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Evaluation of the University of Limerick Mathematics Learning Centre

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Abstract

Evaluation of the University of Limerick Mathematics Learning Centre

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In a time when mathematical unpreparedness is rife and learning support is most urgently needed, this investigation seeks to evaluate the effectiveness of the mathematics learning centre in the University of Limerick. Qualitative and quantitative data on the impact of the mathematics learning centre on the students' mathematics education and students' attitudes towards mathematics were collected through the use of student questionnaires. Analysis of this data provides significant evidence that the mathematics learning centre is making an invaluable contribution to the mathematical experience of the students who are availing of its services. The results of this study strongly support the belief that mathematics learning centres have the potential to provide students with both the affective and cognitive support that is so critical to many of the students entering third level education presently.

Declaration of Originality

I hereby declare that this project is entirely my own work other than the counsel of my supervisor and that it has not been submitted for any academic award, or part thereof, at this or any other educational establishment.

Signed: _____ **Date: _____**

Author

Signed: _____ **Date: _____**

Supervisor

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I would like to thank my supervisor Dr. Olivia Gill for all the help and support throughout this project. I would also like to thank my Mum and Dad, my four siblings; Louise, Emma, Edith and Peter and my boyfriend Dallan for all their support. Finally, I would like to apologise to my dog Sparkie for the neglect she endured for the duration of this project particularly lack of football training and scenic walks.

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Chapter 1

Introduction

1.1 Introduction:

"Mathematics is of central importance to modern society. It provides the language and analytical tools underpinning much of our scientific and industrial research and development. Mathematical concepts, models and techniques are also key to many vital areas of the knowledge economy, including the finance and ICT industries. Mathematics is crucially important, too, for the employment opportunities and achievements of individual citizens".

(Smith, 2004 p. v)

In recent years mathematics has increasingly been put under the spotlight as its potential in a vast array of sectors is gaining increased recognition among society. In spite of this, much of the recent research into the mathematical standards of students entering tertiary institutions has shown a decline in the standard of mathematics in this country and in many other countries around the world (Rylands and Coady 2009; MacGillivray 2009; Hourigan and O' Donoghue 2007). Taking into consideration both the importance of mathematics in modern day society and the decline in standards of mathematics, it is hardly surprising that learning support in mathematics is becoming ever more important. Consequently, this demand for mathematics support has seen a rise in the number of mathematics learning centres in tertiary institutions around the country, including the one here at the University of Limerick (UL). As with any support service, it is essential that having established these mathematics learning centres in the third level institutions, they should be evaluated to ensure that they are serving their purpose. According to Gill et al (2010), evaluation is imperative in ensuring best practice and to ensure that the service provided is meeting the needs of the students. Furthermore MacGillivray (2009) has underlined the importance of evaluation in ensuring continued support and funding from the institution in which they are based. It is on the basis of this resounding evidence of both the importance of mathematics learning support and its subsequent evaluation that the author has undertaken this investigation to evaluate the mathematics learning centre in the University of Limerick.

1.2 Purpose of Study:

The purpose of this study is to evaluate the effectiveness of the mathematics learning centre at UL. The author sought to examine if the mathematics learning centre is fulfilling its role and providing a service which is valuable to the students who use it. Getting feedback from the students who use the mathematics learning centre has been acknowledged by Lawson et al 2001 (cited in

Sigma 2009) and Gill and O' Donoghue (2007), as an effective method of measuring the effectiveness of mathematics learning centres. In this investigation, student questionnaires were used to ascertain if students felt the mathematics learning centre was having a positive impact on their mathematical experience in the university. The questionnaires also allowed the author to examine what aspects of the mathematics learning centre students found to be most effective and what the current attitudes of students towards mathematics were at that time.

1.3 Research Questions:

Before this investigation was undertaken, two questions in particular were highlighted as being very important in evaluating the effectiveness of mathematics learning centre. These were:

- Does the Mathematics Learning Centre impact on students' mathematics education?
- Does the Mathematics Learning Centre impact on students' attitudes to mathematics?

This investigation has provided the author with significant evidence of the effectiveness of the mathematics learning centre, through the exploration of these questions. This evidence will be outlined and discussed in the following chapters. The conclusions reached in this investigation enable the reader to see how the mathematics learning centre in the University of Limerick has impacted students' mathematics education and their attitudes to mathematics. This investigation also revealed particular aspects of the mathematics learning centre, which the students find to be particularly effective, and other aspects which might need to be improved.

1.4Structure:

This investigation will be reported on under five main headings. These are:

- Literature Review
- Methodology
- Results
- Discussion of Results
- Conclusions and Recommendations

A brief synopsis of each chapter has been included to give the reader an overview of what is to come.

Chapter 2: Literature Review

This chapter will provide the reader with an insight into the findings of previous research in this field. It gives a background to the 'mathematics problem' and introduces some of the common factors recognised by the literature as being responsible for this problem. In doing this it highlights the need for learning support and subsequently examines the measures which have been put in place by some of the universities in response to the 'mathematics problem'. Finally it examines attitudes towards mathematics and the implications that these attitudes have for mathematics learning centres.

Chapter 3: Methodology

This chapter outlines the methodology undertaken by the author in conducting this research. It looks at the research instrument; how it was developed, how it was piloted and how it was administered. It also looks at how the participants were chosen, how the results were analysed and what steps were taken to improve the reliability and validity of the investigation. Lastly, the limitations of this study are brought to the attention of the reader.

Chapter 4: Analysis of Results

The results obtained from the research instrument are analysed in this chapter. Both qualitative and quantitative data were obtained in the investigation. These are both included in this section. Graphs and tables produced by the statistical packages; PASW 18 and Nvivo 9, are used to represent the findings in this section. These are accompanied by explanations which take the reader through the information given by the graphs and tables.

Chapter 5: Discussion of Results

In this chapter the author discusses the results obtained in the investigation. It puts the results of the investigation into context by comparing and contrasting them with the findings of previous research. This allows the reader to see the similarities and differences between the findings of this investigation and those of previous research. It also explains why the differences which were noted may have occurred.

Chapter 6: Conclusions and Recommendations

In this chapter the author gives a summary of the main findings and makes some recommendations for the future. It highlights areas in which the mathematics learning centre is

performing well and also those areas where more work is needed. Finally an overall conclusion to the project looks at whether or not answers to the research questions which the author posed have been found.

1.5 Conclusion:

The author undertook this investigation in order to evaluate the effectiveness of the mathematics learning centre. The information gained from this investigation can then be used to show the importance of the service to the students and to ensure that the service is meeting the needs of its current users. In understanding the need for mathematics learning centres and how they should be evaluated it is important to look at the findings of previous researchers in an attempt to assess how to get the most from this investigation. In the next chapter the author will examine the findings of other researchers who have done work in this field.

Chapter 2

Literature Review

2.1 Introduction:

In the previous chapter, the reader was introduced to the research field in which this investigation is associated. This chapter looks at some of the research that has already been carried out in this domain. In this review of the literature, the author hopes to give the reader an understanding of the context of this investigation as well as providing an insight into the findings of previous researchers. Initially the author gives an insight into the 'mathematics problem', which has created the need for mathematics learning centres, before examining the different types of learning support which have consequently been made available. Finally, the author explores previous findings on attitudes towards mathematics and what implications such findings might have for mathematics learning centres in third level institutions today.

2.2 The Mathematics problem

In recent years, universities and colleges across the globe have found that their students do not have sufficient mathematical preparation or the appropriate 'mathematical' background to deal with their first year mathematics courses and because of this, universities and colleges have seen an increase in failure rates for these subjects (Rylands and Coady 2009). The term the 'Mathematics Problem' has been coined to describe this situation. The 'Mathematics Problem' refers to the:
"longstanding international disquiet (e.g. UK, USA) that students are entering mathematics intensive courses with fewer of the basic mathematical skills essential for course success"
(Hourigan and O'Donoghue 2007, p.461)

This 'Mathematics Problem' has been reported to be occurring in countries such as the UK, Ireland, Canada and Australia. Kajander and Lovric (2005) reported on the problems some of the mathematics lecturers were facing in Canada, identifying problems with the mathematical preparation of their students stating that the skills and knowledge of the incoming students were well below what was expected of them. In the UK a report 'Measuring the Mathematics Problem'(cited in Rylands and Coady 2009), found that the depreciated skills and the variety of entry pathways, and consequently a greater variability in skill and knowledge base of their students were causing major problems for the lecturers of mathematical subjects in their universities. Irish third level institutions are facing similar problems regarding the ability of the students entering their courses. *"Mathematics Departments within Irish Third Level Institutions (e.g. Cork Institute of Technology, University of Cork and University of Limerick (UL)) have expressed dissatisfaction*

with the mathematical ability of entrants since the mid-1980 s" (Hourigan and O'Donoghue 2007 p.462).

Both Rylands and Coady (2009) and Hourigan and O'Donoghue (2007) have cited the 'Mathematics Problem' as a major cause of concern for society, education sectors and governments. Gill et al (2010) and Hourigan O' Donoghue (2007) both recognise that the 'Mathematics Problem' is providing both the governments and educational sectors in developed countries with significant difficulties as many of these developed countries are depending on the mathematical skills of their citizens for future economic growth. Therefore, it is imperative that something be done as quickly as possible to help curb this problem.

2.3 Internal Factors Contributing to the 'Mathematics Problem':

Several suggestions have been put forward as to the root of this problem. Some internal factors were highlighted by O' Donoghue (1999) in his report on 'at risk' students in service mathematics courses in UL. These included: variability in mathematics entry standards, wide variability in mathematical ability, large class environment, university teaching methods and difficulties associated with transition to university mathematics. The idea that variability in mathematics entry standards is a contributory factor to the mathematics problem has received widespread support across a diverse range of nations. MacGillivray says of Australian third level institutions that "*increasing numbers of mature age, international, alternative entry and equity outreach students have resulted in an enormous increase in the diversity of academic preparedness*" (2009, p.456). Hourigan and O'Donoghue describe the changing profile of third level mathematics students in the UK "*as the single most detrimental factor leading to under-preparedness within mathematics-intensive courses at tertiary level*" (2007, p.463). Faulkner et al have found a similar problem in Ireland in that a changing profile is a "*major contributing factor to the declining standards in mathematical competency of students entering UL*" (2010, p.87).

The immense difference between teaching methods used by universities and those used in post primary schools has also been cited as a major contributory factor to 'the Mathematics Problem' across the globe. Although this suggestion has received considerable support, it remains a debatable issue as to whether it is the fault of the universities or the post primary schools. It would appear that universities and post primary schools use very different approaches to learning. Post primary schools favour a surface learning approach, "*where the main focus is reproduction of knowledge"* and universities favour a deep learning approach, "*which aims for comprehension"*

(Biggs et al 2001 cited in Liston and O'Donoghue 2009, p.79). Liston and O'Donoghue (2010) says studies have shown that many students of Irish secondary school mathematics have little or no understanding of what or why they are doing mathematics and that, the focus of teaching in Ireland is on memorization and routine performance. This causes problems for the students when they get to University where they are expected to change their attitude *"i.e. to get involved in deep-learning activities"* (Kajander and Lovric 2005, p.157). Nardi 1996 (cited in Hoyles et al 2001) has suggested that this jump from empirical to abstract mathematics, from the informal to the formal is causing problems in the transition from school to university mathematics.

This rote or 'surface' learning used in so many of our secondary schools has been found to be detrimental to students' procedural ability and "*prevent students from gaining an understanding of mathematical concepts*", skills which they are expected to have and use in university mathematics. However Kajander and Lovric (2005) argue that it is understandable that teachers continue to use these methods given that they have been proven to get the students high marks in the past and they are significantly less time-consuming than 'deep learning' methods. It is widely accepted that teachers are not completely to blame for this. English et al. (1992) elicit part of the blame to the overcrowded syllabus and O' Donoghue (1999) attributes part of the blame to the pressure put on teachers to achieve higher points for their students. So perhaps the problem caused by vast differences in teaching styles is created neither by university lecturers nor secondary school teachers rather by something, which is outside both of their control: the 'Leaving Certificate points race' and the Mathematics syllabus.

In Ireland, steps have already been taken by the National Council for Curriculum and Assessment (NCCA) to alleviate the workload on the mathematics Junior and Leaving Certificate courses with the introduction of Project Maths. With the introduction of these two new syllabi, the aim is to increasingly provide genuine mathematical experiences and give pupils an improved understanding of mathematical concepts (Project Mathematics Development Team 2008). The changes in the Leaving Certificate syllabus are aimed at providing the students with the necessary knowledge and skills not only for their future lives but also for further study in areas that rely on mathematics (Project Mathematics Development Team, 2008). Hopefully this will allow secondary teachers to use a deep learning approach to teaching which might in turn make the transition to third level education easier for these pupils.

However, nothing has been done to counteract the adverse effect the 'points system' has, not just on the mathematical experience but on the educational experience in general. The 'points system' has resulted in teachers in the Irish Post-Primary Education System using a 'teach to the examination' approach rather than providing their pupils will rich educational experiences. This is

affecting the mathematics education of these pupils in a variety of ways according to O' Donoghue (1999). Apart from the teaching styles adopted by the teachers, which have already been mentioned it is also affecting the level of mathematics, individuals are taking for their Leaving Certificate i.e. Higher or Ordinary level. O' Donoghue (1999) says that an increasing number of pupils are being advised to take the ordinary level paper "*for reasons more to do with securing higher points totals than academic considerations per se"*. This in its own right is affecting the transition from secondary to tertiary education as the findings of Barry & Chapman (2007 cited in Faulkner et. al. 2010, p. 86)) *"also state that performance in mathematics in third level institutions has been shown to be better when students have Higher Level mathematics as pre-requisite knowledge"*. The idea, highlighted by O' Donoghue (1999), that the large class environments in the tertiary setting is causing the students entering third level education problems has also received support. For example, Liston and O'Donoghue (2010) also found that students in general preferred the smaller class environments, which they were used to from secondary school.

2.4 External Factors Contributing to the 'Mathematics Problem':

Hourigan and O' Donoghue (2007) recognise that although many internal factors, such as those just mentioned, have been pinpointed as potential causes of the 'Mathematics Problem' the suggestion that the root of the problem lies in the failure of many students to successfully make the transition between post-primary and tertiary education is receiving increasing support. Furthermore Hourigan and O' Donoghue (2007) suggest that the reason many students struggle to make the transition between post-primary and tertiary mathematics is due to the '*substantial mismatch'* between the mathematical experiences provided at pre-tertiary mathematics and that of tertiary level mathematics.

This view has been supported by numerous studies, which have found that secondary level grades do not match up with their performances at tertiary level. In the UK for example: *"pupils achieving 'A' grades in mathematics are demonstrating characteristics traditionally associated with poor pupils, e.g. panic when presented with mathematics not seen before"* (Hourigan and O'Donoghue, 2007:461). The University of Limerick has reported similar trends: *"31% of students who achieved good grades, e.g. Ordinary Level 'A1' and 'A2' grades at Leaving Certificate, were diagnosed as being 'at-risk'"* (Hourigan and O' Donoghue, 2007: 461). These figures can be seen in Figure 2.1. Hourigan and O'Donoghue (2007) believe that such findings suggest that there is little correlation between post primary examination results and true mathematical understanding.

