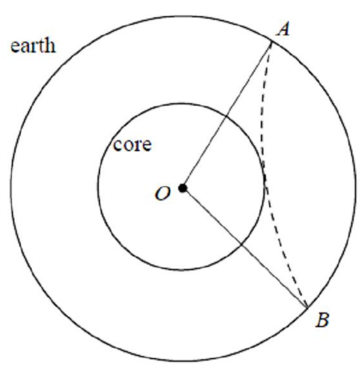
(ii) By taking suitable readings from the diagram, estimate the probability that an earthquake of magnitude between 6·5 and 7·0 will cause a tsunami.

(iii) Consider the next six earthquakes of magnitude at least 7·5. Find an estimate for the probability that at least four of them will cause a tsunami, assuming that these six events are independent of each other.

(c) Scientists use information about seismic waves from earthquakes to find out about the internal structure of the earth.

The diagram below represents a circular cross-section of the earth. The dashed curve represents the path of a seismic wave travelling through the earth from an earthquake near the surface at A to a monitoring station at B. The radius of the earth is 6·4 units and the path of this wave is a circular arc of radius 29·1 units, where 1 unit = 1000 km. Based on information from other stations, it is known that this particular path just touches the earth's core. The angle AOB measures 104°, where O is the centre of the earth.

Find the radius of the earth's core.
(There is space for work on the next page.)



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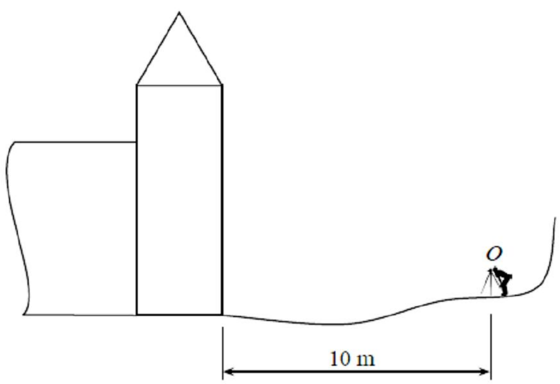
Question 8 **(75 marks)**

(a) A tower that is part of a hotel has a square base of side 4 metres and a roof in the form of a pyramid. The owners plan to cover the roof with copper. To find the amount of copper needed, they need to know the total area of the roof.

A surveyor stands 10 metres from the tower, measured horizontally, and makes observations of angles of elevation from the point O as follows:

The angle of elevation of the top of the roof is 46°.
The angle of elevation of the closest point at the bottom of the roof is 42°.
The angle of depression of the closest point at the bottom of the tower is 9°.



(i) Find the vertical height of the roof.

page	running

(ii) Find the total area of the roof.

(iii) If all of the angles observed are subject to a possible error of $\pm 1°$, find the range of possible areas for the roof.

(b) Twenty five students each measure and record a particular angle of elevation, in degrees, each using his or her own home-made clinometer. The results are as follows:

24	20	22	15	70
15	16	15	16	15
18	16	21	21	73
16	20	12	18	20
18	18	14	22	18

(i) Find what you consider to be the best estimate of the true value of the angle, explaining your reasoning.

(ii) Based on previous experience, a teacher has claimed that, in these circumstances, half of all students will measure the angle correctly to within two degrees. Taking these students to be a simple random sample, and assuming the true value of the angle is the one you calculated in part **(i)**, is there sufficient evidence to reject the teacher's claim at the 5% level of significance?

