Critical Events in Students' Engagement with Mathematics

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Abstract

Researchers in the UK and Ireland have noted declining levels of mathematical preparedness amongst students entering universities over the last twenty years. Third level institutions already invest significant resources in the provision of mathematics tuition to first year students and in response to this decline in standards have further invested in the provision of mathematics supports. Research has shown that a significant minority of students at risk of failing do not engage with these resources appropriately. The central research question of this thesis is to explore the reasons for this non-engagement.

This thesis presents the findings from a study of two groups of students at the National University of Ireland Maynooth. The 1st group consisted of seven students who had failed their first year of mathematics. They all had very low levels of engagement with available supports. The 2nd group consisted of nine students with similar mathematical backgrounds to the 1st group who had passed their first year of mathematics and had engaged to a significant extent. It emerged that students' levels of reaction to a number of critical events in their mathematical education were key to their engagement levels and their subsequent progression. The 2nd group were, in general, able to approach their difficulties with mathematics while the 1st group avoided facing up to their difficulties with mathematics. We supply evidence that the students' behaviour was influenced by fear, social interactions, and motivation.

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Glossary

CETL	Centre for Excellence in Teaching and Learning
DCU	Dublin City University
EGFSN	Expert Group on Future Skills Needs (Irish Government body)
HL	Higher Level Leaving Certificate mathematics
JC	Junior Certificate
LC	Leaving Certificate
MLC	Maths Learning Centre (Dublin City University)
MLSC	Mathematics Learning Support Centre (Loughborough University)
MSC	Mathematics Support Centre (National University of Ireland Maynooth)
NAIRTL	National Academy of Integration of Research, Teaching and Learning
NUIM	National University of Ireland Maynooth
OECD	Organisation for Economic Co-Operation and Development
OL	Ordinary Level Leaving Certificate mathematics
PISA	Programme for International Student Assessment

Chapter 1 – Introduction

This section forms an introduction to the research question of this thesis. In Section 1.1 we consider the research problem itself, Section 1.2 is a short description of the project and 1.3 describes the content and layout of this thesis.

1.1 The Research Problem

Many first year undergraduate students studying mathematics at the National University of Ireland Maynooth (NUIM) enter NUIM with weak mathematical backgrounds. Diagnostic testing at the start of their first semester has highlighted this issue over the last number of years. Of particular worry are students we consider to be 'at-risk'. A student is deemed to be '*at-risk*' if they have a Leaving Certificate (LC) mathematics mark of Ordinary Level (OL) B1 or lower or have failed a diagnostic test at the beginning of their first semester. In response to this problem (generally referred to in the literature as the Mathematics Problem (see Section 2.1)) the Department of Mathematics and Statistics at NUIM has increased the number of mathematics supports initiatives aimed at students, including the opening in 2007 of a drop-in centre, known as the Mathematics Support Centre (MSC).

Research has shown that with regular usage the MSC can help improve students' grades (Mac an Bhaird, Morgan & O'Shea, 2009). However, a significant minority of 'at-risk' students do not avail of these supports. The research described in this thesis was informed by these previous findings and the central research question involved examining the reasons why students do or do not engage with mathematics at NUIM. In particular, we wanted to investigate why some students who need help are reluctant to avail of it, while others are not.

The first year of this project was funded by the National Academy of Integration of Research, Teaching and Learning (NAIRTL) with the aim of investigating how and why mathematics support initiatives help students, to investigate if attending the MSC had an effect on students' attitudes and to investigate why certain 'at-risk' students did not attend the MSC.

1.2 Description of the Project

In order to consider the question of why some students make use of mathematics supports and some do not, we interviewed two groups of students. The 1st group consisted of seven first year undergraduates who were repeating some or all of their mathematics modules. It emerged that none of these students had engaged significantly with mathematics. By this we mean that they had low attendance levels at tutorials and the MSC, and low rates of assignment submission. As part of a follow up study, interviews were conducted with nine students who had completed first year mathematics at NUIM. These students had similar mathematical backgrounds to the 1st group, were from the same cohort, and contrary to the 1st group, they had engaged with mathematics.

The initial aim of the interview process was to investigate the effectiveness of mathematics support initiatives at NUIM. The research was subsequently expanded to include an investigation into the differing behaviours of the two groups and to discover the reasons for those students engaging or not engaging with mathematics. The majority of the interview structure was identical for both groups which allowed for comparison. Students were asked open-ended questions about their experience of school (or pre-university) mathematics, and about their experiences of mathematics in NUIM including sections on experiences of lectures, tutorials, assignments, and the MSC. A copy of the interview structure for both groups can be found in Appendices A and B.

1.3 Content of this Thesis

Chapter 2 of this thesis contains a review of the relevant literature in this area. Section 2.1 outlines the relevance of mathematics to the Irish and global economy and discusses the Mathematics Problem, the decline of the mathematical preparedness of undergraduates entering university in the UK and Ireland over the last twenty years. Section 2.2 is an evaluation of the effectiveness of mathematics support both at NUIM and elsewhere. Section 2.3 describes some of the most relevant current research concerning the issue of fear and embarrassment in relation to mathematics. Section 2.4 deals with the literature on social interactions in relation to mathematics and Section 2.5 concerns current literature on achievement motivation, including sub-sections on goal

orientation theory and the more general model of approach and avoidance motivation. Section 2.6 describes current research on critical events and Section 2.7 examines the literature on the transition from second to third level mathematics. Section 2.8 is a conclusion to the literature review.

Chapter 3 describes the methodology used in this research. Section 3.1 is a description of the research methods used throughout this project. It includes an analysis of quantitative (3.1.1) and qualitative (3.1.2) research. The next section compares and contrasts the acceptable usage of both methods (3.1.3) and then we include a description of the reasons why this project contains only the results from qualitative investigations (3.1.4). Section 3.2 details the participants of this study. We look at how we selected the participants (3.2.1) and describe the participants (3.2.2). Section 3.3 concerns the interview process itself including sections on the structuring (3.3.1), recording and transcribing (3.3.2), and an in-depth look at the use of Grounded Theory to analyse and code the interviews themselves (3.3.3 and 3.3.4). Section 3.4 concerns a research trip to Loughborough University in the UK. Section 3.5 concerns issues of research ethics related to this project. The final section, Section 3.6 discusses the validity and reliability of the research we conducted.

Chapter 4 is the Analysis of the Data section. In this chapter an analysis of the interview data, from the sixteen interviews completed, is presented. Following an introduction in Section 4.1, Section 4.2 outlines the behaviour of the students in both groups. Section 4.2.1 examines the similar tactics used by both groups and Section 4.2.2 explains how they encountered similar difficulties with mathematics at the beginning of semester one. Section 4.2.3 will show how the 2nd group encountered difficulties with assignments and responded to this critical event by seeking help. In the context of this study a *critical event* is defined to be: an event that emerged from the analysis as being important in determining the future engagement of a student, whether they were consciously aware of its critical nature or not. For example, most of our students struggled with assignments early in the first semester. The 2nd group responded to these difficulties by looking for help. The 1st group never made serious attempts to seek help and they entered into a cycle of non-engagement. We can see with hindsight that this was a critical event in determining the future engagement of these students.

From the interview data from the 1st group three critical events were evident: becoming lost or confused with the material in lectures; struggling with assignments; and struggling or becoming embarrassed in tutorials. It is not always clear from the analysis that the 1st group were always aware of the importance of these critical events because, in general, the 1st group did not seek help for their problems. If they did seek help it was in a superficial manner and was of little or no benefit to them (When we use the term superficial we refer to the fact that sometimes the students in the 1st group made comments about attempting to seek help or engage but we know from attendance records that they rarely made use of the supports available to them). For the 2nd group it was evident from the data that there was often one major critical event; they struggled with some aspect of the course and sought to address the problem.

We show (in Section 4.2.4) that the behaviour of the students in this study can be classified into approach or avoidance categories. Some students were motivated to approach their difficulties head on and others displayed avoidance behaviour in attempting to avoid facing up to their difficulties with mathematics. All students in the 1st group displayed avoidance behaviour. Six students in the 2nd group also displayed certain avoidance behaviour; however they all altered their engagement to deal effectively with their problems.

In Section 4.3 we discuss influences on the behaviour of the two groups that emerged from the analysis. We discuss in Section 4.3.1 how fear was the major barrier for engagement for the 1st group. There are four concepts within the category of fear: fear of showing a lack of knowledge or ability (4.3.1.1); fear of being singled out (4.3.1.2); fear of the unknown (4.3.1.3); and fear of failure (4.1.3.4).

We then examine how the 2nd group used social interactions in relation to mathematics to seek help. Section 4.3.2 shows how they used social interactions with their peers and teachers to engage with mathematics. The 1st group rarely mentioned such social interactions in relation to mathematics.

In Section 4.3.3 we offer an analysis of what motivation or drive the 2nd group possessed that the 1st group did not. We show how there is evidence of three students in our 2nd group displaying mastery goal orientations (4.3.3.1). Students from both groups

displayed performance avoidance goal orientations (4.3.3.2) but our results will show that the standard dichotomous model of achievement motivation is not sufficient to describe the motivational issues that emerged from the analysis.

All three influences on behaviour (fear, social interactions and motivation) dealt with in this thesis are over-lapping and inter-related. They did not emerge completely separately during the analysis. Students often discussed issues that can be viewed simultaneously as relating to several of these influences on behaviour.

In Chapter 5 we discuss the results of the thesis in relation to the relevant literature in the area. We outline in detail where our findings are consistent and inconsistent with the literature and discuss further research questions that have emerged from our study of the data.

In Chapter 6 we summarise the conclusions of this thesis. In Section 6.1 we consider the main findings, Section 6.2 looks at the implications of the study and Section 6.3 discusses some of the limitations of this project. Finally, in Section 6.4 we look at potential future research related to the findings of this thesis.

Chapter 2 - Literature Review

In this chapter we present the most relevant and recent literature related to this project. Section 2.1 discusses the relevance of mathematics and the decline in the standards of mathematical preparedness of third level students in both Ireland and abroad. Section 2.2 considers research into the effectiveness of the mathematical support at NUIM and elsewhere that are intended to address this decline in standards. Section 2.3, 2.4 and 2.5 deal with the relevant literature in relation to the influences on behaviour that emerged from the study: fear, social interactions and motivation. Section 2.6 considers the literature on critical events and Section 2.7 concerns the transition from second level to third level.

2.1 The Mathematics Problem

The importance of mathematics in the Irish context is supported by a number of recent findings. In a statement from 2008, the Expert Group on Future Skills Needs (EGFSN) (Expert Group on Future Skills Needs, 2008), an Irish Government body, outlined the need for improving "our national mathematical achievement". The EGFSN highlighted the importance of mathematics knowledge to the economy here. A major concern highlighted by the group was the essential need for mathematics proficiency as part of a knowledge based economy. It also noted that mathematics underpins a number of economy-essential disciplines like science, technology and business. Similar sentiments were expressed in another government report from 2008, Building Ireland's Smart Economy: A Framework for Sustainable Economic Renewal (Department of the Taoiseach, 2008). It noted the importance of enhancing skills in mathematics and science and suggested that increasing the uptake of higher level mathematics at second level would be beneficial for this aim. However, despite the importance of high levels of mathematical literacy to the economy, there have been indications that standards have been falling.

The most recent test of mathematical standards at second level in Ireland was the Programme for International Student Assessment (PISA) 2009 study. Although mathematics was not the main focus of PISA 2009 it was still included in the testing process. In a report from the Educational Research Centre, Dublin (Perkins, Cosgrove,

Moran & Shiel, 2012), it was noted that Ireland ranked 26th out of 34 amongst the Organisation for Economic Co-Operation and Development (OECD) countries, with a mean score of 487 which is significantly below the OECD average. Ireland's score had declined by sixteen points since 2003 (most of that decline came in the period 2006 – 2009) and Ireland registered the second largest decline amongst OECD countries in 2009.

The impact of this decline is felt at NUIM where we deal with a significant number of first year undergraduate students with weak mathematical backgrounds. Researchers have noted a decrease in the mathematical preparedness of students attending university in the UK and Ireland and this is what is generally referred to as the Mathematics Problem. Smith (2004) headed an enquiry into post-14 mathematics education in England, Wales and Northern Ireland in response to a perceived decline in standards. Possible reasons given for this decline in the Smith report were a lack of specialist mathematics teachers, a lack of available resources and the failure of the curriculum. Lawson (2003) conducted a longitudinal study that examined the basic mathematical skills of entrants to Coventry University over the period 1991-2001. Lawson (2003) discovered a fall in standards when he analysed the results of a diagnostic exam given to all first year students taking mathematics. The average score over the period decreased, the number of students scoring more than 90% decreased and the number of students scoring less than 50% increased significantly.

In relation to considering the Mathematics Problem within Ireland, O'Donoghue (2004), as cited in Gill and O'Donoghue (2008), described a number of overlapping facets of the Mathematics Problem in the Irish context:

- Mathematical shortcomings of entering students.
- Mathematical deficiencies of entering students.
- Pre-requisite mathematical knowledge and skills.
- Mathematical preparedness/under-preparedness.
- Mathematics at the school/university interface.
- Issues in Service mathematics teaching.
- Numeracy/Mathematical literacy.