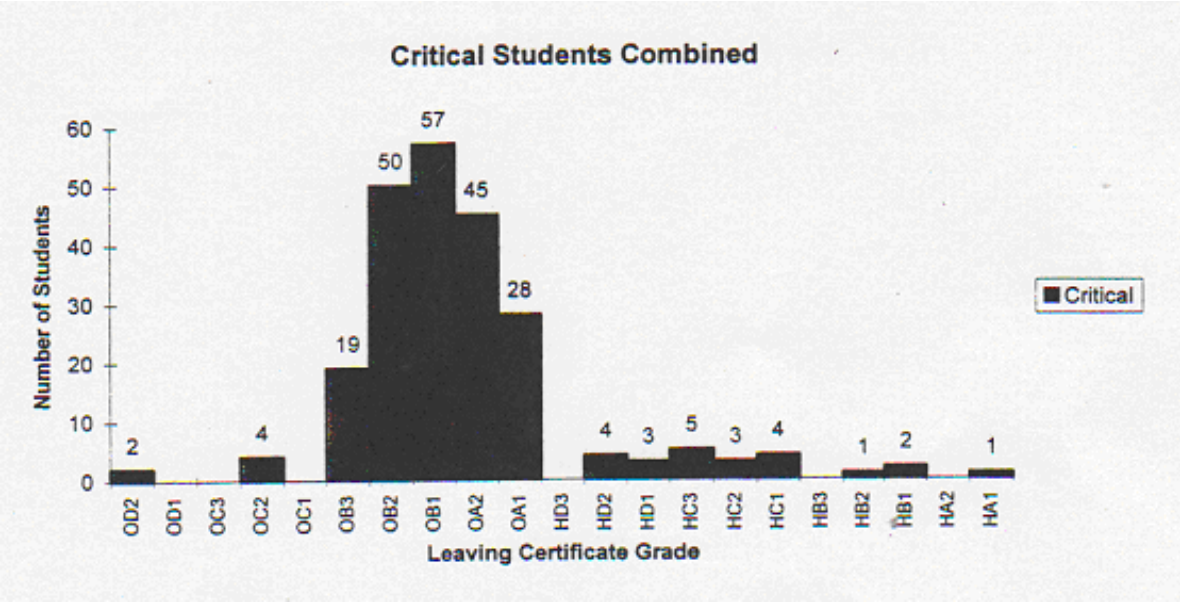

Figure 2.1: Relationship between diagnostic test score and Leaving Certificate grades

Similar findings by O' Donoghue (1999, p.18), in the analysis of the data received in a study in the University of Limerick, lead him to the conclusion that *"caution in the interpretation of what particular LC mathematics grades signify in terms of mathematical competence of students is well founded particularly as regards ordinary level Grades B and below".*

A more recent study in the University of Limerick carried out by Gill et al. (2010) found that although Higher Level students were outperforming Ordinary Level students in the UL diagnostic test their mean diagnostic score was worrying low. The mean diagnostic score for Higher Level students was always greater than the pass mark of 20 (out of 40) but never exceeding the 30 mark, as illustrated in Figure 2.2. This statistic shows that the higher level students were performing way below what would have been expected of them, given that "*35 out of the 40 questions on the test are pitched at a lower level (i.e. Leaving Certificate ordinary level or below"* (Gill et al 2010, p.332).

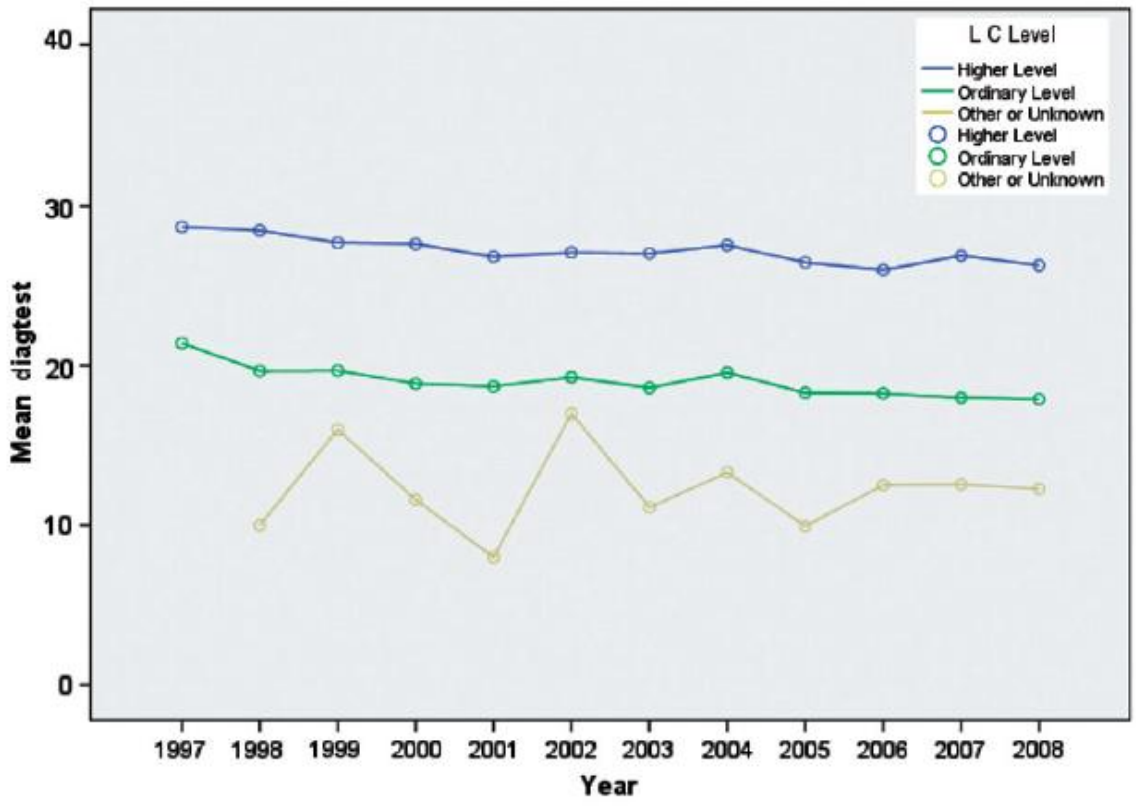

Figure 2.2: Mean diagnostic score for technology mathematics and science mathematics students, 1998-2008.

Therefore, it would seem that those pupils who were excelling in mathematics in secondary level were not achieving the equivalent standard in mathematics at tertiary level. On this evidence it would suggest that the reservations that O'Donoghue and Hourigan (2007) were having in respect of judging a student's mathematical competence based on their mathematics grades were justified. However a study (the result of which can be seen on the following page) carried out by Rylands and Coady (2007) in Australia, had findings (Table 2.1 and 2.2) to the contrary. They concluded that a "*students' level of secondary school mathematics is a good indicator of how prepared the student is for university mathematics and mathematics related subjects*" (Rylands and Coady, 2007: 750). Table 2.1 shows the percentage of students who passed each university subject in that year. It shows that more students with a secondary school advanced mathematics background passed each mathematical subject than their counterparts who had an intermediate or elementary mathematics background.

Table 2.1: Percentage of students who passed each university subject

Mathematics background	Advanced (%)	Intermediate (%)	Elementary (%)
Discrete mathematics	88	65	36
Statistics	81	73	63
Physics	79	63	35
Basic mathematics	100	79	23

Table 2.2 shows the percentage of students who received a passing grade better than a 'P' in that year. This shows that students who had advanced mathematics backgrounds were more likely to perform better than those with lower levels of school mathematics.

Table 2.2: Percentage of all students who got a grade better than 'P'

Mathematics background	Advanced (%)	Intermediate (%)	Elementary (%)
Discrete mathematics	25	21	0
Statistics	44	34	29
Physics	47	26	8
Basic mathematics	67	37	5

However, perhaps this disparity in findings can be explained by the differences between the education systems of the respective countries. Gill et al. (2010, p.324) recognised that although there may be similarities in the 'Mathematics Problem' around the world, individual differences such as *"local conditions, practices and needs"* mean that researchers should examine the problem and contributory factors as it exists in their own country.

2.5 Learning Support

In view of the aforementioned problems with which the tertiary institutions now find themselves facing, learning support is becoming increasingly more important in colleges and universities across the world. O'Donoghue (1999) and MacGillivray (2009) have both made reference to the increasing urgency with which the Higher Education sectors have been tackling this problem as the extent and the significance of the problem becomes more apparent. In light of this a wide variety of learning support services are offered in the various third level institutes. These include bridging courses, tutoring, drop-in centres, C.A.L (Computer Assisted Learning), diagnostic testing, videos, numeracy classes and peer study sessions. Mathematics Learning Centres have increasingly been set up in response to 'the mathematics problem'. In Ireland since the opening of the mathematics learning centre in UL, many other Mathematics Learning Centres have been opened around the country and at the present time most third level institutions offer some form of mathematics learning support (Gill et al 2010). However, Croft (2000) warns that these mathematics learning centres are only a short time solution to the problem. The learning support deemed most important by the people who provide learning support and used most frequently by students is the one to one help offered in mathematics learning centres (MacGillivray 2009; Gill and O'Donoghue 2007; Croft 2000 and Lawson et al 2001). Lawson et al (2001, p.22) went on to clarify that the reason for this was *"because it provided focused help with immediate response to student questions"*.

2.6 Evaluating Learning Support:

Lawson et al 2001 (cited in Sigma 2009) suggested various ways in which mathematics learning support should be evaluated. One such method, which seems to have been adopted by various learning support providers, is evaluating success based on the success rate of the students. Indeed many different types of learning support have been deemed successful when judged in this way. Streaming of students and using different teaching resources and different teaching styles proved successful in Loughborough University, which saw a 19% increase in the pass rate of the less well-prepared students who received support (Symonds et al 2007). Bridging courses in University of Western Sydney also proved successful; students who completed a post test in 2004 had a mean score of 80% (Gillies et al 2005). Peer tutoring was also seen to be effective in Dublin City University where their examination grades improved by greater than 13% and failure rates

dropped (Parkinson 2009). Studies of mathematics learning centres have brought about similar results. Pell and Croft (2008) estimated that mathematics learning centre in Loughborough improved student pass rate by about 3%. Mac An Bhaird et al (2009) at the National University of Ireland Maynooth also found that students, studying humanities and finance who had attended the mathematics support centre, more than once had a pass rate of 89%, whereas those who had attended once or less had a pass rate of only 71%. Both Dowling and Nolan (2006) and Patel and Little (2006) found similar results. Furthermore, they both found that the mathematics support they offered improved student retention. Symonds et al (2007) had similar findings in that the support they provided also had a positive effect on student retention. However the success of a mathematics learning centre cannot be judged on pass rates alone.

Studies have shown how attending mathematics support centres can enhance the performance or grades of well-prepared students (MacGillivray 2009; Pell and Croft 2008). However Pell and Croft (2008) and Gill and O'Donoghue (2007) cited providing support for students who are struggling or the less well-prepared students as one of the main reasons for the initial introduction of these support centres. Therefore, it is important to consider how effective the support centres were in fulfilling this aim. There is considerable evidence, which shows that mathematics support centres are effective in improving the performance of the less well-prepared students for example MacGillivray (2009), Symonds et al (2007), Patel and Little (2006) and Dowling and Nolan (2006). However, it is also well documented that mathematics support centres are failing to reach some of the students who need this support most. Lawson et al (2001) reported significant findings that many of the students who needed help the most were not attending the mathematics support centres provided. Parkinson (2009) reported similar problems of non-attendance at the support tutorials they were offering in D.C.U. Therefore, an awareness among the student body of the mathematics support available is a key issue in the successfully reaching those students who need help. Perhaps even more worryingly, Mac An Bhaird et al (2009) noted that the majority of less well-prepared students did not attend the mathematics support centre (at NUIM).

Alongside the non-attendance, lack of engagement with mathematics has also been reported in Gill et al (2010) and Lawson et al (2001). They cited fear of showing a lack of knowledge or ability as a major causal factor of students being unwilling to engage with mathematics. Indeed many have reported on the importance of mathematics learning centres creating an environment where students feel 'no question is a stupid question'. MacGillivray (2009, p. 463) found that students perceived "improving their confidence and comfort" as a key aspect of the mathematics support they valued. Patel and Little (2006) reported similar findings. Therefore, it is clear that there is a strong link between student support centres and affecting attitudes toward mathematics.

2.7 Attitudes toward Mathematics:

Research has shown that negative attitudes towards mathematics are quite prevalent. As long as thirty years ago Sewell (1981, cited in Klinger 2007), reported that at least half of the adult population in England had negative attitudes toward mathematics. Klinger (2007) says that the situation with regard to the adult population's attitudes towards mathematics is relatively the same now. Larcombe (1985) also warned of the increasing prevalence of negative attitude of secondary school students towards mathematics. Singh (2003) found that these negative attitudes appeared to be more prevalent among females. With regard to third level education, the situation appears to be quite similar to that of the adult population. Klinger's (2007) study on mathematics attitudes in commencing undergraduates found that the situation in commencing undergraduates revealed similar findings to those of the broader population. McLeod (1994) found that children develop a more negative attitude toward mathematics during their secondary education.

2.8 Attitude's Effect on Performance:

Much research has been carried out on the relationship between attitude and achievement. Although Fraser and Butts (1982) found little correlation between the two, there is significant support for the idea that there is a strong link between the two. Coben (2003) reported that evidence showed that learners' attitudes about mathematics affect their learning of mathematics. Papanastasiou and Bottiger (2003) and Reynolds and Walberg (1992) found that positive attitudes towards mathematics are associated with greater achievement. Similarly Philippou and Christou (1998) and Suthar and Ahmad Tarmizi (2010) reported that evidence showed that learners' attitudes towards mathematics affect their learning of mathematics. However, some researchers have argued that it is not attitude that effects achievement rather it is achievement that affects attitude (Aiken and Dreger, 1961 and Hannula, 2002). Parsons (2005) supported the notion that there was a strong link between attitudes and achievement but she believed that they both impact on each other and that neither could be singled out as the cause nor the effect (as illustrated in Figures 2.3 and 2.4; the cycles Parsons used to represent her idea).

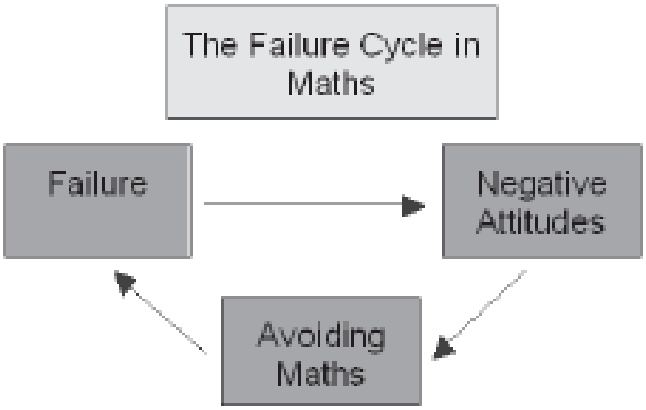

Figure 2.3: The Failure Cycle in Mathematics

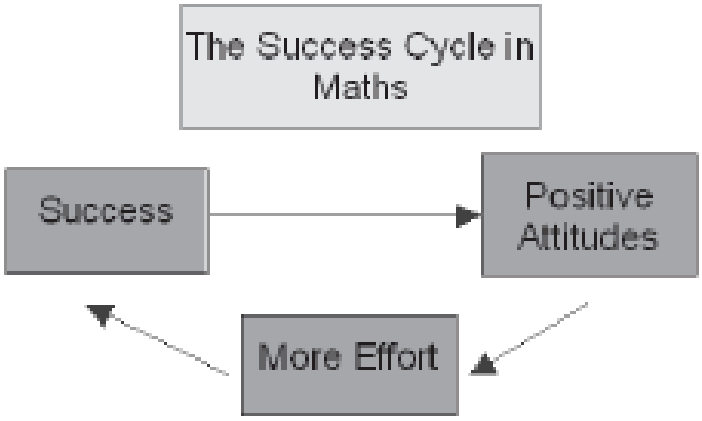

Figure 2.4: The Success Cycle in Mathematics

This idea that attitude can effect achievement would have major implications for those providing mathematics learning support for students who had negative attitudes towards mathematics.

2.9 Implications for Mathematics Learning Centres:

The finding that attitude can affect achievement would suggest that a high priority of any mathematics learning centre providing support for students would be to identify the cause of any negative attitudes and try to improve these students' attitudes towards mathematics. Indeed Klinger (2005, p.170) supports this theory he suggests that mathematics support centres must *"first*

challenge their (the students) *negative attitudes"*. However, this is not an easy process. Kent and Noss (2003 cited in The Ove Arup Foundation, 2011) warn that improving attitudes towards mathematics is a slow process. Relich (1996) warns that many of these problems are deep rooted, suggesting that many of our attitudes towards mathematics are strongly influenced by our early learning experiences and that particularly traumatic early experiences can have a long term effect on our attitude towards mathematics. There are no clear-cut ways for mathematics support centres to try to improve students' attitudes towards mathematics, however several suggestions can be found in the literature. Klinger (2007) suggests analysing past negative experiences with students to help them to overcome them. Philippou and Christou (1998) and Hannula (2002) recommend providing students with opportunities to experience success to help improve their attitude towards mathematics. Kent and Noss 2003 (cited in The Ove Arup Foundation, 2011) suggested that perhaps a teacher would be better positioned to teach mathematics to first year students than lecturers, as they would be more understanding of the students' needs. It is clear from the research that negative attitudes towards mathematics are a huge problem which mathematics support centres in tertiary institutions now find themselves facing and it is of utmost importance that they address this problem as it presents itself.

2.10 Conclusion:

In conclusion, the research highlights the on-going need for mathematics learning centres by identifying the problems that third level students face. It provided an insight into the attitudes towards mathematics of society at present and the implications, which these attitudes can have for mathematics learning centres. It examined how mathematics learning centres have been evaluated in the past and what results these evaluations have obtained. In the next chapter, the author outlines the methodologies that were used in this investigation, in the evaluation of the mathematics learning centre in the University of Limerick.