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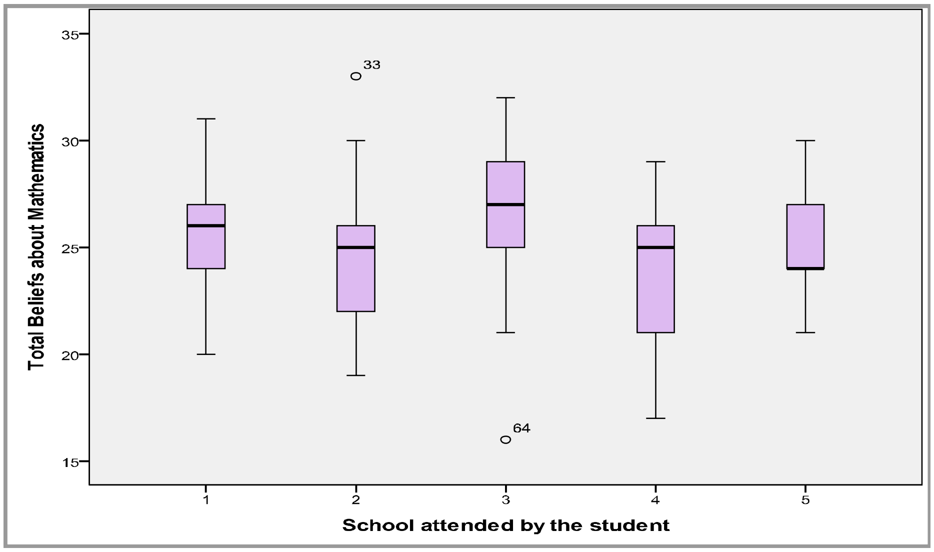
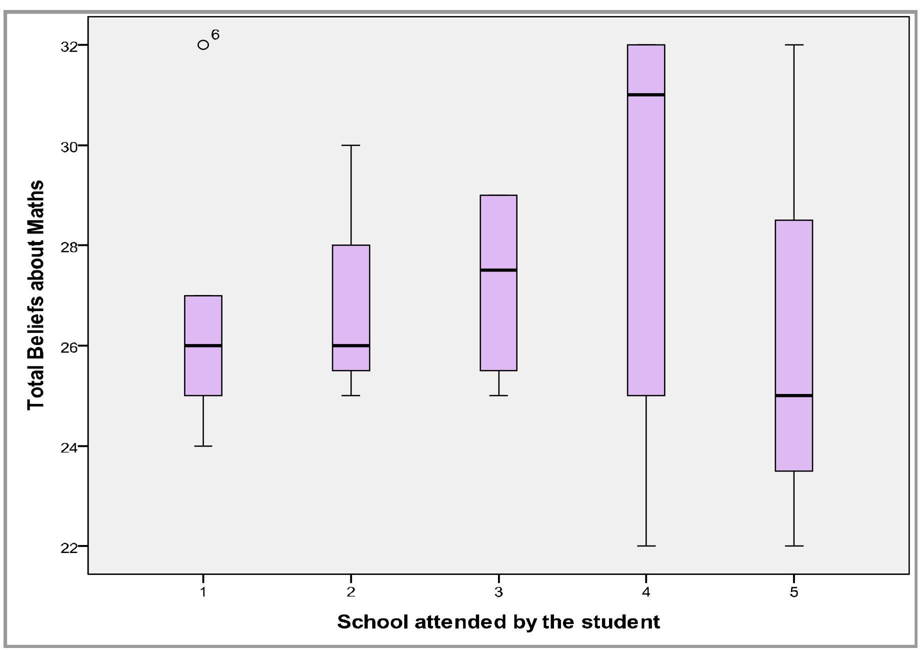
You may use this page for extra work.