A very extensive study was undertaken over a number of years at the University of Limerick (UL) (Gill, O'Donoghue, Faulkner & Hannigan, 2010). This research used

data on over 6000 students over a time period from 1997 to 2008. The study focused on three central research questions:

- Is there a 'Mathematics Problem' in UL regarding service mathematics courses?
- How many entering first-year students in UL service mathematics courses are 'at-risk'?
- Has there been a decline in the mathematical standards of students entering first-year service mathematics courses in UL?

The authors found a decline over the 12 year period in the mathematical standards of students entering service mathematics at UL. The number of 'at-risk' students increased significantly over the time period and reached a peak of 48% in 2008.

In its overview of PISA results from 2003, the OECD (2003) recognised the international dimension of the Mathematics Problem. Specifically the report noted that students who participated in PISA 2003 had less enthusiasm (in relation to previous PISA findings) for mathematics and only 38% of students said they enjoyed doing mathematics. The report also noted how anxiety about mathematics has been shown to have a detrimental effect on performance. We discuss fear-related literature in Section 2.3.

In their report on good practice in the provision of mathematics support (Lawson, Halpin & Croft, 2003) researchers at Loughborough and Coventry Universities suggested that mathematics support was a means of addressing the Mathematics Problem. They did however sound a note of caution, "it is important to state that Mathematics Support Centres are not panaceas that will solve every difficulty associated with 'the Mathematics Problem'" (Lawson, Halpin & Croft, 2003, p. 19).

2.2 Mathematics Support

To try and address the issue of increasing numbers of students entering third level with weak mathematical backgrounds, most universities in Ireland and the UK have increased their levels of mathematics support.

However, it is very difficult to evaluate the effectiveness of Mathematics Support Centres (MSCs), the following authors all alluded to this fact (Mac an Bhaird et al., 2009; Pell & Croft, 2008). Feedback from such centres is generally positive and although we will see that there is generally a correlation between regular MSC attendance and better grades, it is difficult to prove a causal relationship.

However, several studies, both nationally and internationally, have detailed the positive impact for students of engaging with mathematics, and more specifically, mathematics support. At NUIM, a paper by colleagues (Mac an Bhaird et al., 2009) which analysed the effect of the MSC there, showed that there was a positive correlation between MSC attendance and the students' grades. In this study it was shown that mathematical support was especially beneficial to those students with a weak mathematical background.

In a paper assessing the effectiveness of mathematics support at Robert Gordon University in Aberdeen, Patel and Little (2006) showed that face-to-face mathematics support significantly increased the module marks of undergraduate mathematics students. The majority of students who availed of this support were termed to be weak students by the authors and they noted the benefits to these weak students of mathematics support. In a similar paper from researchers at Loughborough University about predicting the performance of first year engineering students, Lee, Harrison, Pell and Robinson (2008) calculated regression models which showed that Mathematics Learning Support Centre (MLSC) attendance was a significant factor in predicting both the overall mark of a student in their first year and their performance in a specific mechanics module. Importantly they also found that attending the MLSC benefited weak students.

However, Mac an Bhaird et al. (2009) noted how it was also apparent that a minority of 'at-risk' students were not availing of mathematics support. It should be noted that the metric of 'at-risk' in this study was slightly different to the one defined in Chapter 1. It covered any student who had taken OL maths at LC level or any student who failed the diagnostic test in their first semester at NUIM. Of these students who took OL maths for their LC, only 32% of Arts students attended the MSC once or more and the figure for

Science students was even less at 26%. Of those students who failed their diagnostic test at the beginning of their first semester at NUIM, 52% of Arts students attended the MSC once or more but only 33% of Science students in this category did the same.

A study at Dublin City University (DCU) by Dowling and Nolan (2006) found similar results when they evaluated the effectiveness of DCU's Maths Learning Centre (MLC). The MLC specifically targeted first year students and particularly those deemed to be 'at-risk'. In 2004-05, forty one out of eighty 'at-risk' students visited the MLC. In 2005-06 ninety five out of one hundred and sixty one 'at-risk' students attended the MLC. Pass rates for 'at-risk' students who attended the MLC were 53% and 60% for the two years respectively. Pass rates for the 'at-risk' students who did not attend were 25% and 49% respectively. It is clear that the MLC had an affect on the retention and progression of these students but the attendance figures back up the data from NUIM, and show that a significant number of 'at-risk' students did not avail of mathematics support.

A study of engineering students using the MLSC at Loughborough University by Pell and Croft (2008) found similar issues with significant numbers of 'at-risk' students not availing of mathematics support. The most surprising result from this paper was that the MLSC was being used mostly by stronger students wishing to achieve higher grades rather than weaker students looking to avoid failure. A study by MacGillivray (2009) at Queensland University of Technology (QUT) found similar results. The Mathematics Access Centre at QUT was being used by a variety of students, including the more able students looking to increase achievement.

An in-depth study of the effectiveness of mathematics support services at Loughborough University was conducted by Symonds (2008). Symonds conducted a quantitative analysis of usage data of the MLSC. The majority of students who needed help most were found not to be attending. She found a very strong correlation between engagement with mathematics and students' mathematics module grades. She also asked students who had not engaged with mathematics support to detail some of the reasons for their behaviour through the use of focus groups and interviews. Some of those reasons were a lack of awareness of the location and type of service available. Symonds (2008) doubts if these are the real reasons for non-engagement however:

> "Such students were able to overcome these barriers in order to avail themselves of the support facilities. This poses the question: would simply implementing the above suggestions (advertising, actively seeking out students who need help, staff changes) be enough to improve the uptake of support amongst failing students?" (Symonds, 2008, P.140)

Symonds noted that many of those students who did not overcome these barriers were 'at-risk' and lacked motivation to engage with mathematics and mathematics support. Symonds postulated that because 'at-risk' students were unwilling to attend a drop-in centre (students must decide to attend themselves) that a more proactive approach might have worked better with such students. She examined a small-group teaching programme at Loughborough University and Coventry University that sought out 'at-risk' students and found that this proactive support did not have an affect on improving the grades of these students despite initial successes. Interviews were conducted with participants and reasons given by students for lack of engagement included a lack of confidence in their own mathematical ability and the importance of teachers in providing motivation.

Other authors have explored the effects of anxiety and low levels of self-confidence on engagement. We will consider some of these studies in the next section.

2.3 Fear

In an in-depth study of motivation Hannula (2006) utilised a case study with one student to examine the effect of emotions upon motivation. He showed how embarrassment can have a negative effect on engagement with mathematics. This paper also focused upon social aspects of motivation (see Section 2.4).

In their review of research into avoidance of help seeking in the classroom Ryan et al. (2001) explored why students do not ask for help. They showed that students worry about negative judgements from teachers and classmates specifically. These judgments relate to their perceived abilities and the authors showed that these worries are related to avoidance of help seeking:

> "Students who feel insecure about their abilities-academically or relating socially to other students-are more likely to avoid help seeking. Students who are focused on their reputation-academic or social-are more likely to avoid help seeking." (Ryan et al., 2001, p. 110-111)

In a study of the association between self efficacy, goal orientations, and fear of failure and engagement for high school students Caraway, Tucker, Reinke and Hall (2003) found that fear of failure has been linked to low self efficacy amongst students. They suggested increasing students' self efficacy could improve this situation while also noting that other factors outside of the classroom environment (e.g. family supports, community support, etc.) also play a role in developing these skills.

Research has shown that mathematics anxiety can have physiological effects on students (Hopko, Ashcraft, Gute, Ruggiero & Lewis, 1998). This study from the US assigned a reading task to ninety undergraduate psychology students. Their mathematics anxiety was rated on a scale and they found that high- and medium- mathematically anxious students took significantly longer to complete the task. This paper concluded that these students are not able to block out distractions to the same degree as students with low levels of mathematical anxiety.

In a study from the University of Birmingham, Metje, Frank and Croft (2007) noted that after a drop in mathematics entry standards for engineering students, teaching students with a fear of mathematics became a new challenge for their colleagues. Two lecturers from non-science related subjects (with no more than a basic knowledge of mathematics) were invited to participate in the study. One of the authors then taught these lecturers some first year undergraduate topics in a classroom environment allowing insight into the anxieties of a novice learner. While in this study the subjects were lecturers and the results may not be generalisable, the level and depth of feedback was high. Major triggers of fear noted in this study were lectures starting at too high a level for the student, and difficulties with mathematical language.

2.4 Social Interactions

Lave and Wenger (1991) discussed the social perspective on learning in their book on situated learning "the relationship between learning and the social situations it occurs in" (Lave and Wenger, 1991, p. 14). They introduced the concept of "communities of

practice" which is defined to be: "groups of people who share a concern or passion for something they do and learn how to do it better by interacting regularly" (Wenger, 2006). They viewed learning as a social activity which takes shape within a community of learners. Students share ideas and understanding amongst themselves and with their teachers.

Solomon, Croft and Lawson (2010) utilised the work of Lave and Wenger in their study of mathematics support centres as social learning spaces. The study took place at two universities in England with long-established mathematics support centres. Twenty one students, who were frequents visitors to these centres, participated in the study through the medium of focus groups. They originally used the space because they needed to and then began to use the centres as group-study areas, in effect the students took over the space for their own needs. The paper concluded with noting: "These data show the value of providing space for students to develop their own communities of practice".

Hannula (2006) explored extensively the social aspect of student motivation. He believed a psychological need for social belonging is one of the major motivators for students and how some students' choices are dominated by social goals. He discussed how students are affected by the social norms of their classrooms and are possibly motivated by a desire to contribute to group work. Ryan et al. (2001) noted that students who perceived themselves as being socially competent were more likely to seek help.

The same authors defined social goal orientations to be: "the purpose and meaning that students ascribe to their social behaviour in the classroom". They described some very preliminary investigations in this area and define two social goal orientations: social intimacy goal orientation and social status goal orientation. The former is defined to be "the desire for both general acceptance and for closer and more interpersonal relationships". The latter is defined to be: "the desire for social visibility and prestige within the larger peer group". These orientations seem quite vague and disconnected from the academic portion of social goal orientations.

Dowson and McInerney (2003) conducted a study of 86 middle school students in Australia using semi-structured interviews and classroom observation. This led to the discovery of five distinct social goal orientations. These goals included the desire for a

sense of belonging to a group; desire to receive praise from peers or teachers, and wanting to assist others with their academic and personal development. Dowson and McInerney (2003) noted how these goals did not exist in isolation (see Section 2.5.1).

In a recent paper from researchers at Loughborough University (Inglis, Palipana, Trenholm & Ward, 2011) it was discovered that students who attended mathematics lectures and the MLSC did better than those students who did not. The paper compared face-to-face interactions in lectures and the MLSC to online learning supports. Those students who availed of the learning support, which was much more social, fared better. What was not clear in this paper was the motivation of the students involved. Inglis et al. (2011) believed that personal traits of the students were more important than what they termed as state characteristics (student beliefs about the quality of lecturer, timetable issues, etc.) in determining what strategy each student adopted.

2.5 Motivation

The central question of our study is what motivates students academically. We examined a broad range of literature in the area of academic motivation. Dweck (1986) detailed how high grades and high IQ were often not indicative of future grades for children and that motivational factors were strongly at play.

2.5.1 Goal Orientation Theory

The most commonly used framework in the area of achievement motivation is goal orientation theory. Kaplan and Maehr (2007), in their survey paper on goal orientation theory, described goal orientation as why and how students set out to achieve academic goals. Traditionally goal orientation theory has been limited to a dichotomous model of mastery and performance goals.

Mastery goal orientated students attempt academic tasks for the purpose of developing competences (Ames, 1992). Dweck (1986) studied how the goals children pursue on cognitive tasks influence their reactions to successes and failures and in-turn influence the quality of their cognitive performance. Dweck (1986) outlined how, regardless of perceived ability, students with mastery goals chose challenging tasks. Kaplan and

Maehr (2007) summarised how students with this goal orientation focus on learning, understanding, developing skills and mastering information. Mastery goal orientations are associated with positive outcomes such as: self efficacy, persistence, preference for challenge, self-regulated learning, positive affect and well being.

Performance goal orientated students attempt academic tasks for the purpose of demonstrating competence (Ames, 1992; Dweck, 1986). They focus on the impression others have of their ability while attempting to give the impression of high ability and avoiding an impression of low ability (Dweck, 1986). Dweck (1986) elaborated how individuals with low confidence in their academic ability choose easy tasks, where success was guaranteed, or excessively difficult tasks which when failed did not necessarily indicate low ability. Dweck (1986) also reported that individuals with high opinions about their own ability will often choose opportunities to make themselves appear smart rather than engage in a task for learning. As a result performance goal orientations are associated with negative outcomes such as surface as opposed to deep learning and negative affect in events involving challenge or difficulty (Dweck, 1986; Ames, 1992). Kaplan and Maehr (2007) noted how performance goal orientations are also, weak or moderately, associated with positive outcomes such as self efficacy, use of effective learning strategies, grades, and positive attitudes and affect.

Ames (1992), in a study of the classroom learning environment in relation to goal-orientation theory, noted how different learning environments can alter the goal orientations of children. The aim of Ames's article was to identify which elements of the learning environment were important to developing a mastery goal orientation. Important factors identified by Ames included: meaningful, diverse and challenging tasks; participation by students in decision making; private evaluation that recognises effort not ability; and encouraging mistakes as a valid part of the learning process. Hannula (2012), in his paper on affect, noted how authors have linked mastery goal orientations to having a positive effect on inter-personal relationships in the classroom. He also noted that performance goal orientations have been linked to negative or non-significant effects on inter-personal relations.