Chapter 3

Methodology

3.1 Introduction:

In the previous chapter the author gave an overview of the problems faced by tertiary institutions regarding the mathematical under-preparedness of the students entering their programmes. In light of the prevalence of these problems this investigation was carried out to evaluate the effectiveness of the support provided by the mathematics learning centre in the University of Limerick. This 'effectiveness' was measured in terms of the impact of the centre on students' mathematics education and on students' attitude toward mathematics. In this chapter the author will analyse the approach used in this evaluation and the methods undertaken in the analysis of the findings that the investigation revealed.

3.2 Description of the Study:

3.2.1 Overview:

Quantitative data regarding how the mathematics leaning centre in the University of Limerick can affect students' performance in their examinations have already been gathered (Gill and O' Donoghue, 2007). In this investigation the author sought to investigate further the effectiveness of the mathematics learning centre through the use of questionnaires, aiming to get feedback from the students on the services provided. The author developed these questionnaires to provide answers to the following questions:

- Does the Mathematics Learning Centre impact on students' mathematics education?
- Does the Mathematics Learning Centre impact on students' attitudes to mathematics?

3.2.2 Purpose of this Research:

Many researchers have reported on the importance of evaluating the effectiveness of mathematics learning centres in tertiary institutions. Gill et al (2010) emphasised the importance of evaluating the services in the process of developing best practice. Both Gill et al (2010) and MacGillivray and Croft (2010) have also highlighted the importance of being able to provide evidence of the impact of their services to ensure continued support and funding from the institution.

3.3 Research Instrument:

3.3.1 Mode of Enquiry:

The research instrument used in this investigation was a student questionnaire. The use of questionnaires in the evaluation of mathematics learning centres has received considerable support from researchers in this field. Lawson et al 2001 (cited in sigma 2009) recommends the use of student questionnaires in the evaluation of mathematics learning centres. MacGillivray (2010) reported that they provide important evidence that the learning support on offer is needed and valued by its users. Ní Fhloinn (2008) and Croft (2000) both emphasise that the evidence afforded by student questionnaires is very important.

3.3.2 Questionnaire Design:

Within the student questionnaire a variety of types of questions were used. There were eight questions requiring a response on a 5-point Likert scale probing participants' attitude toward mathematics, nine closed questions seeking personal information and five open questions looking for participants' opinion. Kumar (2008) listed several advantages to using the Likert scale in questionnaires: they are simple to construct, they make subjects more comfortable in specifying their point of view than just asking them to agree or disagree and they are more reliable than other scales. McNabb (2008) cited the Likert scale as an appropriate method of measuring attitudes. These questions were taken from The *Inventory of mathematics attitude, experience, and self-awareness* (IMAES) instrument (Klinger, 2006). This instrument proved a suitable method for gathering information on attitudes towards mathematics in Klinger's (2006) study. Kothari (2004) recommended the use of open-ended questions when looking for an opinion or 'free response' from the participant. Some open-ended questions pertaining to the impact of the MLC on students' mathematics education were included. These questions were taken from a questionnaire designed by the Irish Maths Support Network to evaluate mathematics learning support on a national scale in 2011 so were deemed suitable for this survey. The author also included some of the Network's closed questions to gather some background information about the participants regarding gender, student type and past experiences of mathematics.

3.3.3 Piloting the Research Instrument:

In designing the questionnaire help was sought from Dr. Chris Klinger, University of South Australia, who has experience in this field. As already mentioned some of the questions were taken from Klinger's IMAES instrument. Dr. Klinger also gave advice to change the wording of some of the proposed questions as he felt that they were leading the participants towards a particular answer. Following this the questionnaire was piloted with a group of third year students who were studying mathematics and who had used the centre on previous occasions. The pilot study showed the author that the research instrument provided a valid method of finding the required information. Following this the questionnaire (Appendix A) was distributed to the participants.

3.4 Data Collection:

3.4.1 Selection of Participants:

Participants were chosen based on the criteria that they use or have used the mathematics learning centre. The questionnaires were distributed by the manager and the tutors of the mathematics learning centre. A total of 124 participants were surveyed. Of these there were 89 males (72%) and 35 (28%) females. 23 (19%) were mature students and 100 (81%) were traditional students (1 gave no response to this question). As regards mathematical backgrounds, there was a good representation of students who had studied mathematics at both higher (45%) and ordinary (53%) level at Leaving Certificate. The participants' Leaving Certificate mathematics results ranged across the entire spectrum at both levels (Table 3.1). Years one to four were represented; there were 76 (61%) first years, 38 (31%) second years, 9 (7%) third years and 1 (1%) fourth year. In total 21 degree programmes were represented (Table 3.2).

Table 3.1: Leaving Certificate Mathematics Level * Leaving Certificate Mathematics Grade Cross tabulation

		Leaving Certificate Mathematics Grade										
		A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3
Leaving Certificate Mathematics Level	Higher	1	5	7	11	6	13	5	3	3	1	0
	Ordinary	11	11	18	6	2	7	1	2	3	0	1
	Other	0	0	0	0	0	0	0	0	0	0	0
	n/a	0	0	0	0	0	0	0	0	0	0	0
Total		12	16	25	17	8	20	6	5	6	1	1

Table 3.2: Degree Programmes represented in the study				
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2.4	2.4	2.4
Wood Science	9	7.3	7.3	9.7
Civil Engineering	15	12.1	12.1	21.8
Biomedical Engineering	5	4.0	4.0	25.8
Aeronautical Engineering	6	4.8	4.8	30.6
Environmental Science	4	3.2	3.2	33.9
Physical Science	2	1.6	1.6	35.5
Pharmaceutical and Industrial Chemistry	2	1.6	1.6	37.1
P.E. and Mathematics	3	2.4	2.4	39.5
Manufacturing Systems	1	.8	.8	40.3
Food Science and Health	2	1.6	1.6	41.9
BSc in Energy	1	.8	.8	42.7
Construction Management	1	.8	.8	43.5
Psychology	1	.8	.8	44.4
Health and Safety	3	2.4	2.4	46.8
Ind. Biochemistry	3	2.4	2.4	49.2
Mechanical Engineering	11	8.9	8.9	58.1
Business Studies	33	26.6	26.6	84.7
Economics and Sociology	5	4.0	4.0	88.7
Robotic Engineering	2	1.6	1.6	90.3
Computer Engineering	3	2.4	2.4	92.7
Electronic Engineering	7	5.6	5.6	98.4
no response	2	1.6	1.6	100.0
Total	124	100.0	100.0	

3.5 Data Analysis:

In analysis of data, both PAWS 18 and Nvivo 9 were used. The results of any closed-ended questions regarding gender, type of student, course studied and mathematical background along with participants' attitudes to mathematics (measured on a Likert scale) were entered into PAWS 18. It was used to develop graphical representations such as frequency tables, cross tabulations and to determine correlations between variables. Nvivo 9 was used to analyse the qualitative data ascertained from the open-ended questions, which required participants to give their opinion. Themes that appeared regularly were identified and within these themes common beliefs or ideas were recorded.

3.6 Validity/ Reliability/ Ethical Issues:

3.6.1 Validity:

Cohen et al (2007, p.133) says that in qualitative data *"validity might be addressed through the honesty, depth, richness and scope of the data achieved"*. Students were encouraged to be honest in their evaluations as the as the results could help to improve the services provided by the mathematics learning centre. Nvivo 9 was used to analyse the qualitative data. Cohen et al (2007, p.133) says that in quantitative data *"validity might be improved through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data"*. In order to improve validity of the study the author used a reasonably large sample size. A good representation of the student body was surveyed with regards to gender, student type, course of study and attitude toward mathematics. All participants were using or had used the mathematics learning centre. PASW 18 was used to analyse the data. This is a statistics package widely used in modern research.

3.6.2 Reliability:

Several steps were taken to try to make this investigation as reliable as possible. Cohen et al (2007, p.146) explains that for research to be reliable *"it must demonstrate that if it were to be carried out on a similar of respondents in a similar context (however defined), then similar results would be found".* The qualitative data found in this investigation was similar to that reported by MacGillivray (2009), Pell and Croft (2008) and Ní Fhloinn (2008) in the positive nature of the feedback. Also similar positive aspects to those identified by MacGillivray (2009) were pinpointed in this investigation; improving achievement, improving confidence and providing supportive,

positive learning environments. Davies (2008) found that combining a Likert scale with a numerical scale, like the one the author used in the investigation can potentially increase the reliability of the results. Cronbach's Alpha was used to determine the reliability of the eight questions using the Likert scale. A reliability value of 0.652 (see Table 3.3) showed that the questions used were quite reliable.

Table 3.3: Cronbach's Alpha Reliability Test

Reliability Statistics

Cronbach's Alpha	N of Items
.652	8

The questionnaire was also piloted before use in the investigation which also added to the reliability of the investigation.

3.6.3 Ethical Issues:

Before the beginning of the investigation ethical approval was given by the University of Limerick Research Ethics committee. Ethics were approved based on the author following particular conditions as were laid out in the ethics application form. These included:

- Providing participants with a participant information sheet (Appendix B) which included what the purpose of the investigation was, what their participation involved and how they would benefit from the investigation.
- Providing participants with a participant consent form (Appendix C), which confirmed they were willing to participate in the study.
- Confidentiality of the participants was guaranteed by not asking for names or student numbers of the participants and by only allowing the investigators access to the data.

3.7 Limitations of the study:

- In the investigation only students who were using or who had used the mathematics learning centre were surveyed. However Lawson et al 2001 (cited in Sigma 2009) suggests that "this is biased to those who already value the centre". Several studies (Lawson et al 2001; Parkinson 2009; Mac An Bhaird et al 2009) have included an evaluation of the ability of the mathematics learning centre to attract students who need help into the centre in their

investigation of whether a mathematics learning centre is effective or not. So perhaps including a sample of students who were not availing of the centre would have dealt with this issue.

- The questionnaires used in this investigation were distributed by the staff of the mathematics learning centre. This might have led to students being more conservative with any negative comments which they may have wished to make. It might have been more suitable to have distributed the questionnaires externally to the mathematics learning centre. However the fact that the questionnaires were confidential and did not require students' name or student number may have alleviated this issue.

3.8 Conclusion:

In this chapter the author outlined the methodologies used in this investigation. The method of enquiry chosen proved successful in answering the research questions posed by the author. The investigation evaluated the effectiveness of the mathematics learning centre and the results correlate with findings of previous studies, which used alternative methods of evaluation such as student retention or student grades (Gill and O'Donoghue, 2007). The results of this investigation will be outlined in the following chapter.

Chapter 4

Results

4.1 Introduction:

In this chapter, both the qualitative and quantitative results obtained of this investigation will be outlined. It will be divided into two sections. Section 1 will look at the qualitative data obtained from the questionnaires (i.e. Section C – The Mathematics Learning Centre), which were analysed using Nvivo 9. These were personal responses from the students on the impact of the mathematics learning centre on their mathematical experience. Section 2 will look at the quantitative data obtained from the questionnaires (i.e. Section B – Attitudes towards Mathematics), which were analysed using PASW 18. These questions looked at the attitudes of the students towards mathematics and were measured on a Likert scale.

4.2 Section 1 - Qualitative Data:

4.2.1 Introduction:

This section details the results obtained from the qualitative data in the questionnaires. In this section students were asked to give their views on the impact of the mathematics learning centre on various aspects of their mathematical experiences. Nvivo 9 was used in the analysis of this data. The data was entered into Nvivo 9 and several common themes were realised. These themes then became the nodes for examining the data in the programme. Each response given by the students was then coded under these nodes. The themes realised were:

- Teaching Strategies
- Extra Help
- Greater Understanding
- Overcome Student Attitude
- Staff Attitude

The percentage coverage for each of these themes can be seen in Figure 4.1. Each of these themes will be examined in greater detail now.

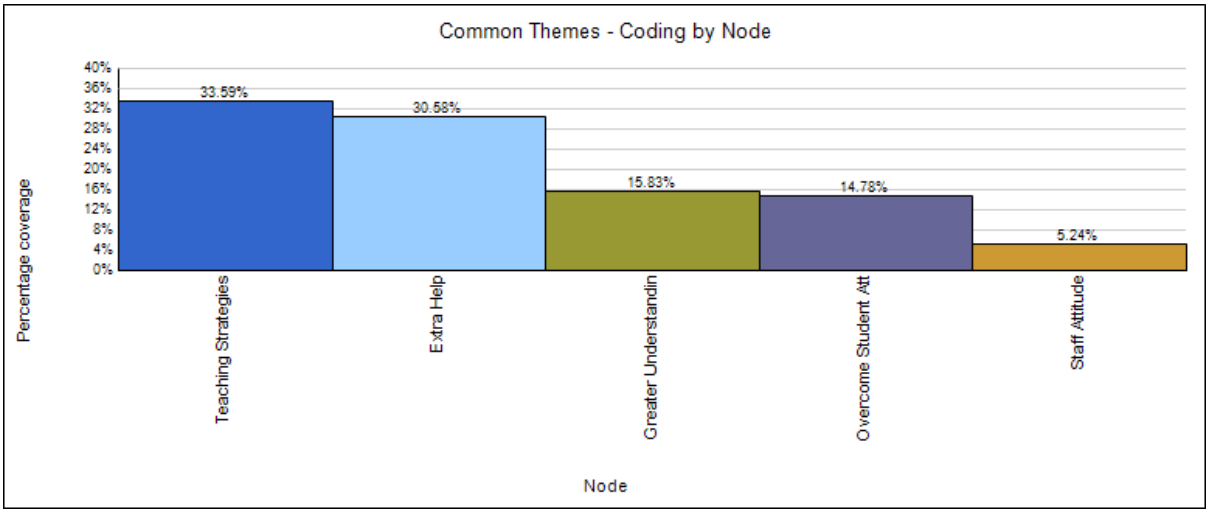

Figure 4.1: Percentage Coverage of the Common Themes

4.2.2 Teaching Strategies:

The most common theme which emerged from the qualitative data was: teaching strategies. Just over one third of the students' comments made reference to the teaching styles adopted in the mathematics learning centre.

"They explain it step by step" (97, Male)
"As everything is explained well, therefore I know how to do it in the future" (122, Male)
"Easy to understand explanations" (44, Female)

Very often the students compared the teaching styles used in the mathematics learning centre with the teaching styles used by the lecturers of their modules. They preferred the teaching style used by the tutors in the mathematics learning centre. One student likened the teaching style used in the mathematics learning centre to the teaching style he was used to from his post-primary education.

"Explains things more clearly than lecturers" (51, Male)
"They are better at explaining how to do it than the lecturers" (25, Female)
"MLC teaches in a way I'm used to from L.C., whereas lectures differ greatly" (30, Male)

The pace of instruction was also mentioned by numerous students. They favoured the slower pace adopted by the staff of the mathematics learning centre. Again comparisons were drawn with the approach adopted by lecturers. Yet again the approach of the tutors in the mathematics learning centre was favoured.

> *"They go through the problems slowly, making it easier" (7, Male)*
> *"The review week went a lot slower and did the maths step by step. I found it easier than the lectures" (5, Male)*

All the comments which made reference to the teaching style of the tutors in the mathematics learning centre were positive. There were no negative comments received in relation to this theme.

4.2.3 Extra Help:

Lawson et al (2001) defined the 'Extra help' category as *"responses which related to the availability of any support in addition to the normal teaching programme"*. The student responses showed that the extra help available was highly valued by the students surveyed. Reference was made to a broad range of the facilities provided not just one particular aspect of the 'extra help' the mathematics learning centre provided.

> *"They were helpful when I had a repeat" (33, Female)*
> *"Support Tutorials are a good facility" (34, Male)*
> *"The head-start I was excellent in Aug '09 and Jan '10" (18, Male)*
> *"Very useful to drop in with specific questions" (50, Male)*

However the one to one aspect of the mathematics learning centre was made reference to more frequently than the other forms of support. Students appreciated that they could drop in with a particular question and receive help.

> *"I can attempt the questions with the 'safety net' of the tutors here and if I 'hit a brick wall' they explain it and I can understand it" (110, Female)*
> *"It helps to know there is somewhere to go when you're stuck" (58, Male)*
> *"I feel now if I don't understand the lecturers, not to panic and get help from MLC" (59, Male)*

Several students who admitted to having considered dropping out of college because of difficulties with mathematics cited the mathematics learning centre as an important factor in their decision to stay. Consequently the 'extra help' provided can be seen to be having an impact on student retention in the university.