Appendix K

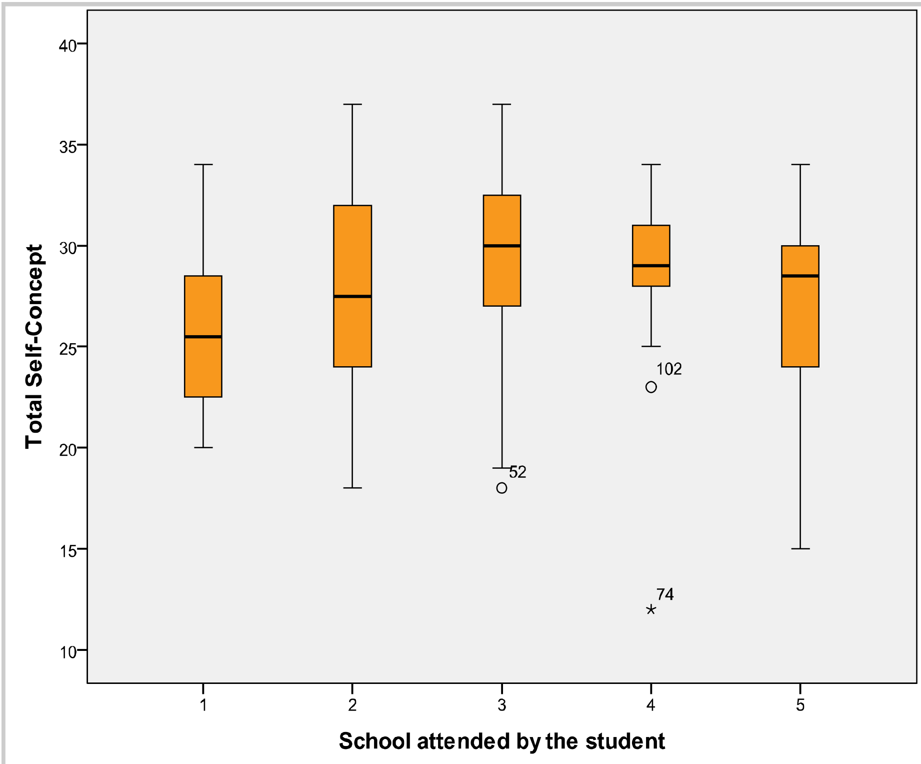
Extra graphs from section 4.7.11



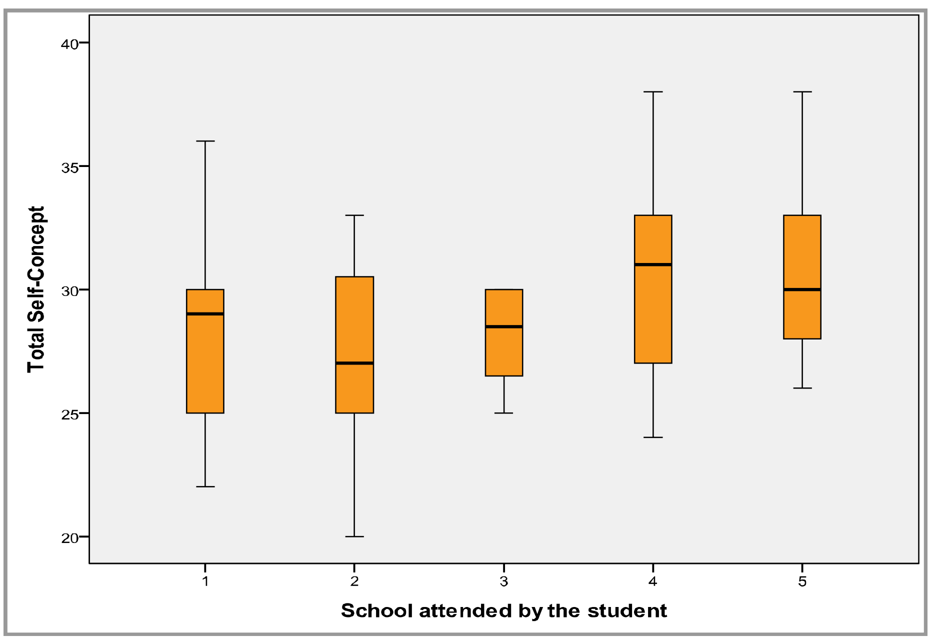
Total *Beliefs* about mathematics in each School for Cohort 1