Kaplan and Maehr (2007) described how researchers decided a reclassification of performance goals was necessary. Two categories were developed: performance

approach goals; and performance avoidance goals. A student with *performance approach goals* focuses on the possibility of achieving success. This is combined with a desire to demonstrate high ability. Performance approach goals are associated with positive outcomes such as persistence, positive affect, and grades but are also associated with negative outcomes such as anxiety, disruptive behaviour, and low retention of knowledge.

Kaplan and Maehr (2007) noted how students with *performance avoidance goals* focus on the possibility of failure. They desire to avoid the demonstration of low ability. These goals are associated with negative outcomes such as low efficacy, anxiety, avoidance of help-seeking, self-handicapping strategies and low grades.

Related to the issue of performance avoidance goal orientations, Urdan and Midgely (2001) define *academic self-handicapping* to be the creation of impediments to successful performance on tasks that the individual considers important (Urdan & Midgely, 2001, p. 116). These impediments can be the result of action (for example staying up late before an examination) or inaction (e.g. deliberately failing to study for a test) on the part of the student. They comment on how some students deliberately sabotage their own engagement so that they themselves or others (fellow students or teachers) will not associate the achievement of a poor grade with poor ability.

The difficulty with these models is that many authors have noted that goal orientations are not mutually exclusive. For example, it is possible for students to have both mastery and performance goals (Hannula, 2006; O'Shea, Cleary & Breen, 2010). O'Shea, Cleary and Breen (2010) examined the beliefs and behaviour of 182 undergraduate mathematics students at NUIM, Tralee Institute of Technology and St Patrick's College, Drumcondra, Dublin. The study aimed to shine more light on the findings of Dweck (1986). They concluded that there was not a strong inverse relationship between mastery and performance goals. Hannula (2006) found similar results.

Levy et al. (2004) conducted fifty semi-structured interviews with Israeli children to study the relationships between goal orientations and social motivations inside the classroom. Mastery goal orientated students were found to have little concern for social status in the classroom and cooperated with other students if it would contribute to their

learning. Whereas performance goal orientated students were much more concerned about social status and the authors noted how this links in with demonstrating high ability or avoiding demonstrating low ability.

In a longitudinal study of middle school students Middleton, Kaplan and Midgley (2004) have suggested that students can transform from one goal orientation to another. They found evidence that students could switch from performance approach to performance avoidance goals. Changes in perceived competence or the likelihood of failure were given as possible reasons for such a transformation.

2.5.2 Approach versus Avoidance

Psychologists have been aware of a general model of achievement motivation since the early 1900s. Hoppe (1930), cited in Elliot's (1999) examination of approach and avoidance achievement goals, described a basic model of the desire for success and the desire to avoid failure. Elliot (1999) himself described *approach* motivation as behaviour directed by a positive outcome. *Avoidance* motivation he defined to be behaviour directed by a negative or undesirable outcome. In an educational context, Ryan et al. (2001) defined "avoidance of help-seeking" as referring to: "instances when students know that they need help but do not seek it". They focus on the two psychosocial reasons that have emerged to explain this avoidance behaviour: desire for autonomy and threat to competence. Desire for autonomy is described as the conflict between seeking help and a desire to not depend on others. Students who have perceived low competence are less likely to seek help due to the fact that the decision to seek help indicates to themselves that they are struggling. Ryan et al. (2001) also noted the link between performance goal orientations and avoidance behaviour. Similarly they linked social status and intimacy goal orientations to avoidance behaviour: "In both cases, there is a heightened awareness of the self relative to others and a potential need to protect self-worth" (Ryan et al., 2001, p.98).

However, intimacy-goal orientations represent a desire to form relationships and work cooperatively with peers in the classroom, and seeking help from one's peers is an opportunity to fulfil such a goal. Ryan et al. (2001) conclude that we cannot consider help seeking or the avoidance of it without considering social interactions.

Related to the idea of approach and avoidance is that of resilience. Williams (2003) examined the links between resilience (ability to recover from failure or a stressful situation) and the inclination of a student to explore unfamiliar mathematical ideas. The study examined interviews with teenage students in Australia and the US and found that the most resilient students were not necessarily those with the highest grades.

Elliot (1999) mentioned how approach and avoidance behaviour are generally viewed as independent within the body of research related to achievement motivation but when considered alongside goal orientation theory they are linked to performance goals. This more general approach fits better with the results from our study and is described in more detail later in Section 4.2.4.

2.6 Critical Events

In the context of this study a *critical event* is defined to be: an event that emerged from the analysis as being important in determining the future engagement of a student, whether they were consciously aware of its critical nature or not. This critical event is related to the critical juncture described by Ryan et al. (2001, p.95). They described it as, "the decision to avoid asking for help when students know they need help". The critical events described in our study appear to be a catalyst for the critical junctures as described by Ryan et al. (2001). A search for the term critical event in the literature found a number of papers that used the term but none of these papers used it in the same context as we did. The reader should refer to our definition above when considering the term critical event.

2.7 The Transition from second to third level mathematics

The transition from second level to third level mathematics can be a difficult one for students. Clarke and Lovric (2009), in research conducted in New Zealand and Canada, theorised that this transition is a rite of passage. Two important aspects of the transition identified in this study included cognitive conflict and culture shock. The paper concluded by stating that the transition from second level to third level cannot occur outside a "proper environment".

The Solomon et al. (2010) study contained interesting data in relation to mathematics and the transition from second to third level. They found in a survey that 46% of students reported mathematics being more fun at school than at university. They noted how some student's self-perception of their own mathematics ability changed once they arrived at third level and this appeared to lead to a loss of confidence in certain cases. Over half the students in their study were also dissatisfied with mathematics teaching styles at university.

Also relevant to the transition from second level to third level was the Students' Experiences of Undergraduate Mathematics (SEUM) study in the UK. This study focused on one cohort of mathematics undergraduates at two traditional, city based universities in the UK. The aims of the SEUM study were to examine the reasons why students experienced mathematics at university in different ways and to investigate why some students developed more positive attitudes towards the subject than others. Like Symonds (2008), the SEUM project asked similar research questions to our own and must be considered in detail. We note here that the SEUM study concerned students studying mathematics whereas our study examined the experiences of service mathematics students. We focus on four papers that came out of this study.

Macrae, Brown, Bartholomew, and Rodd (2003a) looked at thirty two second year students from the SEUM study, that were at risk of failure. They defined 'at-risk' to be: students that had failed two or more modules in semester one of their second year. They compared and contrasted the 'failing' students with the other students from the cohort in an attempt to identify any indicators that might have suggested they were 'at-risk'. The idea behind this to be able to find indicators that could be used to identify students entering university who might be 'at-risk' of failure. The mathematical background of the failing students and the other students in the cohort was quite similar pre-university making it difficult to determine who would struggle upon entry to third level. . A second aim of this study was to use the analysis to suggest ways in which mathematics departments might better support these struggling students.

Although this study used mainly quantitative data the authors concluded that these struggling students tended to withdraw when faced with a lack of success and many found it difficult to talk openly and honestly about their situations. The analysis found that the students who were 'at-risk' seemed to be in difficulty from the beginning. They also suggested introducing compulsory assignments and tutorials to allow staff to 'check-up' on the progress of all students, with particular emphasis on those in danger of failing.

A follow up paper, Macrae, Brown, Bartholomew, and Rodd, M (2003b) included more qualitative data from the same cohort as Macrae et al. (2003a). They interviewed six of the thirty two students. They discovered that these students seemed to have little interest in their course. Theses students were aware their behaviour was causing them to fail but could not pull themselves out of the situation. They also seemed to socialise with students in the same situation. They found that the failing students showed a lack of academic preparedness and were unable to adapt to different learning styles at university. They seemed to have particular difficulty working independently. They noted how other studies had shown that school students in the UK are more 'spoon-fed' in comparison to those at university.

A third paper to utilise the SEUM data, Brown and Rodd (2004), looked at successful students who participated in the SEUM study. Using a mix of interview and quantitative data, the study examined the data for students who completed the period of the study by graduating with 1st Class Honours. The differences between this cohort of students and the failing students examined in Macrae et al. (2003a, 2003b) seemed to be that the successful students displayed greater focus and self discipline, perseverance and determination. These students had the drive to find a solution to problems when things started to go wrong, and displayed less inclination to self delusion. These students also had an interest in the subject and seemed to be integrated into the mathematical social community.

Brown and Macrae (2003) provided an overview of the results of the SEUM study. Many of those results are discussed above but of additional interest to our research are findings about relationships with teaching staff. Enthusiastic, friendly and approachable teaching staff were highly valued by students. However, successful students were

generally able to cope no matter how helpful or approachable they viewed a teacher whereas struggling students were negatively affected by teachers they viewed as not having those qualities. Brown and Macrae (2003) also highlight the importance of a good social support network in helping students to succeed at university mathematics.

In the Irish context Hourigan and O'Donoghue (2007) discussed the growing concern about the inability of Irish mathematics students to make the transition from second to third level. The authors suggested that the root of the problem is a mismatch in the experiences of mathematics of second level students and the subsequent high expectations of mathematics-intensive courses at university. The authors conducted a study of two second level mathematics classrooms. They found issues with students being taught using rote methods (as opposed to more understanding orientated approaches at third level). They also found issues with the exam focused approach leading to fast paced teaching which in turn also contributed to a rote approach to learning. These findings seem to concur with the culture shock (during transition) identified by Clarke and Lovric (2009) as having a negative effect on students upon arrival in a third level mathematics classroom.

2.8 Conclusion

In this chapter we presented the most relevant and recent literature relating to this project. We opened this chapter with a discussion of literature related to the Mathematics Problem. One of the facets of the Mathematics Problem is the difficulty students have in transitioning from second level to third level and we also analysed papers that dealt with this topic in general and in relation to mathematics. A common response to the Mathematics Problem in the UK and Ireland has been the provision of mathematics support. We examined the effectiveness of such supports in Section 2.2. We observed that many studies reported that a minority of those students most ‘at-risk’ did not avail of the supports available.

We presented the most relevant and recent literature in relation to issues that impact on student engagement such as fear, social interactions and motivation. We noted how they were closely related and how they were tied in to the transition from second level to third level mathematics. We will see in Chapter 4 how several critical events in the

engagement cycle of each of the students in this study were vital for determining their future engagement. We examined the literature for similar concepts in Section 2.6.

In conducting this literature review we searched for papers which dealt with the engagement of third level mathematics students and their motivations. We did not find a large volume of relevant literature in relation to these topics and our study is intended to make a contribution to these areas of research.

Chapter 3 – Methodology

This chapter presents a discussion of the relevant research methods used in studies of a similar nature. We explain the reasons for choosing qualitative methods to collect our data, and we outline how the data was collected and analysed.

3.1 Research Methods

After we had established our research problem we then considered various research methods before collecting the data for our study. We focused on quantitative and qualitative research methods.

3.1.1 Quantitative Research

Quantitative research deals with structured data, made up of frequency counts or other quantitative measures. One can then perform statistical analysis upon this type of data. Quantitative research essentially deals with the what, when and where of decision making. *Research Methods in Education* (2001) defines quantitative research to be:

a) The search for causal relationships conceptualized in terms of the interaction of "variables", some of which (independent variables) are seen as the cause of other (dependent) variables.
b) The design and use of standardised research instruments (tests, attitude scales, questionnaires, observation schedules) to collect numerical data.
c) The manipulation of data using statistical techniques (*Research Methods in Education*, 2001, p. 77).

Arthur, Coe, Hedges, and Waring (2012, p.23) mention how quantitative research is designed to "support arguments". In other words we can use quantitative research to test a particular hypothesis and establish the causal relationship in (a) above. For example, during a previous study at NUIM, quantitative research methods had shown a causal relationship between regular MSC attendance and final exam grades for undergraduate students (Mac an Bhaird et al., 2009). But quantitative methods tell us little about the process involved in this causal relationship. That is where qualitative methods come in.

3.1.2 Qualitative Research

Qualitative research concerns the 'why' and 'how' of decision making and typically deals with recordings of verbal accounts. Qualitative researchers are interested in what participants' perspectives are on particular issues. *Research Methods in Education* (2001, p.49) describes qualitative research as "Concerned with life as it is lived, things as they happen, situations as they are constructed in day-to-day, moment-to-moment course of events." Schostak (2002, p.18), when discussing qualitative research, describes the researcher's interest as an "intricate web of purposes, motives, interest, needs, demands, feelings and so on".

Qualitative research pays close attention to process and understanding that process. For example, in our study, we were interested in the process of how a student came to engage or not engage with mathematics and understanding the decisions those students made.

Interviews, focus groups, reflective diaries and texts can all be analysed using qualitative research methods. These types of data cannot normally be subjected to statistical analysis although it is possible to amend certain types of qualitative data to allow quantitative analysis.