"Without this support there is no way there is no way I could have gone on" (109, Female)
"Yes the MLC made a huge difference. The support tutorials are the only reason I got a good grade in it" (58, Male)
"If it hadn't been for the help of the MLC I definitely would have failed it" (59, Male)

Negative comments relating to the extra help available generally referred to students not using it enough or if it was not available perhaps they would feel differently.

"I don't go there enough for it to influence me" (78, Male)
"No but knowing the MLC is there gives me peace of mind" (68, Female)

4.2.4 Greater Understanding:

On numerous occasions (15.83%) students mentioned in their responses that the mathematics learning centre was having a positive impact because it helped them to gain a greater understanding of mathematics.

"I can understand it better" (18, Male)
"It made me understand it better" (35, Male)
"Now I am understanding (the) *concepts better" (46, Male)*
"Yes – because now I can understand the maths a bit better I am able to attempt the questions" (110, Female)

Once again some students compared this to the understanding which they felt they were getting from their lectures. They commented that the tutors in the mathematics learning centre gave them greater understanding than the lecturers.

"The MLC has help(ed) *me fully understand the maths far better than lectures" (47, Male)*

Several students when asked if the mathematics learning centre had changed their opinion of mathematics said that their opinion of mathematics had been changed by the greater understanding afforded to them by the staff of the mathematics learning centre.

"I can understand it better" (18, Male)
"Better understanding" (23, Female)

4.2.5 Overcome Student Attitude

One of the research questions that this investigation sought to answer was: Does the mathematics learning centre impact on students' attitude towards mathematics. All of the respondents' comments relating to improved student attitude were extremely positive. 14.78% mentioned that the mathematics learning centre did have a positive effect on their attitude. Many students felt more confident in dealing with mathematics.

"Extra help made me more confident" (56, Female)
"Gained confidence and being encouraged" (82, Female)
"I feel more confident about Math" (92, Male)

Other students felt less anxious about their mathematics modules because of the service provided by the mathematics learning centre.

"Not as nervous about not understanding things in lectures" (95, Female)
"I was nervous because it is a long time since I studied, they have helped me catch up" (110, Female)

Many students said that they now found mathematics easier, more useful or more interesting since they started using the mathematics learning centre services.

"I am more interested in maths now, therefore I want to study it more" (48, Female)
"I find maths more useful" (91, Male)
"Makes it seem easier" (94, Male)

Even the students who felt that their opinion of mathematics had not changed said that they felt mathematics was an interesting and useful subject.

"It is interesting but it's still a difficult subject that requires a lot of work" (45, Male)
"I'm still not a big fan of it but I know it's important." (58, Male)

4.2.6 Staff Attitude:

Given that one of the aims of the mathematics learning centre is to provide support in a *"relaxed environment"* (Mathematics Learning Centre, 2010) the attitude of the staff is a very important issue. 5.24% of the students' comments made reference to the attitude of the staff. All of these comments were positive.

"Yes you can ask any question even if you feel it is stupid" (107, Female)
"Yes teaching support is exceptional" (109, Female)
"I think the MLC is excellent, the staff are so talented and nice" (121, Female)

Interestingly all the comments relating to staff attitude were made by female students.

4.2.7 Conclusion:

As it can be seen the majority of the qualitative data collected was positive. It is clear that the students value the services that the mathematics learning centre provides. However as stated in the methodology, one limitation of the investigation was that it only examined the views of the students who were already using the mathematics learning centre so perhaps this should be taken into consideration. In the next section the results of the quantitative data will be outlined and it will be seen that these provide a similar outlook on the value students place on the mathematics learning centre services.

4.3 Section 2 – Qualitative Data

4.3.1 Introduction:

In this section the author looks at the quantitative results from the questionnaires. These were analysed using PASW 18, a statistics program. The data from the questionnaires was inputted into the program. This was then used to create graphs, histograms and pie charts to display the results. In part 1 of this section the results from the eight questions taken from the IMAES questionnaire (i.e. Section B of the questionnaire) measured on the Likert scale will be outlined. These look at the attitudes of the students towards mathematics. For ease of data analysis the students' responses were coded as following:

1 = never or almost never true for me (disagree totally)

2 = sometimes true for me (disagree somewhat)

3 = true about half the time (unsure)

4 = mostly true for me (agree somewhat)

5 = completely true for me (agree totally)

In the second part of this section the results from Section C of the questionnaire, specifically the effect of the mathematics learning centre on student education and attitude will be outlined. These will look at the effect of the mathematics learning centre on student retention, student confidence, students' opinion of mathematics and students' study habits.

4.3.2 Part 1 – Attitudes towards Mathematics:

In this part the responses given to the eight statements on students' attitudes to mathematics are graphically represented. Accompanying each graph is a breakdown of the percentages of students who chose each response. The responses to each of these statements form either a normal distribution curve or a bimodal distribution curve. If it is a normal distribution curve the mean is given as the most accurate calculation of the average. If it is a bimodal curve the median is given as the most accurate calculation of the average.

4.3.2.1 Mathematics was my favourite subject at school:

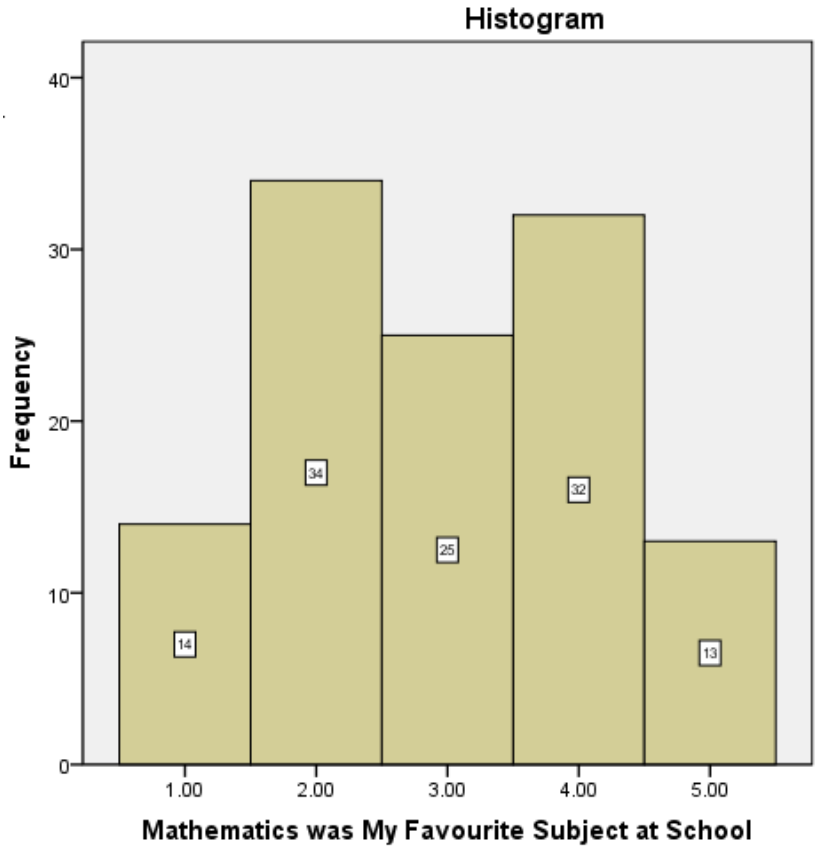

Figure 4.2: Graphical representation of students' responses to the statement 'Mathematics was my favourite subject at school'

The responses to the statement 'Mathematics was my favourite subject at school' can be summarised as the following:

The response chosen by the highest percentage of students was Disagree Somewhat (28.81% - 34 out of 118). However this was closely followed by the 27.12% (32 out of 118) who chose Agree Somewhat. There were also similar scores for Disagree Totally and Agree Totally, 11.86% (14 out of 118) and 11.02% (13 out of 118). The remaining 21.19% (25 out of 118) were unsure. The similar percentages for both positive and negative responses meant that the average (median) response was 3.

4.3.2.2 At school I was afraid to ask questions in a Mathematics class:

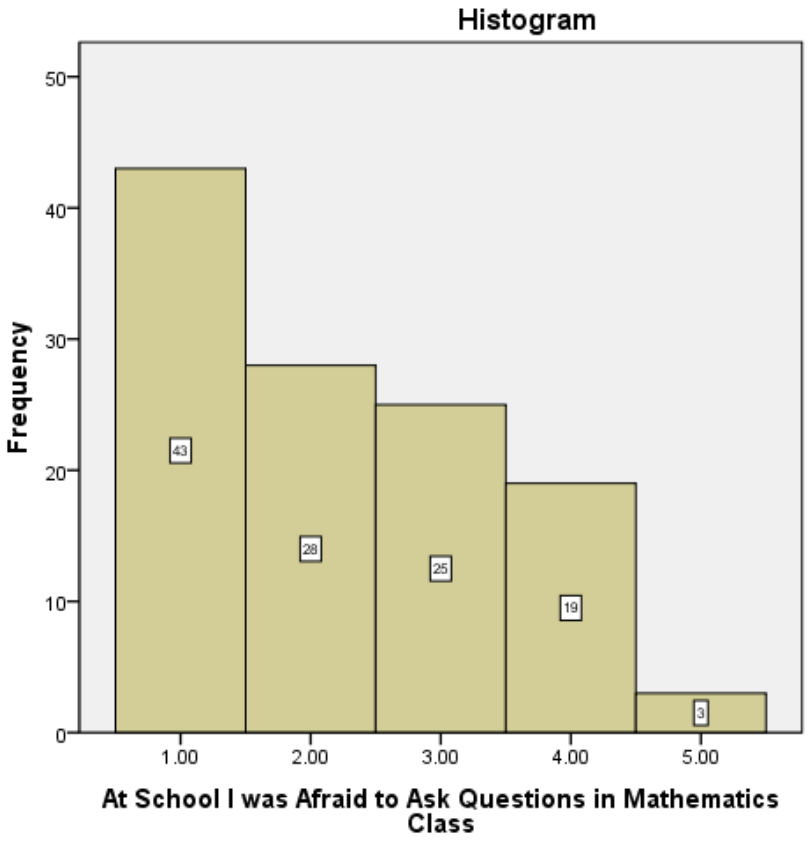

Figure 4.3: Graphical representation of students' responses to the statement 'At school, I was afraid to ask questions in a Mathematics class'

The responses to the statement 'At school, I was afraid to ask questions in a Mathematics class' can be summarised as the following:

A considerably higher percentage disagreed with this statement (Disagree Totally: 36.44% - 43 out of 118 and Disagree Somewhat: 23.73% - 28 out of 118) than agreed (Agree Somewhat: 16.10% - 19 out of 118 and Agree Totally: 2.54% - 3 out of 118). 21.19% (25 out of 118) remained neutral. This meant that the average (mean) for the group was 2.25.

4.3.2.3 I used to feel confident when I was in mathematics classes at school:

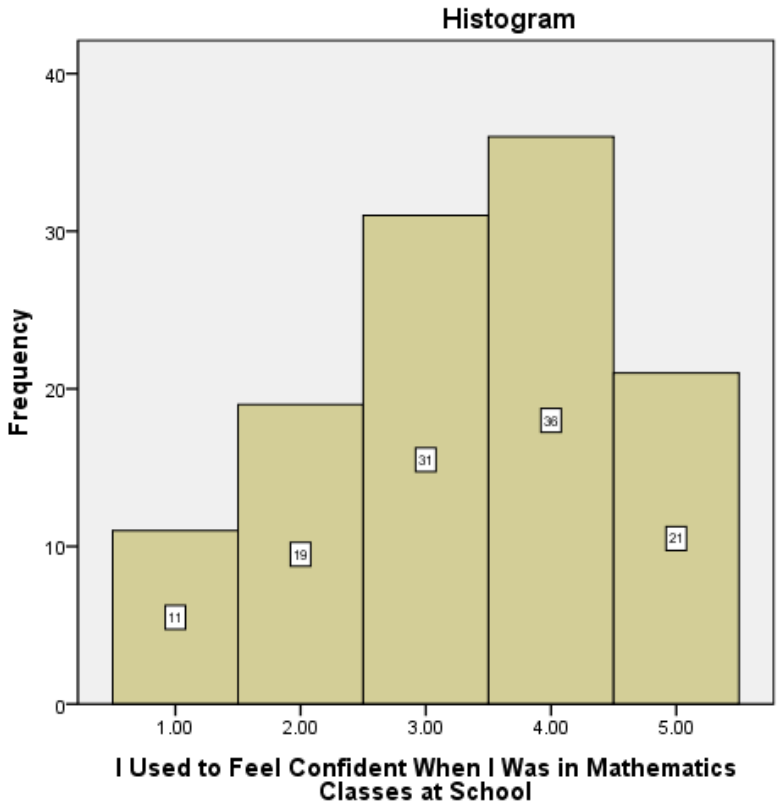

Figure 4.4: Graphical representation of students' responses to the statement 'I used to feel confident when I was in mathematics classes at school'

The responses to the statement 'I used to feel confident when I was in mathematics classes at school' can be summarised as the following:

The greatest percentage of respondents agreed somewhat with this statement (30.51% - 36 out of 118). There was also a high representation who agreed totally (17.80% - 21 out of 118). Smaller percentages, but still a sizeable sample said they disagreed with the statement (Disagree Totally: 9.32% - 11 out of 118 and Disagree Somewhat: 16.10% - 19 out of 118). A high percentage of respondents were unsure: 26.27% -31 out of 118. This led to an average (mean) of 3.31.

4.3.2.4 Mathematics is so difficult that only those who are gifted can understand:

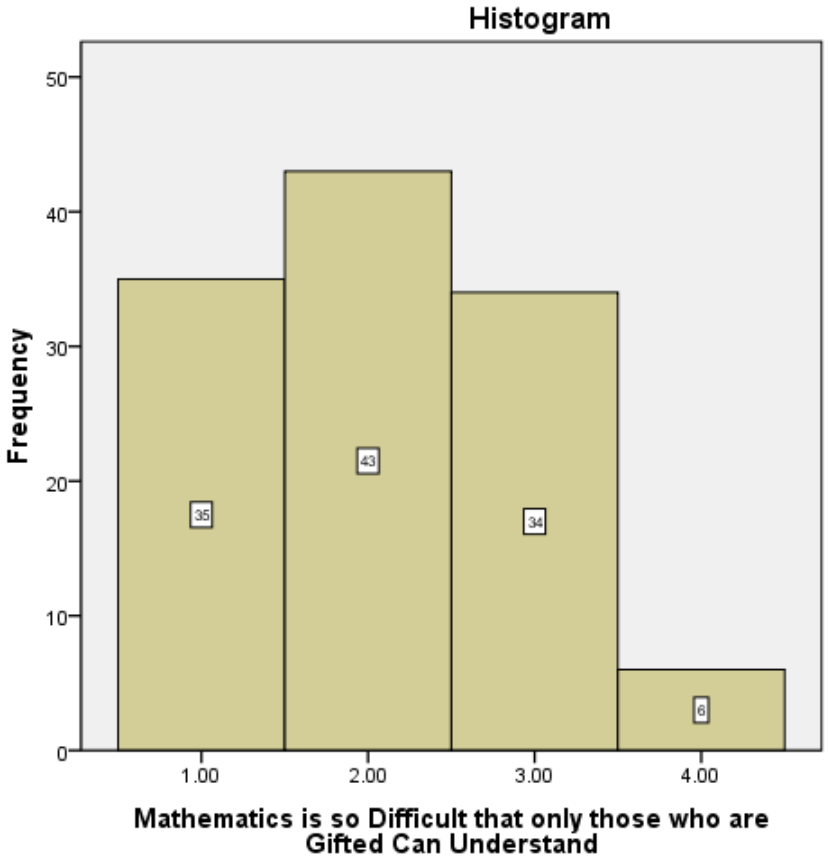

Figure 4.5: Graphical representation of students' responses to the statement 'Mathematics is so difficult that only those who are gifted can understand'

The responses to the statement 'Mathematics is so difficult that only those who are gifted can understand'' can be summarised as the following:

The vast majority of respondents disagreed with this statement (Disagree Totally: 29.66% - 35 out of 118 and Disagree Somewhat: 36.44% - 43 out of 118). Again many were unsure: 28.81% (34 out of 118). Very few agreed with 5.08% (6 out of 118) Agreeing Somewhat and 0% Agreeing Totally. This gave a low average (mean) of 2.09.