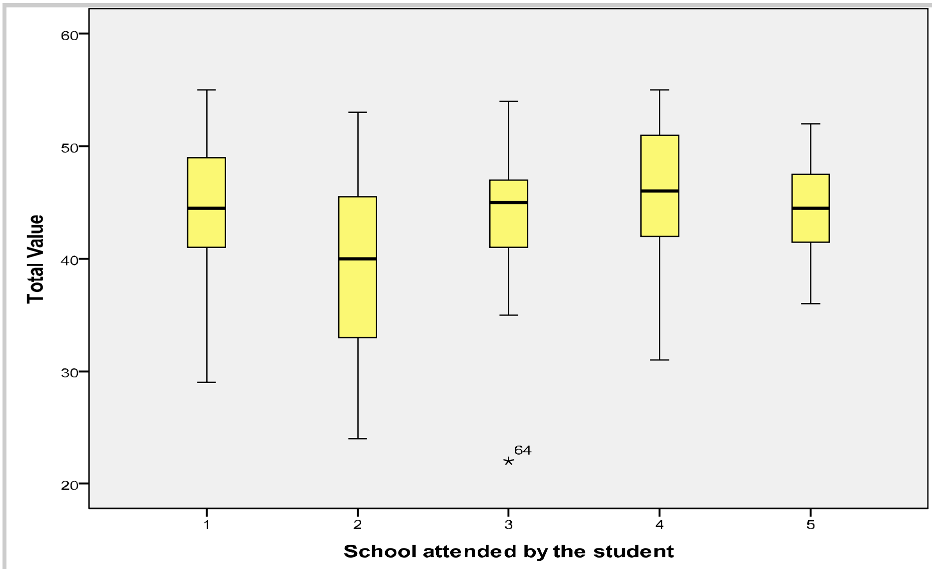
Total *Beliefs* about mathematics in each school for Cohort 2



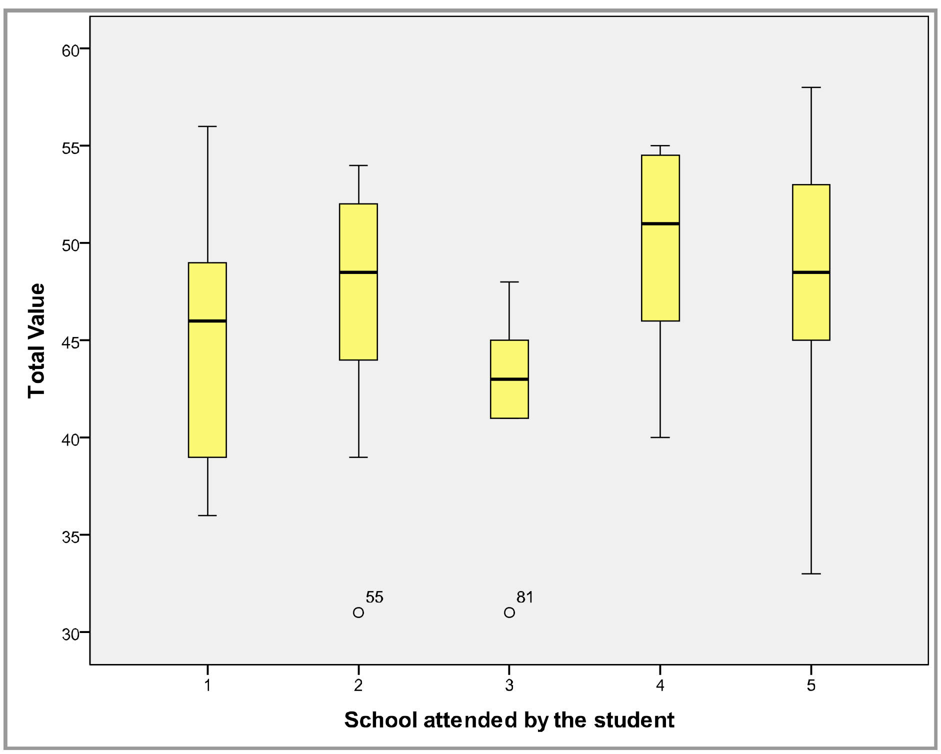
Total *Self-concept* in each School for Cohort 1