3.1.3 Qualitative versus Quantitative

Arthur et al. (2012) describe the motivations for using a 'mixed method' approach to research:

> *'In its most basic form mixed methods research entails a combination of 'qualitative' and 'quantitative' approaches with the ambition to generate a more accurate and adequate understanding of social phenomena than would be possible by using only one of these approaches.'* (Arthur et al., 2012, p.147)

Research Methods in Education (2001) described how qualitative and quantitative research methods can work well together in certain circumstances. When examining

process, quantitative methods can examine whether change has occurred, using before and after measures. Qualitative methods can then examine the finer details and decisions that occurred during that change. In general the authors outlined how quantitative research can produce a theory contrary to that of qualitative methods. One reason given for this conflict is that the quantitative research misses the subtleties and intricacies of decision making. *Research Methods in Education* (2001) considered the research on inter-ethnic associations amongst students recorded in Denscombe, Patrick, Szale and Wood (1986) to demonstrate such contradictions. Previous quantitative research had found that students preferred their own ethnic group and were, in general, not forming inter-ethnic friendships. Denscombe et al. (1986) found that these findings ran contrary to the observations of many teachers. When they conducted a qualitative study, which included observations of students in class and in the playground, they found evidence of inter-ethnic friendships. The authors of *Research Methods in Education* (2001) concluded that either these results were specific to the schools studied by Denscombe et al. (1986) or that the quantitative research "failed to capture the complexity of the situation" (Denscombe et al., 1986). Similar contradictions were found in Levy et al. (2004) where a qualitative study revealed details in the process of adopting goal orientations after conflicting theories generated from other research methods. Bryman (2006) analysed the content of two hundred and thirty two social science articles where qualitative and quantitative analysis methods were used in tandem. He cautioned that researchers must be explicit about research questions and the rationale for using a mixed method approach. Arthur et al. (2012, p.148) cautioned that mixed method research becomes more complicated when dealing with more abstract research questions about the nature of knowledge itself.

Qualitative research has been used before in the area of studying achievement motivation. In their review paper, Kaplan and Maehr (2007) detailed several papers which used qualitative research methods to study goal orientations. Of particular interest are studies which use semi-structured interviews similar to our own study. Kaplan and Maehr (2007) referred to a study by Levy et al. (2004) that used this technique. We also examined a previous series of studies (summarised in Dowson and McInerney (2003)) that relied on semi-structured interviews and revealed a rich set of data about social goal orientations (see Section 2.4). Kaplan and Maehr (2007) mentioned how their open-ended questions were considered controversial at that time

but that the process led to the discovery of a new set of goal orientations, social goal orientations, where previously only anecdotal evidence existed for such academic motivations. Kaplan and Maehr (2007) concluded that the study of achievement motivation could benefit from the addition of diverse methodologies, among them qualitative methods.

3.1.4 This Project: Qualitative or Quantitative?

Initially it was intended for the project to include qualitative and quantitative research methods. Along with the semi-structured interviews, we also conducted a quantitative study of first year undergraduate mathematics students in September 2009 which resulted in the completion of four hundred and seventy one surveys. The survey had questions about study methods for mathematics. It also contained questions on two further measures: mathematical confidence and perceived usefulness of mathematics. The same cohort of students was surveyed again at the end of their first year (May 2010). It was intended to compare both surveys and look at the measures before and after their first year of university mathematics and examine if there were any statistically significant differences.

It became apparent early on in the project that the data from the qualitative part of the study was richer than the quantitative data we had collected. Consequently the survey data is not considered in this thesis. However, collection of the quantitative data was a worthwhile endeavour and the data will be analysed in future studies.

3.2 Participants

Here we will first outline how the participants in the study were selected and then we will give a brief overview of the backgrounds of these students.

3.2.1 Selection of participants

In September 2009 thirty nine students who were repeating a first year mathematics module or modules were contacted and invited to participate in this study. These students were contacted by Dr. Mac an Bhaird. Each student was invited to attend an informal discussion with the first supervisor. Thirteen students agreed to attend this

discussion and Dr. Mac an Bhaird gave each student a brief explanation of the aims of the project. Eleven of those students attended the informal discussion and were asked if they would like to participate in an interview for this study and seven agreed to be interviewed. All eleven students were given an anonymous questionnaire which was similar in format to the interview. The main purpose of the questionnaire was to allow the students to consider and think about the main themes of the interview in advance. Each student was asked to bring the completed questionnaire with them to their allotted interview time. An initial analysis of the questionnaires revealed data similar to that of the interviews. As a result, the questionnaires are not considered separately in this thesis.

After an initial analysis of the data from the 1st group it transpired that none of them had engaged significantly with mathematics support, by this we mean that their attendance levels at lectures, tutorials and the MSC were low. For additional insight we decided to interview a second group of students. This group of students were interviewed in the spring of 2010. They were from the same cohort as the 1st group and had similar mathematical backgrounds, i.e. they had received similar grades in both the diagnostic test and their Leaving Certificate (LC) mathematics exam. The LC is a high-stakes examination in Ireland taken at the end of second level education which determines entry to university. We compiled a list of students who had regularly engaged with mathematics, passed their first year mathematics modules, and who had attended the MSC five or more times. From this group we randomly chose five students from the Arts/Finance cohort and five from the Science cohort. They were contacted in a similar manner to the 1st group. Nine agreed to be interviewed and were given the same questionnaire as the 1st group. Throughout this study these nine students are referred to as the 2nd group.

It should be stressed that no pressure was put on these students to participate in this study. All students who participated in this study volunteered and the 2nd group were chosen through a random selection process as detailed above.

3.2.2 Description of students

Tables 3.1 and 3.2 will act as a point of reference for the reader. This thesis presents the analysis of a large volume of interview data from the sixteen students in this study and the reader may wish to use the tables to refresh their memory on the background of a particular student. Table 3.1 describes the 1st group and Table 3.2 describes the 2nd group. The categories in the tables are explained below:

Pseudonym: A name chosen by the authors to disguise the real identity of the students in this study.

Gender: The gender of the participant.

Course: Science - All students studying science courses must study mathematics as a compulsory subject in their 1st year.

Arts - Students studying mathematics through arts choose to study the subject.

Finance - Mathematics was effectively compulsory for all finance students in this study. Taking mathematics in 1st year was recommended by the Finance Department at NUIM and not taking mathematics would affect a student's module choice in later years of study. Students studying Finance take the same modules as Arts students.

LC Grade: The students Leaving Certificate Grade in mathematics. H indicates Higher Level and O indicates Ordinary Level.

Prof Test: The students grade out of 60 in the mathematical proficiency test administered in their first semester at NUIM. The pass mark is set at 20 and negative marking is in place.

'at-risk': A student is deemed to be 'at-risk' if they have a mathematics grade of B1 or lower on the OL LC paper or failed a diagnostic test at the beginning of the first semester.

Tutorial Attn: Number of tutorials attended by this student out of a total of 20.

MSC Attn: Number of times the student attended the MSC.

Table 3.1: 1st Group

Pseudonym	Gender	Course	LC Grade	Prof Test	'at-risk': Y/N	Tutorial Attnd	MSC Attnd
Amy	F	Finance	OC1	No record	Y	0	0
Ben	M	Science	OC3	12 (F)	Y	12	0
Colm	M	Science	OD2	6 (F)	Y	0	0
Darren	M	Science	OD3	23 (P)	Y	9	4
Emily	F	Finance	HC2	No record	N[1]	7	0
Joe	M	Science	OD1	7 (F)	Y	12	3
Majella	F	Arts	OC	20 (P)	Y	0	0

Table 3.2: 2nd Group

Pseudonym	Gender	Course	LC Grade	Prof Test	'at-risk': Y/N	Tutorial Attnd	MSC Attnd
Adrian	M	Finance	HD1	20 (P)	N	18	60
Áine	F	Arts	OB1	No record	Y	15	20
Dónal	M	Finance	No record	19 (F)	Y	18	26
Janice	F	Science	OB2	12 (F)	Y	18	10
Jason	M	Science	OB1	5 (F)	Y	20	50
Lisa	F	Science	OA2	24 (P)	N	17	20
Shane	M	Science	OA2	16 (F)	Y	20	29
Sharon	F	Arts	OA	20 (P)	N	16	23
Siobhán	F	Science	HC2	52 (P)	N	14	14

3.2.3.1 Description of modules

Students listed above as Arts or Finance took the following modules in their 1st year:

Semester 1:

Calculus I (Differential): Three lectures per week, seven tutorials per semester, seven assignments per semester (worth 25% of module grade).

Introduction to Data Analysis (A): One lecture per week, three tutorials per semester, three assignments per semester (worth 25% of module grade).

[1] We have no record of Emily's score on the diagnostic test but as her Leaving Certificate grade was quite high we have not included her in the 'at-risk' category.

Semester 2:

Calculus II (Integral):	Three lectures per week, seven tutorials per semester, seven assignments per semester (worth 25% of module grade).
Linear Algebra I (A):	One lecture per week, three tutorials per semester, three assignments per semester (worth 25% of module grade).

Students listed above as Science took the following modules in their 1st year:

Semester 1:

Differential Calculus:	Two lectures per week, seven tutorials per semester, seven assignments per semester (worth 25% of module grade).
Linear Algebra I (S):	One lecture per week, three tutorials per semester, three assignments per semester (worth 25% of module grade).

Semester 2:

Integral Calculus:	Two lectures per week, seven tutorials per semester, seven assignments per semester (worth 15% of module grade), and a mid-term examination (worth 10% of module grade).
Introduction to Data Analysis (S):	One lecture per week, three tutorials per semester, three assignments per semester (worth 25% of module grade).

3.3 Interview Process

In this section we describe the interview process as well as the analysis of the data. Patton (1990) described how interviews are used to jointly "find out what is in and on someone's mind" and to find out things from people that we cannot directly observe for whatever reason. Using interviews as a data collection method has advantages as well as disadvantages. Some of the major disadvantages are the time consuming nature of the interviews themselves (Arthur et al., 2012, p.243), as well as the transcription and data analysis processes. In addition, Walford (2001, p.85) noted that "what people say when they are interviewed should be treated with extreme care". For this reason sample sizes of studies that use interviews are usually small, and certainly smaller than the sample

sizes of questionnaire based research. However, the data obtained through interviews can be very rich and this is the main reason that we used them. *Research Methods in Education* (2001, p. 170) praised the interactive nature of face-to-face interviews, and stated how when you interview someone you are "establishing a relationship with them".

Patton (1990) highlighted how interviews are an excellent technique for discovering someone's perspectives while cautioning that we have to be careful not to "put things in someone's mind". *Research Methods in Education* (2001) similarly cautioned the researcher about asking leading questions.

3.3.1 Interview Structure

Robson (2002) outlines the different types of structure possible for an interview. We summarise the three main types mentioned here:

Structured This interview structure will have pre-determined questions in an order decided by the interviewer. There is no flexibility in the wording or order of questions. This structure is useful for reducing bias or for allowing the data to be analysed with quantitative measures.

Semi-structured This interview structure will have pre-determined questions but the order of questions can be modified based on the direction of the interview. Questions can be omitted depending on responses and prompts and other devices to encourage answers can be used.

Unstructured This interview will be an informal discussion regarding a general area of interest. Questions are generally spontaneous.

It was decided to use a semi-structured approach to the interviews in this study to allow us to compare the responses of the students in our study and to allow flexibility (e.g. being able to follow up on interesting points/responses).

Arthur et al. (2012, p.172) recommended employing an interview guide to 'ensure that you cover the topics you want your participants to address' and for in-depth interviews they recommended listing 'primary areas of exploration'. We designed our interview and a copy of the interview questions and structure for both groups can be found in Appendices A and B**.** The majority of the interview structure was identical for both groups to allow for comparison. The first section of the interview was designed to put the student at ease. Students were asked questions about the course they were studying, whether they lived in Maynooth, etc. In the main body of the interview students were asked open-ended questions about their experience of school (or pre-university) mathematics, and about their experiences of mathematics in NUIM.

The questions on pre-university mathematics focused on positive and negative teaching experiences and the student's general impression and feelings about mathematics before beginning their studies in NUIM. Students were also asked to compare studying mathematics at university to studying it at school.

The main section of the interview concerned mathematics at university. There were four sections: one each on lectures, tutorials, assignments, and the MSC. A similar format for each section was used. Students were asked several questions including why they attended or did not attend lectures, tutorials, or the MSC, why they submitted assignments, and they were also asked about their interactions with teaching staff. In addition they were asked for their opinions on each of these supports and services and for ideas on how we might improve them.

For the 2nd group the interview was amended to include additional questions on MSC services. None of the 1st group had attended the MSC regularly but all members of the 2nd group had attended the MSC at least five times. Questions included asking students about working one-on-one with a tutor, group work, quality of handouts available and questions on the extra workshops provided by the MSC.

3.3.2 Recording/Transcription

The interviews were recorded using a digital voice recorder. All sixteen interviews were transcribed fully by the first author using VoiceWalker 2.0 (1999)**.** The author decided to transcribe the interviews fully, as opposed to partially, due to the perceived richness of the data recorded during the interview process. The interview audio files were ten hours and twenty seven minutes long in total. The transcripts totalled three hundred and thirty pages in length.

3.3.3 Analysis of Interviews

Research Methods in Education (2001) outlined how it is generally considered best practice for qualitative researchers to generate theory from the data as opposed to working the opposite way around. Arthur et al. (2012) noted how Grounded Theory 'offers systematic and at the same time flexible guidelines for collecting and analysing data'. Grounded Theory has been used many times before in the field of mathematics education research. For example in Symonds (2008) (see Section 2.2 for a description of this thesis). In a study of what engineering students conceptions of understanding are in relation to mathematics at Singapore Polytechnic, Khiat (2010) used Grounded Theory to analyse in-depth interviews from twenty one students and six lecturers. Khiat used the same methodology as Strauss and Corbin (1998) and praised how "user friendly" (Khiat, 2010) those methods were.