4.3.2.5 I'm afraid I won't be able to keep up with the rest of the class in Mathematics:

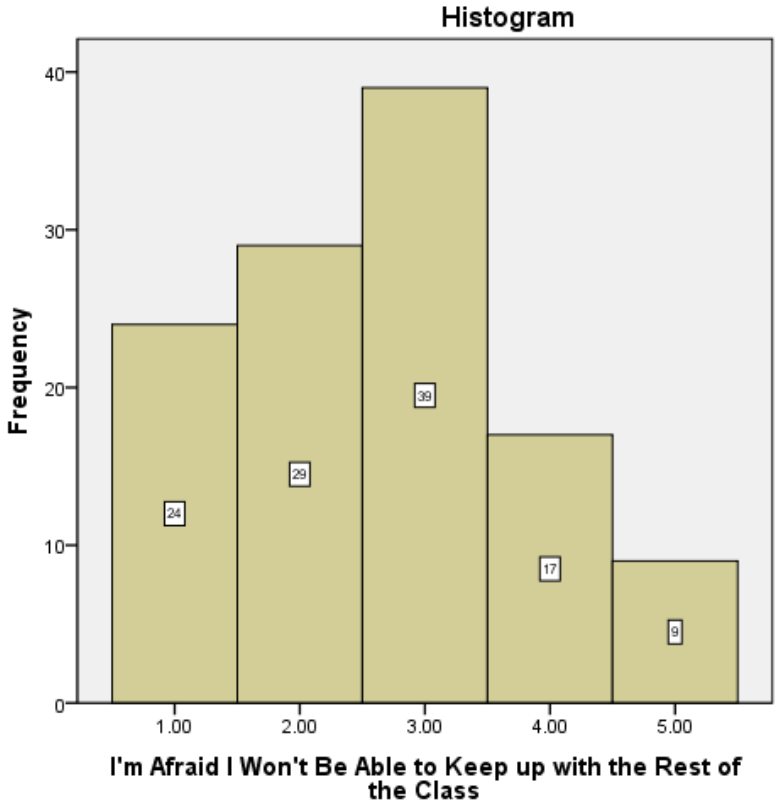

Figure 4.6: Graphical representation of students' responses to the statement 'I'm afraid I won't be able to keep up with the rest of the class in mathematics'

The responses to the statement 'I'm afraid I won't be able to keep up with the rest of the class in mathematics' can be summarised as the following:

This statement was another which met with a lot of disagreement with 20.34% (24 out of 118) disagreeing totally and 24.57% (29 out of 118) disagreeing somewhat. A high percentage 33.05% (39 out of 118) were not sure and a small percentage, in comparison with those above, agreed (Agree Somewhat: 14.41% - 17 out of 118 and Agree Totally: 7.63% - 9 out of 118).again the average (mean) was low - 2.66.

4.3.2.6 A good Mathematics training is a big advantage in entering any line of work:

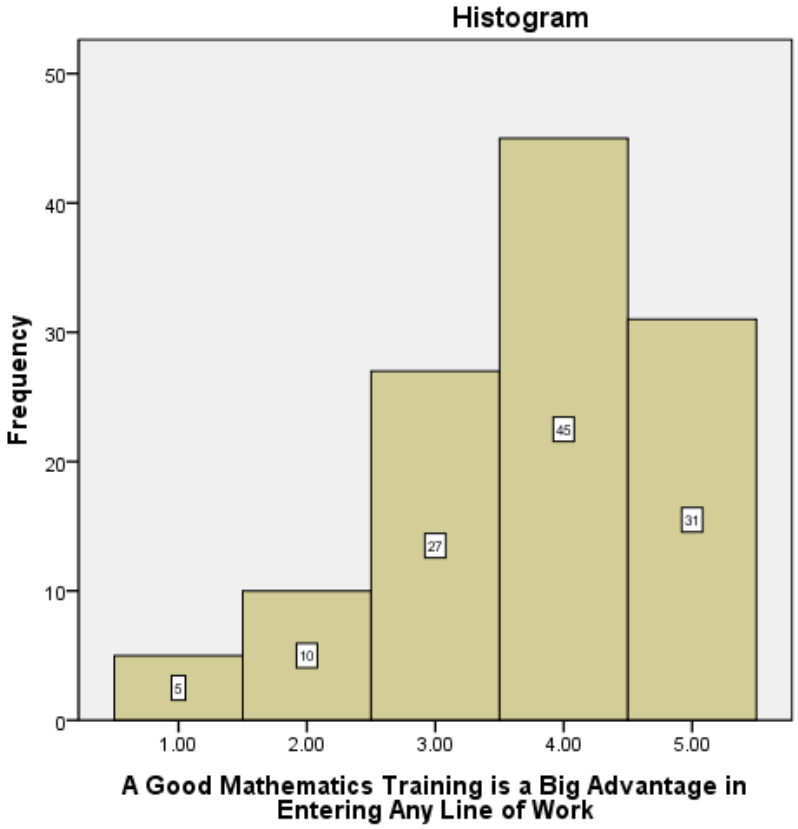

Figure 4.7: Graphical representation of students' responses to the statement 'A good mathematics training is a big advantage in entering any line of work'

The responses to the statement 'A good mathematics training is a big advantage in entering any line of work' can be summarised as the following:

This statement was met with responses completely opposite to those for the preceding statement. The majority of respondents agreed with the statement (Agree Somewhat: 38.14% - 45 out of 118 and Agree Totally: 26.27% - 31 out of 118). Similar to the responses in most of the statements many chose Unsure (22.88% -27 out of 118). Very few disagreed totally (4.24% -5 out of 118) or disagreed somewhat (8.47% - 10 out of 118).This meant the average (mean) was quite high: 3.74.

4.3.2.7 I understand Mathematics now, but I worry that it's going to get really difficult soon:

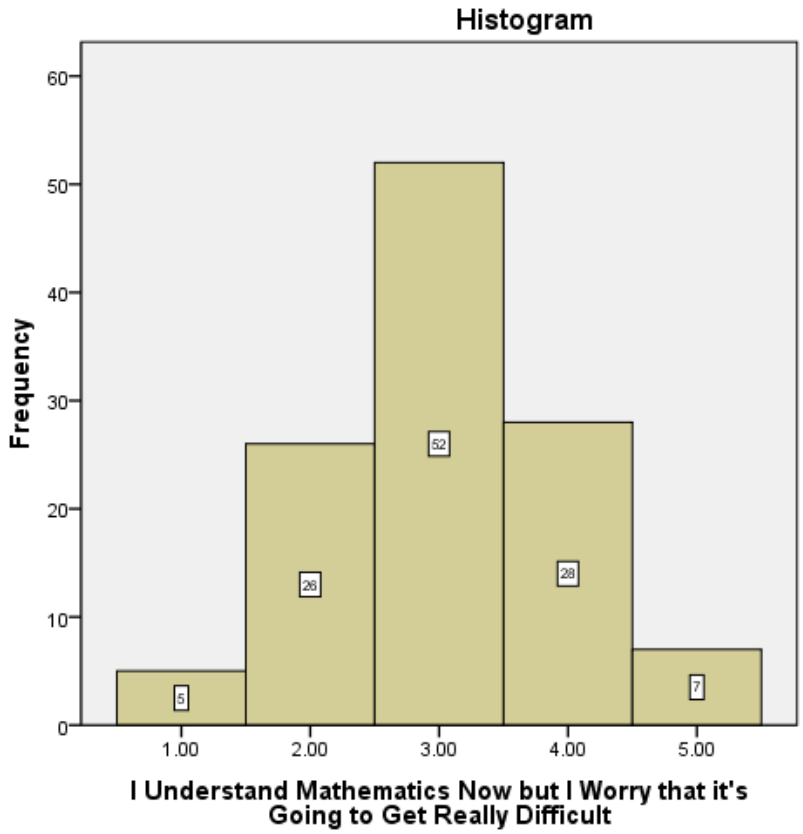

Figure 4.8: Graphical representation of students' responses to the statement 'I understand mathematics now, but I worry that it's going to get really difficult soon'

The responses to the statement 'I understand mathematics now, but I worry that it's going to get really difficult soon' can be summarised as the following:

Nearly half of the surveyed population were unsure (44.07% - 52 out of 118).Approximately the same percentage agreed (Agree Somewhat: 23.73% - 28 out of 118 and Agree Totally: 5.93% - 7 out of 118) and disagreed (Disagree Totally: 4.24% - 5 out of 118 and Disagree Somewhat: 22.03% - 26 out of 118).This left the average (mean) at 3.05 very close to 3 (the exact middle).

4.3.2.8 I know how to study for a Mathematics test:

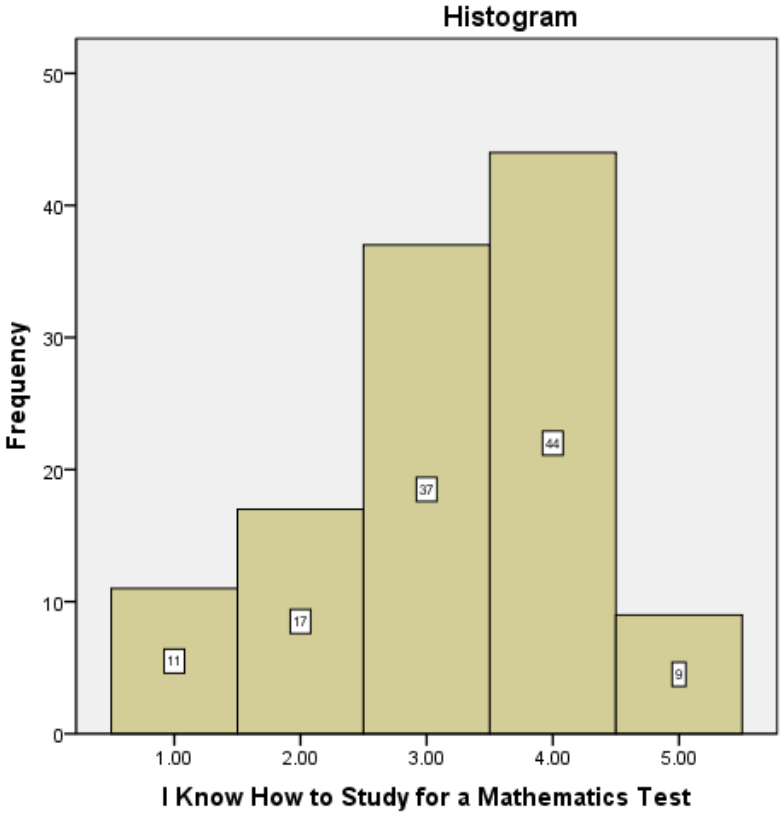

Figure 4.9: Graphical representation of students' responses to the statement 'I know how to study for a mathematics test'

The responses to the statement 'I know how to study for a mathematics test' can be summarised as the following:

Students' responses showed that the majority felt they knew how to study for a test (Agree Somewhat: 37.29% - 44 out of 118 and Agree Totally: 7.63% - 9 out of 118). As was the trend in most of the graphs many were unsure (31.35% - 37 out of 118). The remaining disagreed with the statement (Disagree Totally: 9.32% - 11 out of 118 and Disagree Somewhat: 14.41% - 17 out of 118). Again the average (mean) of 3.19 was very close to the central point 3.

4.3.2.9 Differences in Attitudes by Category:

The results to the eight statements, outlined above, were cross referenced against various groups to see were the findings similar for all groups who were surveyed. Although no difference was seen between the various year groups, degree programmes and Leaving Certificate mathematics grades, differences were observed in some of the results for different gender groups, student type and Leaving Certificate mathematics level. Nonparametric tests were carried out using PASW 18 to see if these differences were significant (i.e. <0.05 on the nonparametric test). The results which were found to be significantly different can be seen in Table 4.1.

Table 4.1: Nonparametric Tests: Comparing medians across groups.

Hypothesis Test Summary

Null Hypothesis	Test	Sig.	Decision
The medians of Mathematics was My Favourite Subject at School are the same across categories of Gender.	Independent-Samples Median Test	.011	Reject the null hypothesis.
The medians of At School I was Afraid to Ask Questions in Mathematics Class are the same across categories of Are You Registered as a Mature Student.	Independent-Samples Median Test	.023	Reject the null hypothesis.
The medians of I Know How to Study for a Mathematics Test are the same across categories of Are You Registered as a Mature Student.	Independent-Samples Median Test	.005	Reject the null hypothesis.
The medians of Mathematics was My Favourite Subject at School are the same across categories of Leaving Certificate Mathematics Level.	Independent-Samples Median Test	.024	Reject the null hypothesis.

In the nonparametric tests above a null hypothesis stating that the frequency distribution of responses to the statement mentioned are the same across the category mentioned. For example in

the first null hypothesis it is assumed that the responses to the statement 'Mathematics was my favourite subject at school' were the same for both males and female. However the resultant value of 0.011 is < 0.05 which shows that this assumption is false and that there are significant differences in the responses given by males and females. These differences and the differences observed in the subsequent three null hypotheses can be clearly seen in the following histograms (Figures 4.10 - 4.13) and in the analysis of the medians across all groups.

4.3.2.9.1 Gender and Attitudes toward Mathematics:

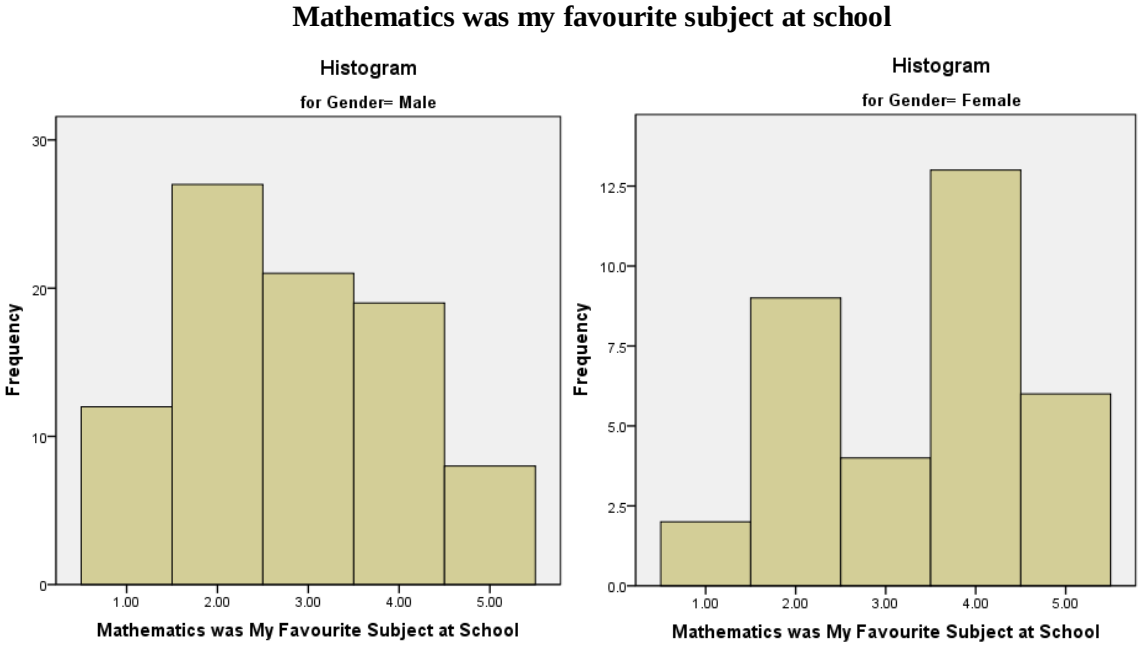

Figure 4.10: Graphical representation of students' responses to the statement 'Mathematics was my favourite subject at school' by Gender.

Firstly in the case of gender there was a significant difference between males and females in their response to the statement 'Mathematics was my favourite subject at school'. From examining the histograms for each gender we can see that more females favoured mathematics at school than males. The mean response for females was 3.35, considerably higher than that of males, 2.82.