Total *Self-concept* in each School for Cohort 2



Total *Value* in each school for Cohort 1



Total *Value* in each school for Cohort 2

Appendix L

National Secretary,

Irish Mathematics Teachers' Association

imtasec@gmail.com

(086) 8431480

24/10/2011

A chara,

I am writing to you on behalf of the National Executive of the Irish Mathematics Teachers' Association. Following a recent Council meeting, it was decided to contact all Project Maths schools and ask the teachers involved one simple question:

What five pieces of advice would you give to teachers facing into the Project Maths syllabus (or to put it more bluntly – what do you know now that you wish you knew at the beginning?)

At this time of year, I realise that schools and teachers are particularly busy so I am taking the liberty of contacting schools using e-mail and would invite you to return your answer in a similar fashion. I appreciate that letters can be mislaid and people can often find it difficult to return correspondence due to time constraints. I also include my mobile number if you would prefer to pass on your comments over the phone.

Over the coming weeks I will collate the responses and present the findings to the Annual General Meeting of the IMTA and we will distribute the information to our branches around the country. Research of this kind would be highly valuable to our members and it will help us, as an organisation, to prepare them for the future. I would sincerely ask that you assist us in this matter and take the opportunity to offer your wisdom and insight to your colleagues around the country.

Hoping to hear from you in due course.

Yours Faithfully,

Brendan O'Sullivan

National Secretary IMTA

Report on Advice from Project Maths Pilot Schools

Introduction: The IMTA Council meeting of October 15^{th} 2011 decided to contact the cohort of pilot schools to garner from them five pieces of advice in relation to the implementation of the new curriculum.

Procedure: The National Secretary contacted all the schools concerned with the assistance of the Project Maths team. All the schools were asked the same question, essentially seeking guidance towards those embracing Project Maths. Respondents replied through email or spoke to the Secretary over the telephone.

Summary of Findings:

Just over 50% of the schools replied to the question that was posed. The following points are of note, in relation to implementing the new style of teaching in the classroom.

- There is a huge work load at the start, but the students appear to enjoy the classes in the long term. Don't lose hope and persevere. Be positive because it is going to take time.
- Remember, especially at Higher Level, that Foundation and Ordinary Level are subsets of the Higher Level course and that content must be covered at well.
- The syllabus is deceptive and be wary of items that can be included by 'implication'.
- Live by the syllabus, the books are only an interpretation of this and not a very good one at times.
- Teachers need to understand that the unexpected should be expected in relation to papers and that a student's understanding is much more important than following patterns in past exam papers.
- Start off slowly with the problem solving type classes and gradually increase the frequency as time goes on.
- Students should be encouraged to write sentences in English to explain their answers. Get the students verbalising their Maths through discussion and classroom activities.
- Use the student disc and website for back up material. There is plenty of content now available on www.projectmaths.ie
- Don't get bogged down playing games, always move the class on towards problem solving. It's very easy to go off on tangents, keep yourself focused on your teaching programme.

Conclusions: The following conclusions were drawn from the replies.

- Teachers must realise that the transition will be difficult in the beginning but it gets easier as familiarity with the process grows.

- Pay particular attention to the syllabus and read it regularly and carefully. Don't be overly reliant on the textbooks that are on the market.
- A different kind of teaching is involved that will prove foreign to teachers at the beginning. It is important to plan classes so as to promote problem solving and have students engage in activities that get them explaining their thought processes.
- Be careful with timing; make sure that you allow yourself sufficient time to cover all topics.
- There is a lot of content now available in terms of resources compared to when the syllabus was first introduced. Teachers should make use of these and allow them to support their teaching.