For this reason and because of the open ended nature of the study the author, in conjunction with the supervisors, decided to utilise aspects of Grounded Theory for analysing the interviews.

Grounded Theory is a method for analysing qualitative data which was developed by two sociologists, Glaser and Strauss (1967). Instead of forming a theory and using the analysis of your research to find evidence supporting that theory, Grounded Theory allows for an open-ended approach. The theory emerges from the data itself. The methodology of analysing such interviews is laid out by Strauss and Corbin (1998).

Before they discussed the analysis of qualitative data using Grounded Theory, Strauss and Corbin (1998) outlined the notion of theoretical sensitivity, essentially the ability of the researcher to bring their knowledge and experiences to the analysis whilst ensuring as little bias as possible. They defined *theoretical sensitivity* to be: "Theoretical sensitivity refers to a personal quality of the researcher. It indicates an awareness of the subtleties of meaning of data." (Strauss and Corbin, 1998, p. 41)

Strauss and Corbin (1998) outlined how there are four main ways of developing theoretical sensitivity: literature; professional experience; personal experience; and the analytic process. The researcher gains sensitivity from the literature by ensuring they have read relevant research that relates to the topic at hand. The researcher also utilises any professional and personal experiences that relate to the research question, these experiences allow insight that other researchers might not have. The authors cautioned against bias however: "You must be careful not to assume that everyone else's experience has been similar to yours." (Strauss and Corbin, 1998, p. 43)

Strauss and Corbin then outlined how the analytic process itself can increase the researcher's sensitivity. The basic principle being, the more you interact and analyse the data you have recorded, the more you learn from it.

3.3.4 Coding Process

In this section we outline the coding process and the development of the theory in this research project in conjunction with a discussion of the methods advocated by Strauss and Corbin (1998).

The first stage of the coding process is called *open coding*. Stauss and Corbin (1998) state that the two main streams of thought while one is coding should be the making of comparisons and the asking of questions and we endeavoured to constantly incorporate these two methods into the coding process.

The author and two supervisors coded the interviews independently of each other. An initial coding was done where portions of the interview were underlined and notes made in the margin. These notes were then compared and discussed by all three coders. This

process and these discussions were crucial to the coding process. The majority of codes and notes were verified independently by each coder. The discussion allowed for the consideration of topics that the individual coders may have missed. Strauss and Corbin (1998) hail this initial line-by-line coding as being extremely "generative" while cautioning about how time consuming it can be.

A second coding then took place to revise the original notes and to develop a list of codes. This process of labelling is viewed as extremely important by Strauss and Corbin (1998), it is a process of asking oneself what this phenomenon represents and comparing and contrasting incidents to see if they fall under the same label or different labels. The codes that emerged were discussed by the author and two supervisors in a fashion similar to the process discussed in the previous paragraph.

The next process involved was what Strauss and Corbin (1998) refer to as *categorising*. They stated that after the initial coding one will be left with hundreds of labels and this was true for our own analysis. It becomes necessary to group these labels together to form *concepts* and later *categories.* The reason for this grouping, as given by Strauss and Corbin (1998), is that it would be impossible to make sense of the data unless this grouping took place. The distinction between the development of concepts and categories is not concrete. There is a hierarchical nature that evolves from building up the commonalities between labels. My supervisors and I re-read our codes many times and met and discussed the categorisation process, once again allowing insight into the data that may previously have been missed.

To explain the development of a category Strauss and Corbin (1998) illuminated with an example and we will do the same. The example explains how the process of creating concepts and categories is not linear. It became clear upon early readings of the 1st group of transcripts that many of the students were suffering from fear or embarrassment issues related to mathematics. Fear was a dominant phenomenon so we designated it worthy of being a category. We focused on this label, re-read the transcripts and discovered that there were different types of fear prevalent amongst the students. These four sub-categories became the concepts that made up the category of fear. They were fear of showing a lack of knowledge or ability, fear of being singled out, fear of the unknown, and fear of failure. It is important to note that the general idea

of fear as a dominant phenomenon came before its breakdown into four separate concepts. Strauss and Corbin (1998) allowed for this non-linear process in their method. This continuous process led to the development of other concepts and categories from the data. These are discussed in Chapters 4 and 5 of this thesis.

To obtain a better overview of themes or patterns that emerged from the data upon completion of the analysis of all sixteen interviews we formulated a *coding grid* (see Appendix C for an example of a completed grid). The reader should note that the completed grid would also contain quotes from the student in question but these have been removed due to space constraints and to protect the identity of the student in question). A grid containing all major categories and a breakdown of each by concept was produced. Strauss and Corbin (1998) devoted a section of their book to using diagrams. They never specifically suggested using a grid like the example described here, but in general they said: "Diagrams provide a "fund" or storehouse of analytic ideas that can be sorted, ordered, and reordered." (Strauss and Corbin, 1998, p. 201)

All three coders examined each transcript for examples of each concept and noted in the grid when an example occurred. The three individual grids were then amalgamated into one. Notes were made as needed for explanation purposes. Several codes did not fit into the main categories or concepts and those were recorded in detail on the grid also. The purpose of this grid was two-fold. Firstly to allow the author and supervisors to have a quantitative measure of the occurrences of concepts and categories for the purpose of discussing the general themes that emerged from all sixteen interviews. Secondly, it was necessary to have a quick guide for finding quotations when compiling papers, reports, and this thesis and the grid acted as a reference point for doing that. For example, if a quote for fear of failure was needed to support an argument it was simply a matter of scanning the grids and finding the fear of failure section. The page numbers of all quotes pertaining to that concept would be listed and the quotes are listed in order of page number below the grid.

3.4 Research Trip to Loughborough University

In May 2010 I travelled to Loughborough University in the UK to visit the School of Mathematical Sciences and specifically, the MLSC. The staff there are viewed as

experts in mathematics support in the UK and Ireland. In 2005, Coventry and Loughborough Universities were awarded Centre for Excellence in Teaching and Learning (CETL) status, and **sigma** CETL was formed. **sigma** CETL comprises of the mathematics support centres in both universities.

The reasons for my visit were threefold: to witness the operation of the MLSC for comparison purposes; to meet and consult with the academic staff there; and to meet Dr. Carol Robinson, co-supervisor of Ria Symonds (see Sections 1.1 and 2.2).

The initial aim of this project was to study the provision of services in the MSC at NUIM. (See Section 1.1) Hence the main focus of this trip was to observe another mathematics support centre in operation and discuss the contrasting approaches with the staff members there. I spent a few hours in the MLSC shadowing Dr. Matthew Inglis and observed how the centre operated.

I met several academic staff to discuss the research project and to gather new ideas. It was during discussions with Dr. Carol Robinson on what motivates mathematics students that the subject of Goal Orientation Theory arose. This discussion was important in the genesis of the project into a more general study of student motivation.

3.5 Research Ethics

Before contacting any of the students who took part in this study ethical approval was sought from the NUIM Ethics Committee in September 2009. Each student was required to complete a consent form (see Appendix D) that confirmed that they understood the nature of the study and that all information would be stored securely and anonymously.

All interviews were recorded on a digital voice recorder. They were then transferred to a PC and saved to a secure server. All voice recordings were assigned a code which corresponding to a pseudonym. Pseudonyms were chosen by the author and were known only to the author and supervisors. Pseudonyms were also stored securely on a server. Completed transcripts were stored on the same secure server and all identifying features were removed. A hard copy (CD) of the interviews was created as a backup and

placed under lock and key in a safe location with the Department of Mathematics and Statistics at NUIM.

3.6 Validity and Reliability

In this section we discuss the reliability and validity of the research we conducted.

McKnight, Magid, Murphy and McKnight (2000, p.67) define validity as "the extent to which to which a concept represents the phenomenon it is intended to represent". Cohen, Manion, and Morrison (2011, p.179) describe validity in the context of qualitative data as being addressed "through the honesty, depth, richness and scope of the data achieved'. McKnight et al. (2000, p.67-70) suggest some mechanisms through which validity can be achieved: researcher credibility (including how the study was conducted), multiple data sources and member checking, confronting outliers and sceptics, and cohesion. It is our opinion that the data we obtained from the interviews in this study was of a high quality and resulted in a cohesive series of results. We had no problem in persuading students to participate in this study and we felt that students were open, honest and forthcoming about their experiences at NUIM. We used questionnaire data taken from before each interview to double check students responses. For fifteen out of sixteen students our records of attendance matched the responses they gave. One student, Darren, was shown to give answers which were inconsistent with our attendance records and thus we use quotations from Darren sparingly throughout this thesis.

Reliability in the context of qualitative research is not easily defined (Cohen et al., 2011, p.201). McKnight et al. (2000, p.67) define reliability as "the ability to be reproduced – to be independent of the specific researcher". Cohen et al. (2011, p.202) conclude that "in qualitative research reliability can be regarded as a fit between what researchers record as data and what actually occurs in the natural setting that is being researched.". McKnight et al. (2000, p.71) claim that some strategies to improve reliability include: multiple researchers, and repetition. In Section 3.4 we detailed that the author and two supervisors coded the interviews independently of each other. Notes were compared and discussed by all three coders. The discussion allowed for the consideration of topics that the individual coders may have missed. A copy of all

interview questions asked and the interview format is available in Appendices A and B. So a similar study could be repeated by another research team. We feel that this makes our data as reliable as possible in the context described above by Cohen et al. (2011) and McKnight et al. (2000).

The validity and reliability of this study would have been enhanced by adding a third group of students with similar mathematical backgrounds to the 1st and 2nd groups. The original groups did not include students who had passed their first year examinations but who had not engaged significantly with mathematics. By including students who attended the MSC five times or more some of the outcomes of this study might have been expected. However, we were concerned with the reasons why some students are able to ask for help while others are not. For this reason, it was important to interview students who displayed a regular pattern of attendance.

A follow up study is underway at NUIM. Twenty five students with similar mathematical backgrounds, including students who passed their 1st year examinations but did not engage with mathematics to a significant extent, were interviewed in 2010 and an analysis of these interviews is in progress. The aim of this follow-up study is twofold: to investigate further the influences on behaviour that emerged in this study; and to investigate if students who did not engage with mathematics but who did pass have insights that the original groups of students did not have.

Chapter 4 - Analysis of the Data

4.1 Introduction

This section is divided into two parts: behaviour; and influences on behaviour. The Behaviour Section (4.2) will describe and outline the behaviour and actions of the students considered in this study. We will show how the majority of students in both groups initially engage with mathematics at the beginning of their first year of university and how both groups have a reasonably uniform beginning to their mathematics education at third level. Only two students did not engage with mathematics at the start of the course. We will then give evidence detailing the similar problems with mathematics that both groups face early on in the first semester. It was only later on when these students faced difficulties with mathematics that their divergences in behaviour appear. There were several important critical events (see Section 1.3 for the definition of this term) for each group. These events revolve around difficulties with lectures, tutorials, and assignments. Section 4.2 will describe these critical events and emphasise that not all of our students were aware of the importance of these events when they occurred. The reactions to these critical events are discussed in detail and we show how, at some point, the 1st group became overwhelmed by their difficulties and all of them either failed to seek help or tried to seek help and could not go through with it for some reason. The 2nd group all managed to engage with mathematical supports or sought help from friends or peers to some extent. We will see how the 1st group were motivated to avoid seeking help and the 2nd group approached their difficulties with mathematics.

In Section 4.3, Influences on Behaviour, we will examine three major themes that emerged from the analysis: fear; social interactions; and motivation.

4.2 Behaviour

In this section we detail the behaviour of students and their responses to a number of critical events and we see how students display approach or avoidance behaviour as a reaction to their difficulties with mathematics. This section is broken down into four separate sub-sections. The first, Similar Tactics (4.2.1), offers a description of the initial

uniform approach to engaging with mathematics of all but two of the students in our study. The remainder of the group attended most of their lectures, tutorials and submitted assignments at the beginning of the academic year. Section 4.2.2, Similar Difficulties, describes how all of our students, except for one from the 2nd group, had problems with mathematics early on in the first semester. These difficulties vary but, as we will see, all of these students had difficulties with assignments. A difficulty with understanding lecture material was common and was related to the difficulties experienced with assignments.

Section 4.2.3 is about the critical events encountered by both groups. Examples of critical events include: struggling with assignments; and difficulties with understanding lecture materials. We look at the two groups separately in this section as it became apparent from the analysis of the interview data that the reaction to these events was what set these two groups apart. Students were not always aware of the critical nature of these events, especially those students in the 1st group. Section 4.2.4 will detail the approach and avoidance behaviours that these students display. This section is a natural follow-on to the previous section (4.2.3) in that, once the critical events have occurred, the reaction and subsequent engagement or non-engagement that occurred was vital in determining whether these students ended up passing their first year of mathematics or not.

4.2.1 Similar Tactics

In this section we will describe the similar approaches taken by students at the beginning of their first semester of university.