4.3.2.9.2 Student Type and Attitudes towards Mathematics:

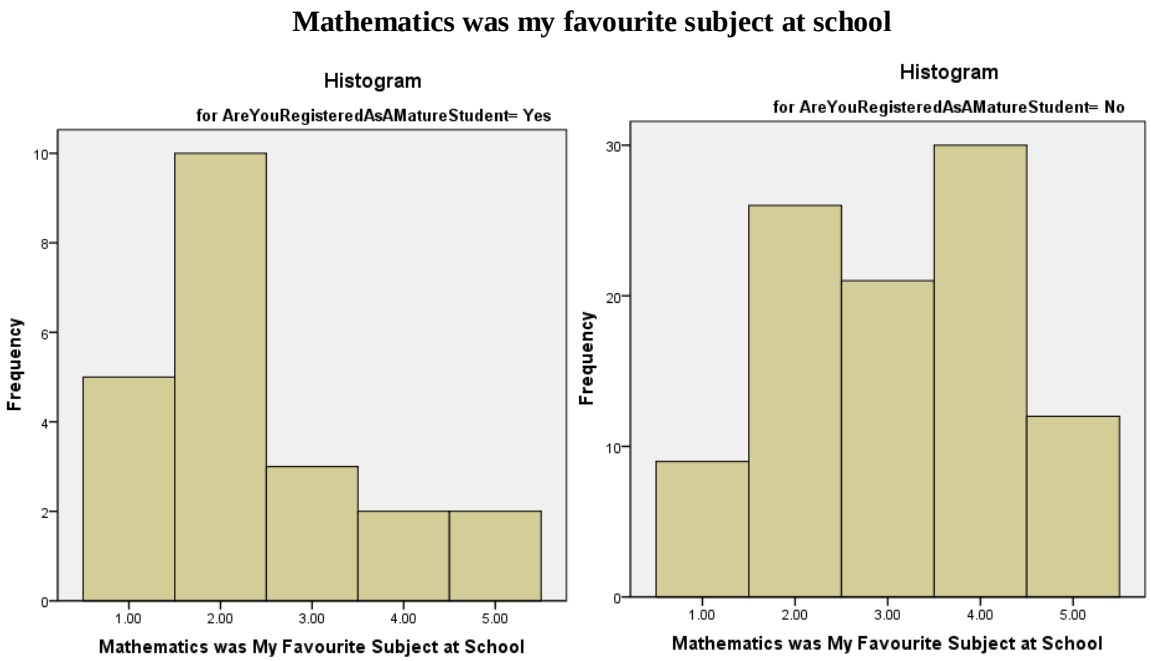

Figure 4.11: Graphical representation of students' responses to the statement 'Mathematics was my favourite subject at school' by Student Type.

Differences in attitude were also seen in the category of student type (i.e. whether the student was a mature or a traditional student). Traditional students favoured mathematics in school more than mature students. The mean response for traditional student was 3.10. The mature students responses were more negative with a mean of 2.36.

At school I was afraid to ask questions in mathematics class

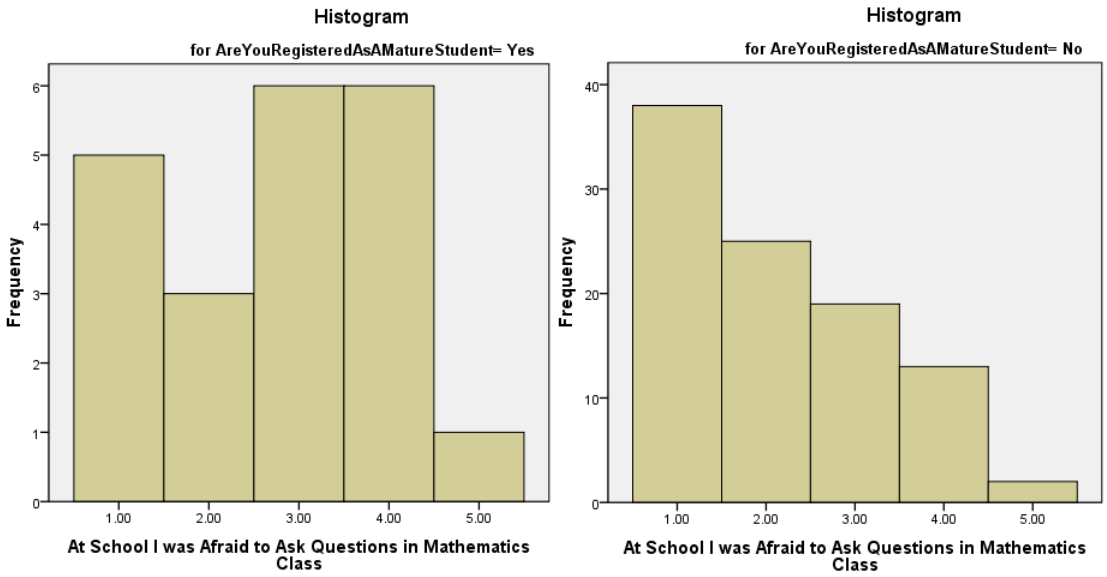

Figure 4.12: Graphical representation of students' responses to the statement 'At school I was afraid to answer questions in mathematics class' by Student Type.

Similarly there were differences in the statement 'At school I was afraid to ask questions in mathematics class' when examined across the category student type. Again the traditional students gave a more positive response. The mean for this group was 2.13 whereas for mature students the it was 2.76.

4.3.2.9.3 Mathematics Leaving Certificate Level and Attitudes toward Mathematics

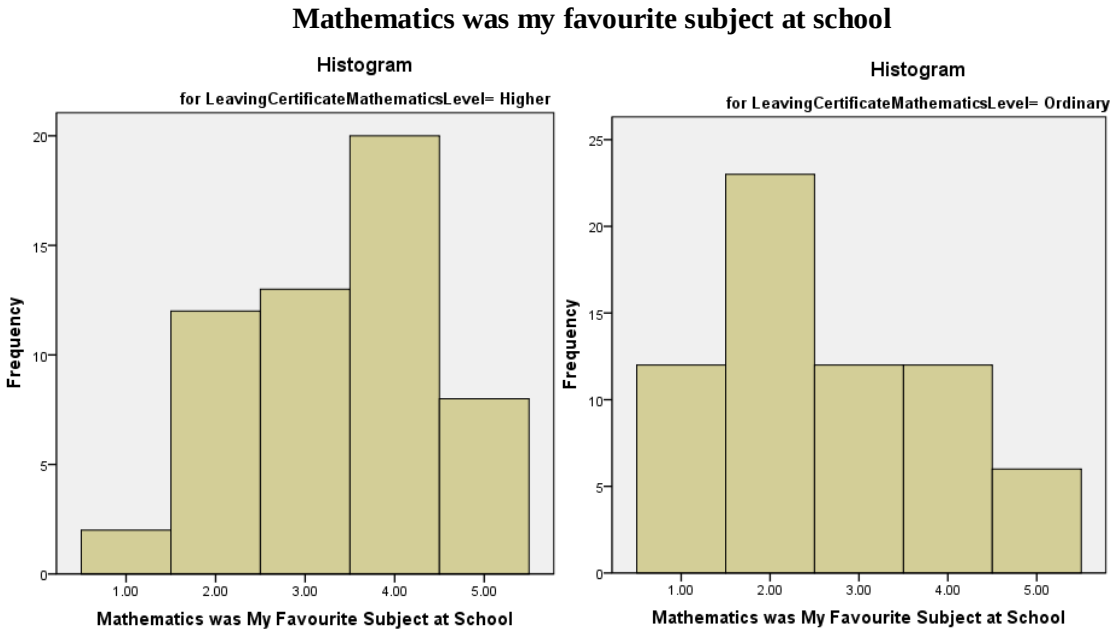

Figure 4.13: Graphical representation of students' responses to the statement 'Mathematics was my favourite subject at school' by Leaving Certificate Level.

Students with different Leaving Certificate Mathematics Levels showed to have significant differences in their response to the statement: 'Mathematics was my favourite subject at school'. The mean for the students who had studied Higher Level mathematics was 3.36. In the case of those students who did Ordinary Level mathematics the mean was only 2.65.

4.3.3 Part 2 - Effects of the Mathematics Learning Centre:

In this Section of the questionnaire students were asked various questions relating to their mathematics education, attitudes towards mathematics and how the mathematics learning centre affected them. Students' responses to each of these questions will be represented by pie charts. In each of the pie charts blue represents the percentage of students who answered yes and green represents the students who answered no. The pie charts are further labelled with the percentage of the student sample that chose that particular answer. Finally some interesting differences were noted when the questions were further examined for each particular group. These differences are illustrated by Figures 4.19 and 4.20.

4.3.3.1 Have you ever considered dropping out of college because of difficulties with Mathematics?

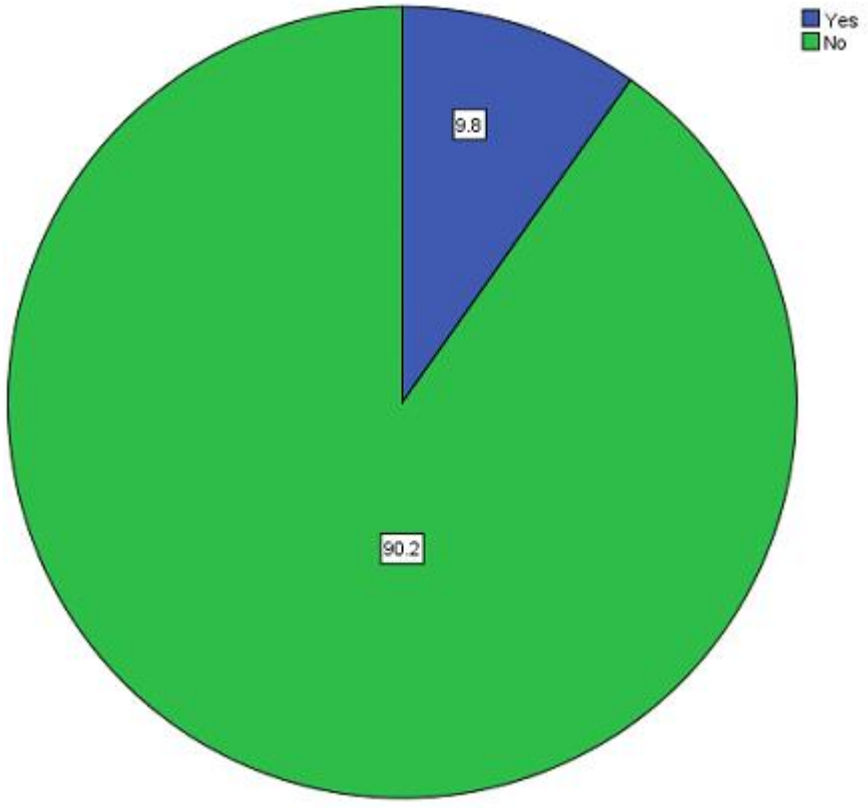

Figure 4.14: Graphical representation of students' responses to the question: Have you ever considered dropping out of college because of difficulties with Mathematics?

Figure 4.14 represents the percentage of students who responded Yes/No to the question: Have you ever considered dropping out of college because of difficulties with Mathematics? 90.2% of students have never considered dropping out because of difficulties with mathematics and 9.8% of students have considered dropping out because of mathematics. The majority of students have not considered dropping out because of mathematics.

4.3.3.2 If you answered yes to Q9, has the MLC influenced your decision to remain in U.L.?

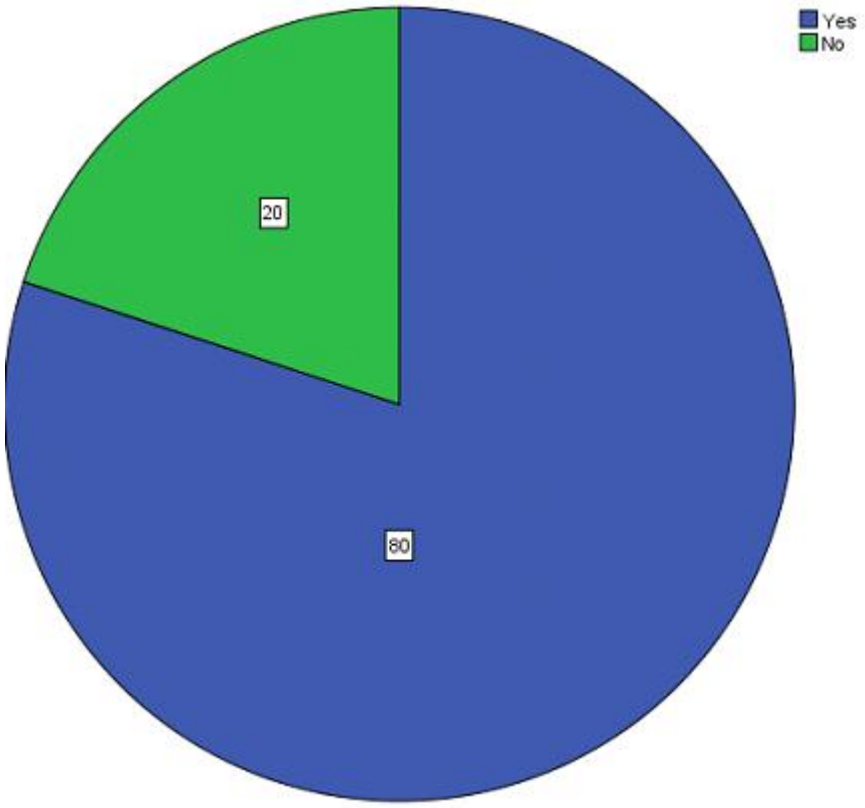

Figure 4.15: Graphical representation of students' responses to the question: If you answered yes to Q9, has the MLC influenced your decision to remain in U.L.?

The students who had considered dropping out of college were further asked as to whether the mathematics learning centre had influenced their decision to remain in U.L. Of those students who had considered dropping out 80% of them (8 out of 10) said that the mathematics learning centre had influenced their decision to stay. The other 20% said that the mathematics learning centre had no bearing on their decision to stay. Therefore it can be said that the mathematics learning centre was responsible for the retention of 6.45% of the total sample surveyed.

4.3.3.3 Has the MLC helped you feel more confident about your ability in Mathematics?

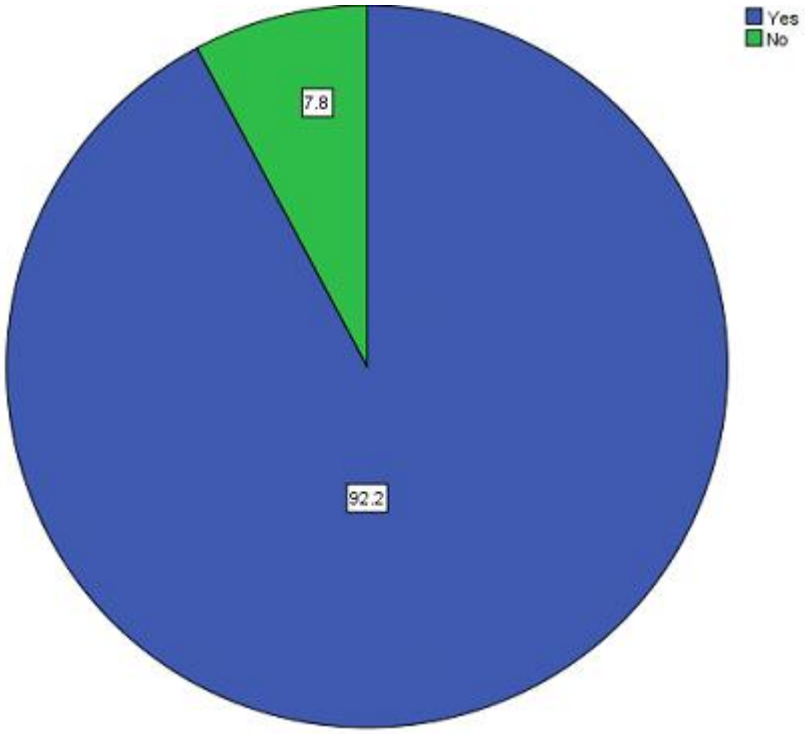

Figure 4.16: Graphical representation of students' responses to the question: Has the MLC helped you feel more confident about your ability in Mathematics?

The students were then asked: Has the MLC helped you feel more confident about your ability in Mathematics? 92.2% of those surveyed said that the mathematics learning centre had made them feel more confident about their mathematics ability, while 7.8% said that the mathematics learning centre had not improved their confidence. From these statistics it can be seen that the mathematics learning centre was having a major impact on students' mathematics confidence in the university.