Fourteen out of the sixteen students in both groups approached the beginning of their mathematics course in university with similar tactics. Only two students, both from the 1st group, did not engage fully with mathematics at the beginning of their first semester. Amy had financial and personal issues that impacted upon her engagement in semester one. Colm was not attending lectures often and said that he rarely paid attention in class when he did attend. Colm had a difficult relationship with mathematics from school which may have influenced his lack of engagement:

> *I was always terrible at maths… Like, the whole way through primary, through secondary school I was always struggling.*

Only one of the sixteen students was enthusiastic about the prospect of studying mathematics at university. Reasons for this might include the fact that twelve of sixteen students had struggled with mathematics in school (except for Darren and Majella from the 1st group, and Sharon and Áine from the 2nd group) or that only three out of sixteen students had chosen to study mathematics at university. Joe (1st group) explained how he felt about taking maths as a compulsory subject:

> *I knew from day one that maths was gonna be a thing that I was gonna struggle with and I was actually tempted to drop out because of maths.*

A quotation from Lisa (2nd group) exemplifies the lack of awareness of the mathematical content of their courses by fifteen out of sixteen of the students in this study:

> *I talked to just my career guidance teacher and she just said aww, it involved maths…I knew I had to do a maths module but I didn't think there'd be that much in it like.*

In fact only one student, Jason (2nd group), gave the impression that he was fully aware of the mathematical content of the course he had chosen to study.

When asked why they attended lectures and tutorials in their first semester the general response from both groups was quite uniform. The majority of students stated that they felt they would be missing out by not attending class. When asked about why he attended lectures Jason (2nd group) said:

> *I was petrified that I'd miss out on the material.*

Students also said that they simply felt compelled to attend:

> *Last year we thought we had to go to all of them or else we didn't pass.* (Siobhán, 2nd group)

Another common response was that they needed to attend to keep on top of mathematics. A response similar to this one by Majella (1st group) was common:

> *I'd always be afraid I'd lose too much or miss too much in the lectures. Now I've loads of friends, I could always get notes or whatever but it wasn't that it....I just, I didn't like to miss lectures.*

Responses like Janice's (2nd Group) were also common, she talked about needing to go to lectures to make sure she had notes and how she would never miss lectures:

> *Because the notes weren't on moodle. I would have gone anyway because I don't miss lectures. But, the main reason I had to go was because the notes weren't on moodle.*

Interestingly four out of nine students in the 2nd group also noted how they attended tutorials due to the belief that they were compulsory. However, this is not actually the case; students are told that they are expected to attend tutorials but are not penalised if they subsequently did not attend.

In contrast only one student from the 1st group, Ben, stated he attended tutorials on the basis of thinking they were compulsory. The interview format was flexible at this point and if students stated they did not attend the majority of their tutorials, then they were asked why they did not attend. The students in the 2nd group mostly attended tutorials and were asked why they did attend. See Appendices A and B for a detailed view of the questions about tutorials.

When asked about submitting assignments, seven students (two in the 1st group, five in the 2nd group) mentioned that they were motivated by wanting to understand or to "learn" the material but nine out of sixteen students described how they felt the submission of assignments was primarily motivated by the continuous assessment marks that were attached to them. When asked about why he submitted assignments Shane (2nd group) said:

> *I knew how much they were worth and I thought, I didn't know what the exam was going to be like so I thought if I kept the CA high.*

Joe (1st group), rather worryingly, emphasised the motivating factor of continuous assessment over that of understanding the material:

> *It's not really if you understand them, it's the fact that it's* [the] *CA is the only initiative, not that they're gonna help ya.*

As noted in the introduction to this section, not all students were engaging at the beginning of their first semester. Two of our 1st group admitted being absent from lectures and tutorials for a variety of reasons. Amy had a full time job in the first semester which did not allow her to attend most classes. Colm admitted that he rarely attended and if he did he was not paying much attention:

> *Em, classes were so big, I had a tendency to sit towards the back…was probably my own fault…I'd be talking and trying to take notes at the same time. And then the notes that I'd taken down, when I looked back on them later on they'd be half of each section you know what I mean, so, but then in my own head I'd think, "Ah yeh, well I took these down, this must be what it is" and then I'd look at it again and it just doesn't make any sense. In hindsight, it was just a half lecture,* [you] *can't really make sense* [of it].

The majority (fourteen out of sixteen) of students started their first semester by attending lectures and engaging with mathematics. We have already explained how the majority of students did not choose to do mathematics at university nor were they aware of the full extent of the mathematical content of their courses. These similarities in behaviour and mindset at the beginning of their mathematics education at NUIM highlight the difficulty in identifying, at the start of the academic year, those who will engage from those who will not.

We have seen that students felt that they were obliged to attend and more than half of our students were submitting assignments based on the motivation of keeping on top of their continuous assessment. In Section 4.2.2 we will describe how almost all of the students faced difficulties with mathematics early in their first semester.

4.2.2 Similar Difficulties

In this section we describe how both groups of students encountered similar difficulties with mathematics from early on in their first semester at university.

Both groups, with the exception of one student from the 2nd group, had difficulties with mathematics early on in their first semester. Students in both groups (all seven in the 1st group and seven out of nine in the 2nd group) described their difficulties in understanding and engaging with the material presented in mathematics lectures.

> *I had great trouble understanding what was going on. I was glad to be there but at the same I was like "what the hell is just going on, I've no clue".* (Joe, 1st group)

> *I had no idea what was ever going on in a lecture…all that you ever had to do in the lectures was take notes. And I don't even think it was about trying to understand them, it was more about rush, rush, rush, get through everything.* (Sharon, 2nd group)

> *To be honest, lectures, you don't really learn anything in maths lectures, well I didn't.* (Janice, 2nd group)

> *They're* [lectures] *a lot more in-depth, em, after a while then, from going to, if I missed a class, I'd come into the next class and I'd be completely* [lost]. *I wouldn't understand it and would put me off again from going to the next one*. (Colm, 1st group)

Eleven out of sixteen (all seven of the 1st group and four out of nine of the 2nd group) students felt that they were unable to ask the lecturers for help or to ask a question in lectures. The reasons they gave included that they were too embarrassed, the size of the class was too daunting, or they felt the lecturer was unapproachable. The following responses were typical:

> *In lectures I'd never ask questions, I'd never go to, I've never been to any lecturer's rooms at their availability times… I know they just have to put it up there, but I wouldn't see it as something they want you doing… you just expect the couple of nerds lining up outside the door pulling up everything in lecture notes.* (Shane, 2nd group)

> *Well in maths I wouldn't* [have] *been ab*[le]*, well I don't really know how to ask a question, well no, it's not that, I do have questions but, I suppose it is because of class size, they're gonna laugh at me if I ask this in front of everyone.* (Amy, (1st group) when asked about not asking questions in a mathematics lecture)

> *Coming back from being a 1st year just coming from secondary school I would have thought as well that if I went up to lecturers and said things, like "I haven't been coming to many of your classes, I haven't a clue what's going on". I would have thought I just be given out to or I dunno, I didn't know what way it worked you know?* (Colm, 1st group)

The next difficulty that our students encountered was problems with assignments. All but one student (Jason, 2nd group) reported having difficulties with assignments early in the first semester and responses like those below were typical:

> *I got my first assignment back and I think I probably got about 30% in it and I don't even know how I got that cause I wrote down the most random load of rubbish.* (Janice, 2nd group)

> *I mean they were just very, very difficult, as well as the fact that you would be getting about 4 or 5 questions at a time and they're all quite long in themselves but you'd be only getting marked on 1 which is very, em, kinda, something that would put you down cause you'd be putting so much work into some questions and doing it really well and you'd be finding others very difficult.* (Ben, 1st group)

> *I think I did really bad in my first homework and I couldn't really understand why*. (Sharon, 2nd group)

> *Something I dread*[ed] *would be going onto moodle and looking at the homework and just thinking what is this?* (Colm, 1st group)

We have seen how two major difficulties emerged for the majority of our students: difficulties with lecture material; and problems with assignments. We noted how many students felt they could not approach lecturers for help with their problems. We discuss in Section 4.2.3 how there were several critical events which affected their engagement and how a difference of tactics soon emerged between the two groups.

4.2.3 Critical Events

Every student in this study experienced a number of critical events in relation to their engagement with mathematics. We remind ourselves of the definition of a critical event: an event that emerged from the analysis as being important in determining the future engagement of a student, whether they were consciously aware of its critical nature or not. These critical events can be seen as a catalyst to the critical junctures described by Ryan et al. (2001). They described it as, "the decision to avoid asking for help when students know they need help". While presenting the critical events, we also discuss students' reactions to these events. The 2nd group's reactions to the critical events were what highlighted these events to us during the data analysis. We subsequently returned to the 1st group and examined their interviews for critical events in their engagement. We found that they also experienced these critical events but often did not react to them. In this thesis, when we use the term 'reactions to critical events' we define this to include both reactions and lack of reactions to these events.

In this section we analyse the behaviours of the two groups separately. The reasons for this are twofold: firstly, the behaviour of students in each group was broadly similar to the other students in that group; and secondly, both groups had divergent reactions to these critical events. These differing reactions had a huge effect on these students' ability to pass their first year of mathematics. The students in the 1st group in general avoided facing up to their difficulties with mathematics whereas the 2nd group approached their difficulties. We also refer to this approach or avoidance behaviour as a *flight or fight* response and we examine this in Section 4.2.4.

In the next section we examine those critical events that occurred for the 2nd group.

4.2.3.1 2nd Group

For eight out of nine of our 2nd group a critical event occurred almost immediately. All eight of these students attended the MSC upon having problems with their first few assignments. The ninth student, Jason, also attended the MSC at the beginning of the first semester with the intention of asking for help if he began to struggle with mathematics. These students were, in general, nervous about initially attending the MSC. For example, six out of the nine did not attend the MSC on their own, but they overcame this issue and utilised this support by attending the MSC with their peers and working together in groups. The following quotes explore the decision of the 2nd group to approach their problems:

> *I think I did really bad in my first homework and I couldn't really understand why, so I had to, make sure I wasn't going to do crappy in the rest of them.* (Sharon)

> *Well I'd be trawling through books upon books looking for a similar example to the one on the assignment and then try apply it to the question. They'd* [MSC staff] *always know straight up what to do with it. It was a lot faster, easier as well.* (Shane)

> *I had trouble with one of the questions, I couldn't understand what was going on. So I brought my notes* [to the MSC]. *What I decided after the 1st visit is that, it's clear to me that number 1, it could be helpful, number 2, coming more frequently rather than less frequently is obviously going to be, it'll have a cumulative type benefit.* (Adrian)

The 2nd group displayed varying levels of engagement with the MSC. Four of these students were comfortable working on a one-to-one basis with a tutor in the MSC. Jason mentioned how if he got time with a tutor alone he found it beneficial:

> *Yeh, if you get it, it's great. If you can get someone there to sit down, you can bounce ideas of them, bounce questions off them, you know, it's great.*

The other five were embarrassed or fearful of doing so. Responses like the two below were common amongst these five:

> *Say like when you're going over, if I went over on my own I hated it! I dunno, I just felt really like, just didn't wanna be there, felt kind of stupid, even though everyone's really nice and really lovely like, you're just still just kind of stuck there.* (Áine)

> *I went once by myself and I actually didn't really like* [it] *cause I felt like I was being stupid.* (Sharon)

However, these five students did not avoid the MSC like the 1st group did. Instead they used the safety of group-work to avoid being singled out by tutors. Sharon talked about how she and two other students attended the MSC and worked in a group:

> *There was just 3 of us usually. It was just, like one of you knew one step, the other knew one other step, it was easier to explain it to each other rather than having a lecturer or someone trying to explain it to you where it's like, impossible!*

Four of these students sought help from friends and peers outside of the MSC which was something that our 1st group rarely mentioned. Janice (2nd group) commented on how she could never have passed without the help of her friends:

> *To be honest if I thought I could pass maths I'd still be doing it. But considering I got through 1st year, and I'll willingly admit that I got through 1st year with people who were willing to help me. I have a couple of friends who are brilliant at maths and they sat down during the study week for maybe 6 hours for a couple of days and just grilled maths into me.*

At the other end of the scale, Adrian, the most capable of the students in our study, formed a study group with other enthusiastic students:

> *Sometimes after one of the maths classes the schedule is convenient for Callan Hall* [lecture theatre], *myself,* [student's name] *and* [student's name], *although it's not the MSC, we work together and we solve things on our own and it's great.*

Adding to the complexity of the 2nd group was the fact that like the 1st group they sometimes stopped attending lectures or tutorials. It was not because they had given up making an effort or were finding it too overwhelming, but because they felt they could get the help they required with mathematics elsewhere, either in the MSC or from their friends. This exemplifies how aware these students were of what worked for them. They knew that certain supports worked better for their style of learning and they discarded those that did not. This could be easily dismissed as a lack of engagement in a quantitative analysis but the following quote from Shane displays the complexity of the decision making some of these students used:

> *I just realised all I was getting out of the lectures was notes and all I was ever doing was looking over the notes when I came out of it and I got the same understanding of it, but just the notes as I would going to the lectures…I'd say if I didn't bother with lectures at all and just followed the course content I'd be getting past the exam.*

Similarly, Siobhán did not see the use in attending tutorials:

> *You spend hours in the MSC doing your homework and then explain how to do it and you go in and she* [the tutor] *explains the exact same thing that you're after learning, so it's a bit pointless just sitting there for an hour.*

Eight out of nine students in the 2nd group struggled with an assignment and attended the MSC as a reaction to the critical event of struggling with assignments at the beginning of their first semester. The ninth student, a mature student, was exceptional in that he was determined to hunt down all avenues of help and never allowed himself to get into a situation where he struggled. The students in the 2nd group also encountered further difficulties when they reacted to their initial problems, but they still found some way to approach these issues. This was in total contrast to the 1st group whose lack of reaction to and possible lack of awareness of critical events was detrimental for their engagement.

4.2.3.2 1st Group

In this section we examine the critical events that occurred for the 1st group. In general, there were three types of critical event for students in the 1st group: becoming lost or confused with the material in lectures; struggling with assignments; and struggling or

becoming embarrassed in tutorials. We demonstrate how, in complete contrast to the 2nd group, the 1st group did not respond effectively to these critical events. This had clear negative effects on their engagement.

This section differs slightly from the previous one as the 1st group did not have the same uniform reaction to struggling with an early assignment as the 2nd group did. So for the 1st group, in general, there are three types of critical events. The first was becoming lost or confused with the material in lectures:

> *I'd literally be jotting stuff down and I wouldn't have anytime to actually understand what I'm doing. You know if you didn't get everything down you're kind of messed* [up]. (Joe)

The second was struggling with assignments:

> *Well I mean the assignments were again complicated and very long, and you were trying to do them and you just couldn't get through them.* (Ben)

The third was struggling or becoming embarrassed in tutorials:

> *Well, me personally, I wouldn't in front of a group* [tutorial group]*, I wouldn't ask a question*. (Emily)

Whereas the 2nd group sought help in the MSC the 1st group did not. We demonstrate how the 1st group did not, in general, respond to these critical events in a positive manner. This had negative effects on their engagement. Colm talked about how he reacted to struggling with assignments:

> *… just let it get on top of me and then even if I did, I was almost, something I dread would be going onto moodle and looking at the homework and just thinking what is this?...so even after the first couple of times where I'd do it and struggle with or whatever, hand in a bad homework, but I thought better than handing in nothing. Then…had a look at it and oh my god, this is ridiculous…I just looked at and I'm not gonna be able to do this. And then progressed on from that, just what's the point in even looking? I know I'm not gonna be able to do it so that was it.*

For Amy, difficulties with assignments transformed into an unwillingness to attend tutorials:

> *I didn't go, no cause I found them really daunting and you know the way they hand back your assignments? Like, I found I was sitting beside people*

> *and they were like "oh my god, I got a 100%". And I was like "I didn't hand in my homework"…You know that they ask you questions and you're like "I haven't a clue" and everyone is looking at you and like "Why don't you know?".*

Another common response to the critical event of struggling in lectures was that eventually students become frustrated with not being able to follow in class and stopped attending:

> *2nd semester would have gotten far more difficult and it just started to weigh down. And you just didn't want to attend anymore.* (Ben, on lectures)

Recall that Shane (2nd group) also stopped attending lectures, however, he sought help in the MSC. This behaviour was in complete contrast to the behaviour of the students in the 1st group.

Students in the 1st group did adopt some strategies when confronted by these critical events. These included reliance on methods like cramming that perhaps got them by in school:

> *I tried to cram, em, just wasn't going in I suppose and even if I thought I had learned something, then when I did the test, I realised I hadn't. So that was all really, I tried to cram it in.* (Colm)

Two of them changed their study habits to only include subjects they enjoyed:

> *I just kinda pushed it to the side and worked on my other subjects.* (Emily)

Five of the students in the 1st group displayed a pattern of behaviour that indicated that they did not make a sustained attempt to seek help. If they did attempt to seek help it did not seem to have a significant impact upon their engagement levels:

> *Em, sometimes no, just decided that there was no point cause I mean you'd be going to your friends and stuff like that and they still wouldn't have an idea. Or you'd be stuck together. But you just got more and more down about it and you just don't care.* (Ben)

Fear was a common reason why students in the 1st group did not seek help. In the case of Amy, the fear or embarrassment of asking for help in the MSC overcame her at the last moment and she could not go through with it:

> *I heard about it, thought it would be a great idea. But didn't have time and didn't go. Then second semester I went to the door, looked in and it was really, really busy and I just thought "hmmm, no!". And I turned around.*

Emily commented on how she felt she did not need to ask for help as she had convinced herself she could get by on her own. It was not clear where this attitude developed but it is a worrying trend due to the fact that these students were unlikely to seek help, either from a friend or from one of the supports available. Amy had realised she was in trouble but her response was not to seek help. She said:

> *Cause I knew in my head how bad it was or how bad things were but I just kinda kept thinking some miracles is just…I'm just gonna become a maths brain and that's it.*

Emily used almost the same words:

> *I think I was kind of hoping for some miracle.*

Even though these students were aware of their difficulties they seemed unable to respond in a positive way.

It seems that the critical events outlined for the 1st group passed them by. In contrast to the 2nd group, the 1st group did not react appropriately to getting into difficulty and hence did not seek help in a meaningful way. We should note that it is not apparent that many of these students were, in general, aware of the importance of these critical events at the time or even upon reflection. The critical events emerged from the analysis as important in determining the future engagement of these students. In the next section we discuss how we can categorise the behaviours of both groups as either an approach to or an avoidance of difficulties with mathematics.

4.2.4 Approach and Avoidance

In this section we outline the approach and avoidance behaviours that students in both groups displayed. A behavioural pattern was clear from the study of these sixteen students. In general, the students in the 1st group avoided facing up to their difficulties with mathematics. The 2nd group were all motivated to approach their problems.

From our analysis it is clear that motivation plays an important role in the approach and avoidance behaviour displayed by these students and we discuss this in Section 4.3.3. Previous quotations in Section 4.2.3 have already alluded to a general fight or flight response from students when faced with difficulties.

Students in the 2nd group, as detailed in Section 4.2.3.1, were motivated to seek help for their problems with mathematics:

> *I went to the MSC constantly and I think at first it was about homework, to make sure you get them right. But put it this way, I wouldn't have passed any exams without that.* (Sharon, on why she went to the MSC)

> *I felt that, as I said, there were procedures in place, when I didn't understand something, my own personal decision, my own personal resolve was that nothing would go by me that I didn't understand. I wouldn't let anything go to the next week without understanding it.* (Adrian, on the understanding of mathematics)

Dónal's persistence was exemplified by the next quotation. He spent hours working at mathematics, and eventually realised that he could save time by attending the MSC. However, most importantly, he never gave up:

> *And, I suppose my experience would be, if I encountered a problem, for the 1st half of the semester I em, sort of tried to figure out problems by myself. Spend hours just trying to work through a little problem, whereas when it came to the MSC they just sort of like, put me on the right track.*

That persistence was mirrored by Áine who discussed assignments:

> *Like I wouldn't say any of them were particularly easy like. Some of them you'd get a couple of them done fairly quickly but a lot of them were quite challenging and like you would spend a while on them. I'd spend maybe two hours, between 2 and 3 hours on my assignments every week.*

If they encountered difficulties, students in the 2nd group altered their engagement and were motivated to seek help elsewhere. As seen in Sections 4.2.2 and 4.2.3, Shane and Janice both struggled in lectures. Áine became frustrated with the lectures, she did not see the relevance of them:

> *Just attending those lectures actually irritated me so much and the notes even weren't great like…I'd say I would have found it so much worse without the MSC. Because I always went there to do my assignments.*

As we describe in Section 4.3.2.2, Janice sought help from friends and in the MSC. Áine attended the MSC to get help with her assignments. Shane eventually viewed attending lectures as pointless as he was not getting any extra understanding from them. He viewed assignments as important and was motivated to find help with them:

> *Eh, a lot of time when you got the assignment you didn't really know what to make of it. And then maybe when you went to the MSC with it you'd get it then. I'd say I could not attend a lecture and not attend tutorials and go into the MSC and it'd be explained and worked out. And I've done it before,* [inaudible] *and went and had it explained.*

The 1st group in general, avoided dealing with their problems. Section 4.2.3.2 already outlined a pattern of avoidance behaviour for the 1st group. As we have detailed, they found excuses to avoid tutorials:

> *My tutorial was on a Monday morning at 9am and I was far behind so I said I want an extra hour in bed!* (Joe)

And gave up when faced with a difficult assignment:

> *Sometimes yeh, you were just like "this is too hard" and I just, and other weeks I just didn't even* [bother]. (Emily)

> *If you tried, you know tried to do a few homeworks for could be 3 hours and I'd just get really, really frustrated and that kind of memory of frustration I suppose would reoccur. Next time I'd even think about* [not doing it], *you know I just don't want to annoy myself like that again.* (Colm)

Ben made some attempts to seek help from friends but eventually ended up giving up:

> *I just decided that there was no point cause I mean you'd be going to your friends and stuff like that and they still wouldn't have an idea. Or you'd be stuck together. But you just got more and more down about it and you just don't care.*

This quote from Emily encapsulated the flight response of students in the 1st group:

> *I wasn't going to lectures, when I was doing my homework I didn't have a clue so I was just like "I cant go to a tutorial cause I wont know how to do...." you know that sort of way?*

The next quote from Amy demonstrated how, even when she realised she needed help, she still avoided seeking it:

> *I just didn't go. I thought, I suppose I did think about going but I just kept putting it off thinking "no, we'll go next week". You know, and there was always that thing where I'll go to lectures, tutorials, go to the MSC next week.*

We have detailed the behaviour demonstrated by both groups and showed how, in general, the 1st group avoided dealing with their difficulties with mathematics and the 2nd group approached their difficulties.

We have detailed in this section how most of the students from both groups have similar problems with mathematics at the beginning of their first semester. However a divergence in behaviour of the students in both groups soon occurs. We showed how both groups encountered a number of critical events. The reactions of the students to these critical events is crucial, the 1st group avoided facing their difficulties with mathematics whereas the 2nd group approached their difficulties. Trying to ascertain what separates these two groups of students was the central aim of this study and the next section outlines three major influences on the behaviour of these students.

4.3 Influences on Behaviour

In this section we elaborate on the different behaviours detailed in Section 4.2. The motivation for analysing the data in this way was to determine what differentiates the 1st group from the 2nd. We have noted in the introduction that quantitative measures to determine whether a student is 'at-risk' or not may not always accurately indicate if they struggle with mathematics at university. We demonstrated how both groups exhibited similar tactics and encountered similar difficulties at the beginning of their university mathematics courses. We looked at the importance of critical events to students' engagement with mathematics, we briefly considered their reactions (or lack of reactions) to these events and outlined how students tended to either approach or avoid these difficulties. So far, this difference in reaction is the key difference between the two groups. To gain some insight into the reasons why the students reacted in these ways we present an analysis of the interview data in this section. This section deals with the three main categories that emerged from the analysis of the interview data: fear; social interactions; and motivation.

These categories were not always distinct and sometimes overlapped. This is to be expected due to the complexity of the responses. For example, students often mentioned how they felt fear or embarrassment in a social situation in relation to mathematics. As such, this section only presents those categories and concepts that emerged clearly from the analysis.

4.3.1 Fear

In this section we examine how our analysis showed that the 1st group suffered from fear or embarrassment in relation to seeking help. This fear was critical in preventing the first group from engaging with mathematics. The 2nd group experienced similar fears but those fears were not a barrier to their engagement.

For six out of seven of the students in the 1st group, fear or embarrassment had a profound impact on their engagement. The seventh student, Majella, was a mature student and her motivations and behaviour were difficult to analyse. She did mention suffering from fear or embarrassment but, as we show, it was not to the same extent as the other six students in the 1st group.

During initial analysis of the transcripts of the 1st group it was apparent that fear and embarrassment were quite prevalent. Upon specific analysis of the category of fear we found that this fear manifested itself in four different ways: *fear of showing a lack of knowledge or ability* (a fear of embarrassing oneself in front of a teacher in relation to mathematics)*; fear of being singled out* (a fear of embarrassing oneself in front of friends or peers in relation to mathematics); *fear of the unknown* (a fear of services or aspects of their mathematics education at third level that they would not necessarily have experienced before)*; and fear of failure* (a fear of facing one's own shortcomings and a fear of one's own emotional reactions to failure). Each of these concepts is examined in detail in this section. The reader should note that these concepts sometimes overlap.

It was perhaps with surprise that we discovered that the 2nd group were also often affected by similar fears and embarrassment. The analysis soon showed, however, that those fears were not detrimental to the engagement of the 2nd group (see also Sections

4.2.3.1 and 4.2.4). These students found ways to deal with their fear. For example, if students were afraid to ask for help from their lecturers, they went to the MSC instead. If they were afraid of asking for help on their own they used the safety of a group to seek help.

4.3.1.1 Fear of showing a lack of knowledge or ability

In this section we discuss the concept *fear of showing a lack of knowledge or ability*. This was defined to be a general fear or embarrassment of showing a lack of knowledge of mathematics in front of staff members or fear of asking for help from members of teaching staff.