4.3.3.4 Has the MLC changed your opinion of Mathematics since you started using its services?

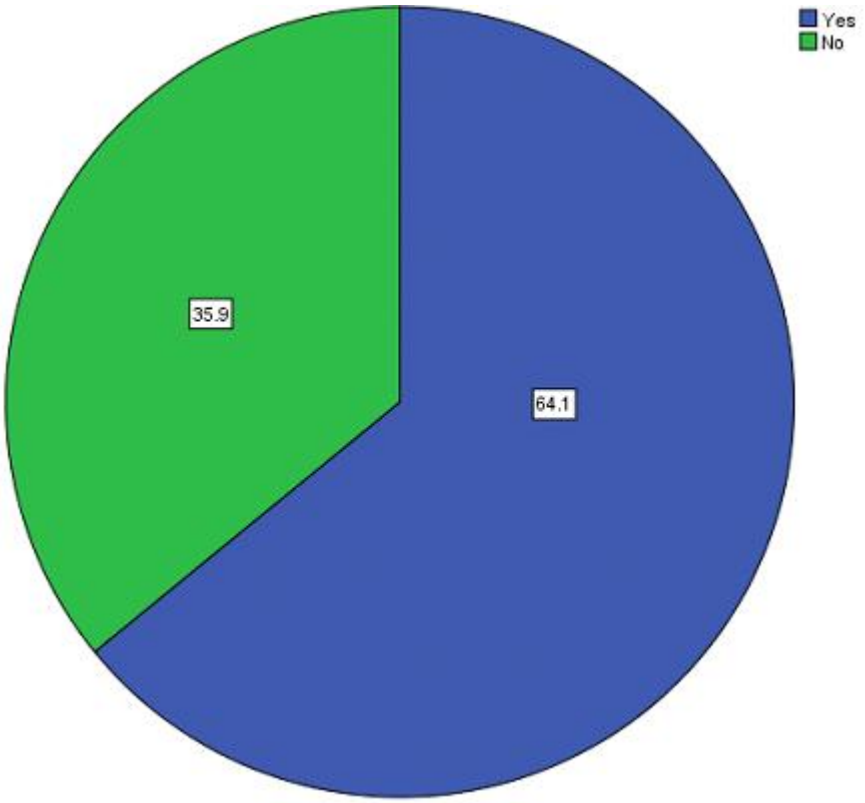

Figure 4.17: Graphical representation of students' responses to the question: Has the MLC changed your opinion of Mathematics since you started using its services?

This pie chart illustrates the response of the students to the question: Has the MLC changed your opinion of Mathematics since you started using its services? 64.1% of respondents said that the mathematics learning centre had changed their opinion of mathematics, the remaining 35.9% said that the mathematics learning centre had not changed their opinion of mathematics. Again this shows that, for the majority, the mathematics learning centre was having a beneficial effect on students' attitudes towards mathematics.

4.3.3.5 Has the Mathematics Learning Centre changed your study habits?

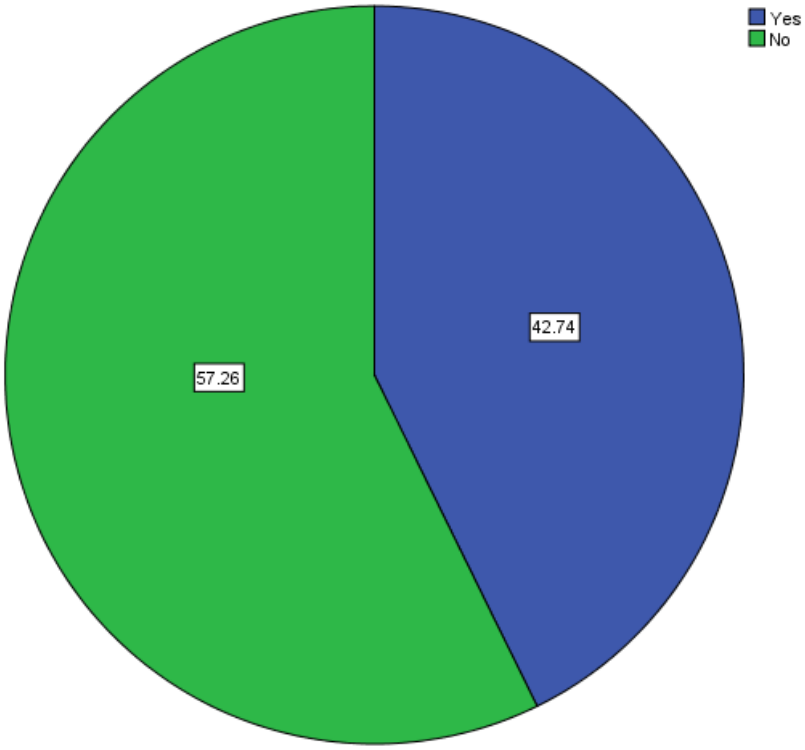

Figure 4.18: Graphical representation of students' responses to the question: Has the Mathematics Learning Centre changed your study habits?

The responses to the question: Has the Mathematics Learning Centre changed your study habits? can be seen in the pie chart above. 42.74% of respondents said that the mathematics learning centre had changed their study habits, while 57.26% said that their study habits had not changed. Although the majority of those surveyed said their study habits had not changed, a large number (50 out of 117 respondents) had changed their study habits because of the influence of the mathematics learning centre.

4.3.3.6 Differences between Categories:

These results were cross referenced against various groups to see were the findings similar for all groups who were surveyed. Although no differences were seen between the various year groups, Leaving Certificate mathematics grades, gender and Leaving Certificate mathematics level differences were observed in some of the results across the category student type. Pearson Chi-Square tests were carried out using PASW 18 to see if these differences were significant (i.e. a

Pearson Chi-Square value <0.05). The results which were found to be significantly different can be seen in Tables 4.2 and 4.3.

Table 4.2: Chi-Square Test for: Are You Registered as a Mature Student * Have You Ever Considered Dropping out Because of Difficulties with Mathematics Cross tabulation

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.442	1	.035		
Continuity Correction	2.959	1	.085		
Likelihood Ratio	3.710	1	.054		
Fisher's Exact Test				.050	.050
Linear-by-Linear Association	4.406	1	.036		
N of Valid Cases	121				

The Pearson Chi-Square in Table 4.2 tested a null hypothesis stating that the frequency distribution of students who said yes, they had considered dropping out of college because of difficulties with mathematics was the same for both the traditional and mature students surveyed. However the resulting Pearson Chi-Square value of 0.035 is < 0.05 which provides justification to reject the null hypothesis (i.e. shows that there were significant differences in the answers given by traditional students when compared with those given by mature students).

Table 4.3: Chi-Square Test for: Are You Registered as a Mature Student * Has the Mathematics Learning Centre Changed Your Study Habits Cross tabulation

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.953	1	.003		
Continuity Correction	7.552	1	.006		
Likelihood Ratio	8.961	1	.003		
Fisher's Exact Test				.004	.003
Linear-by-Linear Association	8.876	1	.003		
N of Valid Cases	116				

The Pearson Chi-Square in Table 4.3 tested a null hypothesis stating that the frequency distribution of students who said that the mathematics learning centre had changed their study habits was the same for both the traditional and mature students surveyed. However the resulting Pearson Chi-Square value of 0.003 is < 0.05 which provides justification to reject the null hypothesis (i.e. shows that there were significant differences in the answers given by traditional students when compared with those given by traditional students).The differences in the answers given by traditional and mature students to both of these questions can be seen in the following bar charts (Figures 4.19 and 4.20).

Have You Ever Considered Dropping Out Because of Difficulties with Mathematics?

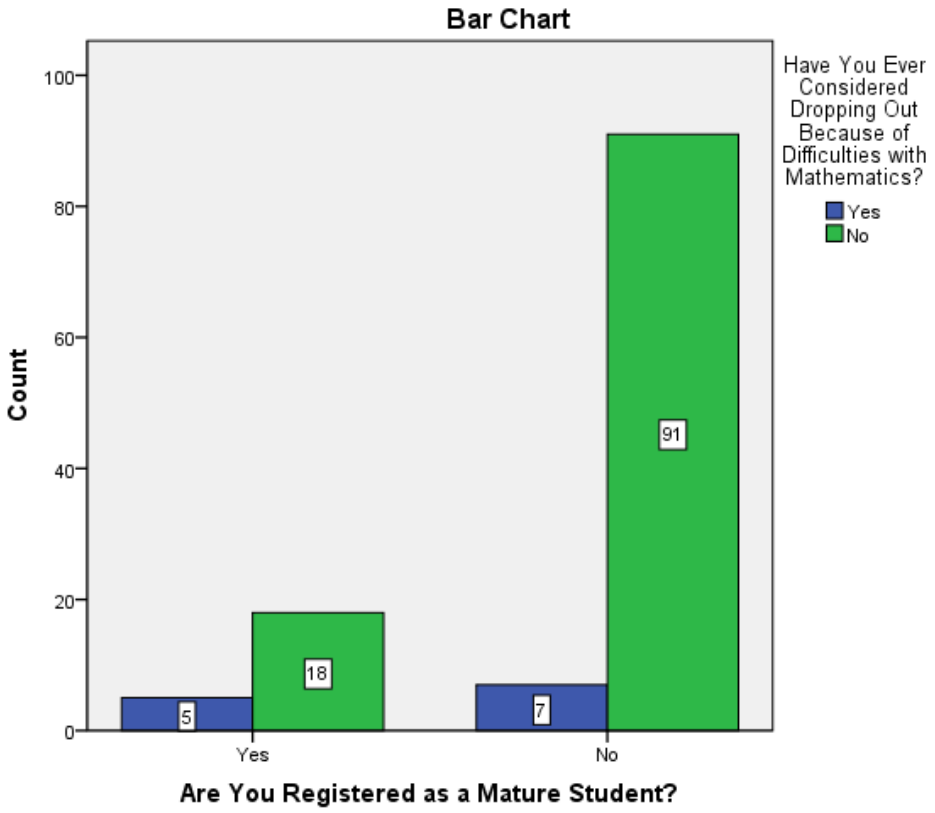

Figure 4.19: Graphical representation of students' responses to the question: Have You Ever Considered Dropping out Because of Difficulties with Mathematics? by student type.

Firstly in the case of student type and the question: Have you ever considered dropping out because of difficulties with mathematics? - there was a significant difference. 21.74% (5 out of 23) of mature students responded yes to this question and 78.26% (18 out of 23) responded no. 7.14% (7 out of 98) of traditional students responded yes to the same question and 92.86% (91 out of 98) responded no. A much smaller percentage of traditional students had considered dropping out of college because of difficulties with mathematics. In fact mature students were more than three times more likely to consider dropping out because of difficulties with mathematics than their traditional student counterparts.

Has the Mathematics Learning Centre Changed Your Study Habits?

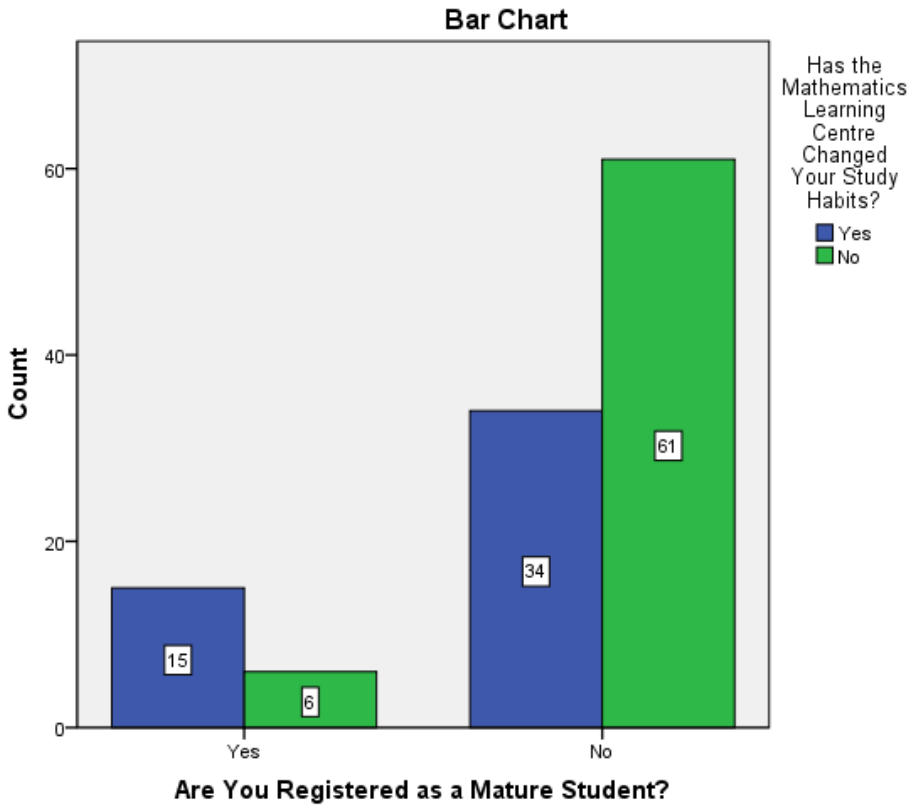

Figure 4.20: Graphical representation of students' responses to the question: Has the Mathematics Learning Centre Changed Your Study Habits? by student type.

Differences between traditional and mature students were also seen when students were asked whether or not the mathematics learning centre had changed their study habits. 71.43% (15 out of 21) mature students responded yes and 28.57% (6 out of 21) responded no. 35.79% (34 out of 95) of traditional students answered yes and 64.21% (61 out of 95) students answered no. It was almost twice as likely that the study habits of mature students would be changed by the mathematics learning centre as those of the traditional students.

4.4 Conclusion:

In this chapter, the results of the student questionnaires were outlined. Both the qualitative and the quantitative data were characterised by the positive view that the students had of the mathematics learning centre. It is clear that the mathematics learning centre is having a positive effect on both the students' mathematics education and their attitudes toward mathematics. In the next chapter these results will be further discussed and recommendations will be made by the author, outlining what steps can be taken to improve the services of the mathematics learning centre in the future.

Chapter 5

Discussion of Results

5.1 Introduction:

In the last chapter the results of this investigation were outlined. In this chapter those results will be compared and contrasted with the findings discussed in the review of the literature. In some cases the results found in this investigation may reinforce the findings of previous research whereas in others it may contradict previous results. The instances where the findings of this investigation may contradict previous findings might be explained by the point made by Gill et al (2010) in that results obtained may depend on the context of the study. In the discussion several aspects of the results will be examined. These will include:

- the findings on students attitudes towards mathematics
- the affect the mathematics learning centre had on these students' attitudes towards mathematics since entering third level education
- the effect of the mathematics learning centre on other aspects of the students' mathematics education e.g. student retention and study habits
- features of the mathematics learning centre that are deemed important by the users e.g. teaching strategies employed, extra help etc.

5.2 Summary of Findings:

In the previous chapter the findings of the investigation were outlined. The findings can be summarised as following:

- The attitudes of the students to mathematics were predominantly positive. 49% of the responses to the questions pertaining to attitude towards mathematics illustrated a positive attitude to mathematics. Only 22.5% of the responses highlighted a negative attitude and the remaining 28.5% showed neither a positive nor negative attitude towards mathematics.
- The results showed that the mathematics learning centre has a huge bearing on both the students' mathematics education and their attitude towards mathematics. They emphasise the need for learning support in this tertiary setting. Particular areas in which it was shown to be having a positive affect were; student retention, students' confidence in their mathematical ability, students' opinion of mathematics and students' study habits.
- The qualitative data gave the author a further understanding of the benefits of the mathematics learning centre by highlighting features of the centre which were deemed to be

most important by its users. These features were teaching strategies, extra help, greater understanding, overcoming student attitude and the attitude of the staff in the centre.

In the next section some of these results will be examined further to determine what can be taken from the results obtained.

5.3 Context of the Results:

5.3.1 Attitudes towards mathematics:

Several discrepancies were seen in the results obtained on attitudes towards mathematics. These include differences between genders, differences between mature and traditional students and differences depending on Leaving Certificate mathematics level. Females had a more positive attitude towards mathematics with 56% of females stating that mathematics was their favourite subject in school as opposed to only 31% of males. Those who took mathematics at Higher Level rather than Ordinary Level also had a stronger liking of mathematics, 51% to 28%. Traditional students had a more positive attitude to mathematics than their mature student counterparts. 43% of traditional students said that mathematics was their favourite subject in school whereas only 18% of mature students stated this. 33⅓% of mature students admitted to being afraid to ask questions in mathematics class with only 15% of traditional students admitting the same.

5.3.2 Benefits of the Mathematics Learning Centre:

In the questionnaires the author looked at specific areas of the students' mathematics education to evaluate whether the mathematics learning centre had a positive effect on these areas or not. As it was seen in the previous chapter the results were extremely positive. Success was seen in each of the areas examined. In this discussion the author will focus on three of those aspects in particular: confidence regarding mathematical ability, attitude towards mathematics and study habits.

5.3.2.1 Improving Student Confidence:

In the case of the first of these, the author compared the students' confidence in mathematics in school and the effect that the mathematics learning centre had on their confidence. 30 students said that they never used to feel confident in mathematics class in school. Of those 30, 26 students (87%) said that the mathematics learning centre improved their confidence in their

mathematical ability. Of the remaining 82 students, who were either unsure of how they felt or who used to feel confident in class, 77 students (94%) said that the mathematics learning centre had improved their confidence.

5.3.2.2 Improving Students' Attitude towards Mathematics:

The author compared students' attitudes towards mathematics in school and if the mathematics learning centre had an effect on students' attitudes towards mathematics. As seen in the results chapter, 64% of students reported that the mathematics learning centre had improved their attitude towards mathematics. However a further 14% had already expressed a positive attitude toward mathematics (they had said that mathematics was their favourite subject in school) and an additional 6% said that although they did not like the subject of mathematics that they recognised the importance of mathematics (they believed that a good training in mathematics is a big advantage in entering any line of work).

5.3.2.3 Improving Students' Study Habits:

The author examined the effect of the mathematics learning centre on students' study habits taking into consideration their view of their study habits prior to using the mathematics learning centre. 42.74% of respondents said that the mathematics learning centre changed their study habits. However a further 30% of the respondents had already stated, in a previous section on the questionnaire, that they know how to study for a mathematics test.

5.4 Findings of this Investigation and the Research:

5.4.1 Student Beliefs on the Effectiveness of the Mathematics Learning Centre

Analysis of the qualitative data identified themes under which students' opinions on the mathematics learning centre can be categorised. Several of the themes that arose were supported by similar studies. These were teaching strategies, extra help and overcoming student attitudes. In the coming section the author will examine each of these in greater detail in light of the research which has been done on these areas in the past.

5.4.1.1 Teaching Strategies:

The teaching strategies adopted by the staff of the mathematics learning centre were made reference to on numerous occasions by the students. Many students favoured the teaching styles of the tutors of the mathematics learning centre to that of their lecturers. The teaching style of the tutors was likened to the teaching styles used in post primary by one student. There has been much support for this idea that the university teaching methods have been causing problems for students in third level education. O Donoghue (1999) cited university teaching methods as an internal factor leading to the 'mathematics problem'. Liston and O'Donoghue (2010), Kajander and Lovric (2005) and Biggs et al 2001 (cited in Liston and O'Donoghue 2009) have also supported this idea that the teaching strategies in universities cause students considerable problems. Kent and Noss 2003 (cited in The Ove Arup Foundation, 2011) went as far as to suggest that teachers might be better positioned than lecturers to teach first year university students as their teaching styles would be more suited to the needs of the students entering third level.

5.4.1.2 'Extra Help':

The need for 'extra help' frequently mentioned by students in their comments only serves to emphasise the fact that there is indeed a 'mathematics problem' in the University of Limerick as was suggested by Hourigan and O' Donoghue (2007). Similar to the findings of MacGillivray, (2009), Gill and O'Donoghue (2007), Croft (2000) and Lawson et al (2001) the aspect of the mathematics learning centre that appeared to be found most useful and valuable by the students was the one to one help available in the mathematics learning centre. The data obtained in this investigation was further supported by the findings of Lawson et al (2001). In their study the students cited that the reason that they found the one to one so helpful was that it provided the students with a place to go when they needed help with a specific question or area of study.

5.4.1.3 Overcoming Student Attitude:

Overcoming students' negative attitudes to mathematics was also an area which received a considerable amount of feedback from the students. It was clear from the students' comments that they felt that their attitude towards mathematics was an important issue which needed to be addressed by the mathematics learning centre. This is supported by the findings of MacGillivray (2009) and Patel and Little (2006) who found that their students perceived improving their confidence and comfort as a very important feature of their mathematics support centres. This is an

issue which has also been previously raised by Klinger (2007) in his research on self-efficacy and anxiety in mathematics. Indeed many other researchers have alluded to the importance of tackling students' negative attitudes towards mathematics including Kent and Noss 2003 (cited in The Ove Arup Foundation, 2011), Philippou and Christou (1998), Hannula (2002) and Relich (1996).

5.4.2 Attitudes towards Mathematics:

Discussions on attitudes towards mathematics in the past have generally highlighted the prevalence of negative attitudes towards mathematics. In the second chapter which looked at research in the area of attitudes towards mathematics the findings were no different. Sewell (1981) and Klinger (2007) both reported that about 50% of the adult population exhibit negative attitudes towards mathematics. However the findings of this investigation suggest that the levels of negative attitudes towards mathematics among students in this university are not quite as high as those previously mentioned. Only 22.5% of responses pertained to students having a negative attitude to mathematics. However, perhaps the disparity in the frequencies of negative attitudes towards mathematics can be explained by comparing the ages of the participants involved in each of the investigations. Sewell's (1981) and Klinger's (2007) studies both examined attitudes in the adult population. The students in this investigation varied in age from the traditional students to mature students. The traditional students in this study would be in the approximate age bracket of 17-23 which might have been considerably lower than the participants of the aforementioned studies. Indeed when the results for the mature students only were examined, the results showed similar levels of negativity as those found in the studies previously mentioned. Differences were also noted between the males and females in this investigation although contrary to the findings of Singh (2003) the females in this study had a considerably more positive attitude towards mathematics than the males.

5.4.3 Effects of the Learning Support:

In this investigation several key aspects of the learning support provided were investigated. These were student retention, students' confidence in their mathematical ability, students' opinion of mathematics and students' study habits.

5.4.3.1 Mathematics Learning Centre and Student Retention:

Previous research evaluating mathematics learning support has shown that mathematics support centres can be beneficial to those less well-prepared or struggling students for example Pell and Croft (2008) and Gill and O'Donoghue (2007). However Symonds et al (2007), Dowling and Nolan (2006) and Patel and Little (2006) have said that this support goes even further than just helping students with their mathematics education, in some instances mathematics support centres have been found to be actually enabling students to continue in their mathematics education. This would support the findings of this investigation which showed similar trends. 80% of the students who had considered dropping out of college because of difficulties with mathematics said that the mathematics learning centre had influenced their decision to stay. The results obtained showed that the mathematics learning centre was responsible for the retention of approximately 7% of the surveyed population.

5.4.3.2 Mathematics Learning Centre and Students' Mathematical Confidence:

As already mentioned MacGillivray (2009) and Patel and Little (2006) both found that mathematics support centres helped to improve the mathematical confidence of their students. This investigation provided similar evidence to what they had found. 92% of students reported that the mathematics learning centre had helped them to feel more confident about their mathematical ability. Alongside improving student confidence, several of the students' comments acknowledged that the mathematics learning centre had helped them to overcome mathematics anxiety and consequently making them feel less nervous in their lectures.

5.4.3.3 Mathematics Learning Centre and Students' Attitude towards Mathematics:

Suthar and Ahmad Tarmizi (2010), Coben (2003) and Papanastasiou and Bottiger (2003) among others have shown that attitude can affect performance. Based on this theory Klinger (2005) has said that mathematics learning centres must tackle their students' negative attitudes towards mathematics, of their students. Both Relich (1996) and Kent and Noss 2003 (cited in The Ove Arup Foundation, 2011) said that teachers can have an effect on their students' attitude towards mathematics. This investigation has found this to be true in the case of the tutors in the mathematics learning centre in UL. Results from the questionnaires showed that 64% of students surveyed, felt that the mathematics learning centre had changed their attitude towards mathematics.

5.4.3.4 Mathematics Learning Centre and Students' Study Habits:

The results from the questionnaire revealed that the mathematics learning centre had changed the study habits of 43% of the students surveyed. Although not all students commented on how their study habits had changed, many of the students who did comment made reference to a 'deep' learning approach which had greater understanding at its core. This would suggest that the mathematics learning centre was helping the pupils move away from the rote or 'surface' learning that Porter and Masingila (2000) and Kajander and Lovric (2005) say characterises the learning in most post primary schools today. However the mathematics learning centre was also found to be effective in changing the study habits of mature students. This could relate to the findings of Ní Fhloinn (2007) who found that mature students have difficulty prioritising the important material. Indeed the comments of many of the mature students who said that the mathematics learning centre had helped them to change their study habits mentioned that the mathematics learning centre "highlighted important topics" and "gave them a more structured approach" (students' comments).

5.5 Conclusion:

In general it can be seen that many of the results yielded by this investigation correlate with the findings of research that has previously been undertaken. In particular, the literature reinforces the findings of this investigation on the benefits of the mathematics learning centres in the areas of student retention, student confidence and student attitude towards mathematics. Most importantly it has echoed the findings of researchers in other universities, such as Pell and Croft (2008) and Mac An Bhaird et al (2009), in showing that mathematics learning centres provide invaluable learning support for students in the university. In the next chapter the author will outline the conclusions that can be drawn from the findings that were discussed in this chapter.

Chapter 6

Conclusions and Recommendations

6.1 Introduction:

In the previous chapter the findings of the research project were discussed. As was stated in the introduction chapter the main aim of this investigation was to evaluate the effectiveness of the mathematics learning centre. The author identified two key questions which could be examined in order to achieve this aim. These were:

- Does the Mathematics Learning Centre impact on students' mathematics education?
- Does the Mathematics Learning Centre impact on students' attitudes to mathematics?

Answers to these questions were then sought through the use of a student questionnaire as recommended by Lawson et al 2001 (cited in Sigma 2009)). The student questionnaire proved to be an effective instrument in answering these questions providing the author with some useful insights into the provision of mathematics learning support. In this chapter the author will summarise the findings from these questionnaires, present the conclusions which can be deduced from these findings and suggest some recommendations which might be considered in the future.

6.2 Summary of the Main Findings:

Corresponding to the findings of other research done in this field, the findings of this investigation indicate that the mathematics learning centre plays an integral role in both the mathematics education and the attitude towards mathematics of the students in this university. The author established that the mathematics learning centre:

- improved students' confidence in their mathematical ability
- improved students' attitudes towards mathematics
- helped to improve students' study habits
- played an influential role in preventing several students from withdrawing from college completely.

These findings provide significant evidence that the mathematics learning centre is an essential service which the university must continue to provide given the 'mathematics problem' which Hourigan and O'Donoghue (2007) have shown is evident in this university.

In the discovery of these findings several key features of the mathematics learning centre were highlighted by the students as being instrumental in the success of the centre. These were; the teaching strategies implemented by the staff of the centre, the availability of the extra help, the promotion of greater understanding encouraged by the staff of the mathematics learning centre, the

effort of the staff to overcome the negative attitudes of the students and to promote greater confidence in their students and of course the supportive, caring attitude adopted by the staff of the centre. In brief this shows that the students are finding the approaches adopted by the mathematics learning centre to be effective in positively impacting on both their mathematics education and on their attitude towards mathematics.

6.3 Recommendations:

This investigation has again like many others (O'Donoghue 1999; Liston and O'Donoghue 2010; Kajander and Lovric 2005) highlighted the difficulties third level students are having in adapting to the teaching styles used by lecturers in third level institutions. Comments made by students show that students prefer the teaching methods used by the staff of the mathematics learning centre. Ní Fhloinn et al (2007) have suggested that mathematics learning centres need to be *"integrated more into the mathematics departments and there should be more communication with faculty members who teach the mathematics courses where these students are having trouble"*. It is strongly recommended that this approach would be adopted in this university as it is clear from this investigation that many students are struggling to follow the teaching strategies that are being used by lecturers currently. The author feels that students would benefit more if the mathematics learning centre had an input into the way in which the material was being taught.

Secondly, this study has highlighted the positive impact that the mathematics learning centre can have on students' attitudes towards mathematics. Given the strong relationship between attitudes towards mathematics and performance in mathematics that was alluded to in the review of the literature perhaps this is an area which the mathematics learning centre could devote more attention to. The staff of the mathematics learning centre are in a good position to get to the root of students' negative attitudes (Klinger 2007) and to provide the students with positive mathematical experiences and opportunities to succeed (Philippou and Christou 1998 and Hannula 2002).

6.4 Further Research:

This study has shown that the mathematics learning centre is effective in helping students who avail of its services. However the review of the literature has highlighted non-attendance as a problem which mathematics learning centres are now facing. As was already mentioned in the

methodology chapter one of the limitations of this investigation was that it only looked at the students who were already using the mathematics learning centre. Therefore it does not take this problem of non-attendance into consideration. Having undertaken this investigation and having reviewed the literature in this area the author believes that there is a need for further research on the issue of non-attendance at the mathematics learning centre. Considering the impact that this investigation has shown that the mathematics learning centre can make on students' mathematical experience, it is vital that every effort be made to ensure that the mathematics learning centre reaches as many of those students as possible, particularly those in most need of help. Further research into what barriers can prevent these students from using the mathematics learning centre facilities is therefore strongly recommended by the author.

6.5 Conclusion:

In conclusion, it is widely accepted that the transition to tertiary level mathematics can be a difficult one for many students to make. Many obstacles can make it more difficult for them, including variability in mathematics entry standards, the large class environments and teaching methods that differ greatly to those they were used to from post primary education. In light of this the role the mathematics learning centre is required to play in shaping their mathematical experiences is growing in importance. It is of utmost importance that the mathematics learning centres in tertiary institutions rise to the new challenges that now face them. This investigation has shown that the mathematics learning centre in UL is doing just that, and is effectively fulfilling both the cognitive and affective needs of a broad range of students of varying abilities, mathematical backgrounds and degree programmes. As the needs of the students are constantly changing it is important that the mathematics learning centre is continuously being evaluated to ensure it is meeting the needs of the students who are using it.

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Appendices

Appendix A:

Mathematics Learning Centre Questionnaire

Section A: Personal Details

1. Degree Programme: ……

2. Year: Access 1st year 2nd year 3rd year 4th year Postgrad

3. Student Category: Full-time Part-time

4. Gender: Male Female

5. Leaving Certificate Mathematics Level (if applicable):

Higher Ordinary Foundation Other N/A

6. Leaving Certificate Mathematics Grade (if applicable):

A1 A2 B1 B2 B3 C1 C2 C3 D1 D2 D3 Other N/A

7. Are you registered as a mature student? Yes No

8. Are you an Irish citizen or permanent resident? Yes No

9. Are you an international / overseas student? Yes No

Section B: Attitudes towards Mathematics

For each statement, there is a five-point scale and you are asked to consider how each statement applies to you and to circle the appropriate number, where the numbers stand for the following responses:

1	**2**	**3**	**4**	**5**
never or almost never true for me (disagree totally)	**sometimes true for me (disagree somewhat)**	**true about half the time (unsure)**	**mostly true for me (agree somewhat)**	**completely true for me (agree totally)**

1. Mathematics was my favourite subject at school.	**1**	**2**	**3**	**4**	**5**
2. At school, I was afraid to ask questions in a Mathematics class.	**1**	**2**	**3**	**4**	**5**
3. I used to feel confident when I was in math classes at school.	**1**	**2**	**3**	**4**	**5**
4. Mathematics is so difficult that only those who are gifted can understand.	**1**	**2**	**3**	**4**	**5**
5. I'm afraid I won't be able to keep up with the rest of the class in Mathematics.	**1**	**2**	**3**	**4**	**5**
6. A good Mathematics training is a big advantage in entering any line of work.	**1**	**2**	**3**	**4**	**5**
7. I understand Mathematics now, but I worry that it's going to get really difficult soon.	**1**	**2**	**3**	**4**	**5**
8. I know how to study for a Mathematics test.	**1**	**2**	**3**	**4**	**5**

Section C: The Mathematics Learning Centre (MLC)

The following questions relate to your experience of the Mathematics Learning Centre facilities. If any of the statements are true for you, too, please circle "Y". Otherwise circle "N":

9. Have you ever considered dropping out of college because of difficulties with Mathematics? **Please explain** _____ _____	**Y N**
10. If you answered yes to Q9., has the MLC influenced your decision to remain in U.L.? **Please explain** _____ _____	**Y N**
11. Has the MLC helped you feel more confident about your ability in Mathematics? **Please explain** _____ _____	**Y N**
12. Has the MLC changed your opinion of Mathematics since you started using its services? **Please explain** _____ _____	**Y N**
13. Has the Mathematics Learning Centre Changed your study habits? **Please explain** _____ _____	**Y N**

Any Other Comments

_____.

_____.

_____.

_____.

Appendix B:

Participant Information Sheet

Mathematics Learning Centre Project:

In this research project I am looking to evaluate the service provided by the mathematics learning centre here in the University of Limerick.

What is the research project about?

In conducting this research I am looking to find out:

- Does the mathematics learning centre impact positively on students' mathematics education?
- Does the mathematics learning centre impact on students' attitudes to mathematics?

What will you have to do?

If you wish to participate you will be asked to complete a questionnaire in which you will be asked to give your opinion on the services provided by the mathematics learning centre and how your attitude towards mathematics has changed over the years.

What are the benefits for you?

The aim of this research is to evaluate the effectiveness of the mathematics learning centre. Using the results from this project hopefully improvements can be made to improve the services the centre provides for you the students.

What if I don't want to take part?

You do not have to take part if you don't want to, it is your choice. You can leave the project anytime you want to and we will thank you for helping us.

Appendix C:

Participant Consent Form

Having read the attached information sheet I agree to participate in this study. My involvement is voluntary, and I have been told that I may withdraw from participating at any time.

Participant

Print: _____ Sign: _____ Date: _____.