The first group let this fear detrimentally affect their engagement. Colm explained:

> *If you hand in a bad homework the lecturer can focus a lot more on you and you know it will make you feel, not stupid but if you hand in a bad homework, this is me personally, I'd be less inclined to go to the tutorial.*

And Joe explained how that fear prevented him from attending the MSC:

> *I was actually really embarrassed and intimidated about going and saying, "listen guys, I struggle horribly with maths"…That's where you feel like a bit of a dumb-ass saying I'm kind of struggling on your basic calculus here, do you mind going back a few steps.*

Joe's issue may have stemmed from bad experiences from school in relation to mathematics:

> *In primary school with fractions, I was very nervous as a kid, so I was always afraid to ask questions. And you know, you're, I was always afraid to be called up in front of class if I had a problem, I just literally shied away and the problems got worse and worse.*

Amy was constantly worried about looking stupid or, as we'll see in Section 4.3.1.2, being singled out for attention by her peers. As a result she would not ask questions in mathematics lectures:

> *Well in maths I wouldn't* [have] *been ab*[le]*, well I don't really know how to ask a question.*

Interestingly she had no issue asking a question in her Accounting lectures which emphasised that she was worried about her perceived lack of knowledge of the subject:

> *I did in one, in Accounting, but that's because I was comfortable with it and I knew what I was talking about and I corrected the lecturer and I asked a question. So, I was comfortable with that.*

Fear of showing a lack of knowledge or ability also featured heavily amongst the 2nd group. Five out of the nine students in the 2nd group found one to one interactions with MSC tutors difficult:

> *I just never went by myself in the first place. I went once by myself and I actually didn't really like cause I felt like I was being stupid.* (Sharon)

However, this student, along with the four students who displayed similar behaviour, attended the MSC with friends and was comfortable asking for help in the safety of a group. One explanation for this may be contained within the following quotation from Áine where she detailed (in the context of working in a group with a tutor) how the tutors never made her feel inadequate even if she herself sometimes felt that way:

> *All the tutors were really nice like as well which made it so much easier to kinda, you didn't feel like a complete twat going in, you know that kinda way? Sometimes you just feel so stupid and you're like "I can't do this" and it could be so simple like you multiplied wrong or something. And they'd, they'd just be like "well, you did that wrong". It was just kinda the way they said it, it was so sound, it was so nice. And you were talked to like you were an adult, you were never talked down to. No matter how stupid the question was or how small or how large, you were always helped like, you were never kinda put down.*

Janice always worked in the MSC on her own and she backed up Áine's comments about the tutors helping to alleviate some of the fear of showing a lack of knowledge or ability:

> *Yeh, they were helpful, just the 1-1 help where you felt that you could ask and the fact that they never laughed at you. Cause that's always the big fear asking a question that they're gonna turn round and laugh at you and none of them ever looked at you to say you're stupid.*

So we have seen that exposure to the MSC and the tutors may have helped alleviate the fears of some of these students in the 2nd group. The 1st group never engaged with the MSC to any proper extent and hence might never have been exposed to the relaxed and

friendly atmosphere that exists there. However, some of the students in the 2nd group had no issue at all with showing a lack of knowledge or ability. In particular three mature students, Adrian, Dónal and Jason did not worry about demonstrating a lack of knowledge. Adrian's response was typical:

> *I'm not afraid to ask questions, I don't think it reflects poorly on me if I don't understand something.*

4.3.1.2 Fear of being singled out

In this section we discuss the concept *fear of being singled out*. We defined this fear to be a fear of standing out from the crowd and not wanting to show inadequacies in front of peers.

Students in both groups suffered from a fear of being singled out, although the 1st group suffered more acutely from this concept. Ben feared standing out in lectures with large numbers:

> *I mean in such large groups it's hard to ask questions cause there's just so many people around. ... It's just, it can be, I mean you don't want to say something stupid in front of 200, 250 people.*

Amy was particularly afflicted by fear and embarrassment in relation to interactions with teachers at third level as we have seen in Section 4.3.1.1. Here she discussed her fear of being singled out in front of peers in a tutorial:

> *You know that they ask you questions and you're like "I haven't a clue" and everyone is looking at you and like "Why don't you know?"*

Joe refused to ask questions in lectures due to a fear of his classmates thinking less of him:

> *It's really hard to ask a lecturer a question you know. Cause there's so many people in a lecture, you don't know if they think what a dumb-ass, not that that bothers me, but there's just so many people you know.*

Ben had the same issue, he also felt class size in lectures made it difficult to ask questions:

> *Just if they were a little bit smaller, in groups a little bit smaller that would've been nice. I mean in such large groups it's hard to ask questions cause there's just so many people around.*

For the 2nd group a common worry about working with peers in the MSC was that of embarrassment:

> *Well just the whole you don't want to stick up your hand cause you'd feel embarrassed if you were keeping everyone back. (Janice)*

However, Janice, like the majority of students in the 2nd group, had a core group of friends with whom she worked on mathematics. Several of these students spoke about the unease and embarrassment they had with asking questions in the MSC when working by themselves, and how working in a group helped negate that fear:

> *I'd feel a bit more shy cause you feel like you're the only one yourself saying "I don't know that". Where there's obviously a few of you* [in a group] *saying we all don't know.* (Lisa)

When questioned about group work in the MSC, many of the students in the 2nd group mentioned how beneficial it was to be able to bounce ideas off others. They also noted how working in groups left them less reliant on the help of MSC tutors and commented on the sense of team work that built up from working on problems together.

4.3.1.3 Fear of the unknown

In this section we discuss the concept of *fear of the unknown*. We defined this to be a fear of services or aspects of their mathematics education at third level that students would not necessarily have experienced previously.

Students in both groups were sometimes paralysed by a fear of the unknown. The transition from second to third level was difficult for most of these students, and often they were not sure how the system works:

> *It was extremely daunting, it was very scary, cause when you're told you're doing Higher Level (HL) maths, like 3rd level maths you know? It's not at all nice to know, you know it's very scary, you know, like exposition*[2]*, never used at OL. Yeh, so that, you know what I mean, you lose 20% of your grade*

[2] On each assignment, 20% of the marks were awarded for mathematical exposition. This term refers to the correct use of mathematical symbols and language.

> *before they even start looking at you know what I mean? It's a lot to take on. And the notes weren't on moodle so that scared the crap out of me as well.* (Joe, 1st group)

Similarly, Janice (2nd group) displayed a fear of teachers "skipping lines" throughout her interview and it was obvious that she was fearful of this upon transition to third level:

> *Well in school, my LC OL teacher, cause they've so much time in OL to go over and over stuff. She went over it and over it and over it, constant repetition. So it was drummed into you. Every line was written out, there was no skipping lines, you know even 2/4=x…every line, no skipping. The second you came into college you could go from the 1st line to the 2nd last line of the sum and you wouldn't know how they got there!*

Fear of the unknown materialises most saliently when the students in the 1st group discussed the MSC. None of the students in this group engaged to any serious extent with the MSC. The following quotes illustrate the fear felt by these students when considering the MSC:

> *You know, kinda nervous to go off somewhere you didn't understand, you know you didn't, stuff that you want to* [inaudible] *strangers or stuff that you did not understand. And you just kind of felt embarrassed. (Ben)*

> *I heard about it, thought it would be a great idea. But didn't have time and didn't go. Then second semester I went to the door, looked in and it was really, really busy and I just thought "hmmm, no!". And I turned around.* (Amy)

From our experience, students can hear conflicting information about the mathematics support services provided at NUIM and in Emily's case this manifested itself in a fear of attending the MSC:

> *I knew you could go in and do your homework and if you had any questions…but then there was also this thing that you need to have your notes with you and if you didn't have….I dunno what it was… you've to bring your lecture notes with you cause different lecturers teach different…so if I didn't have the notes for that.* (Emily)

While students are told they must bring their lecture notes with them to the MSC, in practice no student is ever turned away if they do not. It is almost always possible for students to work using resources available inside the MSC and they are encouraged to bring a full set of notes the next time they attend.

For Colm a fear of the unknown still afflicted him even after he had realised he had failed his first year and knew he needed help. After he received his results he was paralysed with inaction:

> *I didn't really even think to go into college, I didn't know, I wouldn't know who to talk to. I don't know...at that stage I didn't even know some of the names of my lecturers, I knew* [lecturer's name] *and that was it but I didn't even know his second name.*

The 2nd group had similar fears. Jason, a mature student, was concerned about returning to college after a number of years at work:

> *Eh, well I mean, the time difference, the time span, I just came in and I knew nothing about it to be honest about it. Absolutely nothing.*

Dónal had been home-schooled and was concerned if he would be up to the standard required:

> *Yeh, but my biggest concern would have come because I was never at school I was never sure if I was up to the standard so maybe some of my insecurities came from that.*

Neither Dónal nor Jason was affected significantly by these insecurities. Both were mature students and both got through their first year of mathematics at NUIM without much difficulty.

Two students in the 2nd group expressed fear of the unknown with regards to the MSC. Lisa was nervous about not knowing what went on in the MSC:

> *I was obviously shy walking in, you don't know where you're going or what's happening.*

Lisa quickly overcame those fears and regularly attended the MSC. Shane specifically mentioned how he was afraid of being alone in the MSC but he overcame that fear when he saw how busy it was:

> *Well I wasn't sure about it now, I didn't think, maybe how popular it'd be. So I thought, you know, if I go in maybe I'll be the only one in there…But when I went in it was packed out of it so.*

Unlike the 1st group, students in the 2nd group had peers or friends to ask about the MSC or whom they attended the MSC with. The 1st group never mentioned discussing the MSC with their peers or knowing anyone who attended regularly. Five of the 2nd group always attended the MSC with a friend and three of the remaining students in the 2nd group would often work in groups inside the MSC. It was clear from the analysis that social interactions and the influence of friends and peers was an important differential between the two groups in relation to this concept. We explore these social supports further in Section 4.3.2.

4.3.1.4 Fear of failure

In this section we examine the concept of *fear of failure*. This can be defined as a fear of facing one's own shortcomings and a fear of one's own emotional reactions to failure. This fear was more prevalent in the 1st group but we also examine how the 2nd group used fear of failure as motivation to do well.

In the case of the 1st group we note how this fear in some cases had a clear and explicit effect on the engagement of these students. Amy was afraid of receiving a bad mark:

> *Cause if it's handed back and I see an F beside it and I didn't wanna see that F. And that's kind of gearing towards an exam you don't wanna see Fs coming at you.*

Colm explained how the memory of previous unsuccessful attempts on assignments was de-motivating:

> *Emmmm, it was probably frustration, you know? If you tried, you know tried to do a few homeworks for could be 3 hours and I'd just get really, really frustrated and that kind of memory of frustration I suppose would reoccur. Next time I'd even think about going* [inaudible] *you know I just don't want to annoy myself like that again.*

Colm also refused to face up to the fact that he failed his first year mathematics:

> *Yeh, I put it straight to the back of my mind, when I got the letter I just left it in my car, I didn't know what to do and just put it to the back of my mind, got on with whatever I was doing, working and such.*

Students in the 2nd group also spoke about frustration in relation to mathematics but the frustration often motivated them to work harder or to seek help:

> *You kinda, I think I kinda, I actually dwell on it. Like I really, really think about it and spend ages and ages. It'll actually bug me until I can figure it out. So I'll try and get someone that would know more about maths or try and get it on the internet or something…No, that'd just niggle at me. I probably would throw it down and just go no, not going near but then a couple of hours later I'd just be like no!* (Áine)

> *Em, freak out. No, no, em, generally just go, "oh, no I don't get this" and then I have an incredible desire to get it and I'll work at it until I get it.* (Dónal, on how he copes with problems in mathematics)

We saw evidence throughout the project that students in the 2nd group all displayed a willingness to admit to themselves that they had problems, while the 1st group seemed to have had a fear of admitting to themselves that they were struggling.

No students in either group wanted to fail their examinations; however the fear of failure seemed to drive the 2nd group to succeed, Eight out of nine students in this group reported that they attended the MSC at the first sign that they were not doing as well as they expected (Jason was the only exception in that he attended even before he encountered any difficulties):

> *Well I just thought, ok, if I don't go now, this is gonna build up and before you know it, it's gonna be a week before the exams and I'm gonna think, "ok, I've been taking all these notes and I don't know what they mean". So I thought, I had better go and if I go regular, then at least if they can fill in some of the blanks. Plus I failed the maths proficiency test, I did about two in it. Don't laugh! And I got my first assignment back and I think I probably got about 30% in it and I don't even know how I got that cause I wrote down the most random load of rubbish.* (Janice, on her reasons for attending the MSC)

> *I think I did really bad in my first homework and I couldn't really understand why so I had to, makes sure I wasn't going to do crappy in the rest of them.* (Sharon)

However, the students in the 2nd group were not stable in their reaction to the fear of failing or of not doing well. Lisa initially planned to quit mathematics based upon fears about not achieving a high mark in her degree. However, she subsequently reversed that decision and took mathematics to degree level:

Yeh, I feel like I'm gonna end up failing and then as well it's putting me off doing it next year in case I do get another bad lecturer.

Fear prevented the 1st group from engaging with mathematics but did not have a detrimental affect on the engagement of the 2nd group. In fact we have shown that the 2nd group used fear of failure to motivate themselves to engage with mathematics. The next major category of behaviour to emerge from the interviews was social interactions in relation to mathematics.

4.3.2 Social Interactions

In this section we examine another major category to emerge from the analysis, social interactions in relation to mathematics. The interactions can be split into two concepts: relationships and interactions with teaching staff; and influence of friends or peers on engagement.

Students in the 1st group rarely mentioned such interactions in relation to mathematics whereas the 2nd group frequently did. We demonstrate how the 2nd group used these social interactions as one of many coping mechanisms to allow themselves to deal with their difficulties with mathematics. This contrasted with the fact that the 1st group may have been seeking help in a superficial manner. When we use the term superficial in this section we refer to the fact that sometimes the students in the 1st group have positive comments about staff or friends in relation to engagement but we know from attendance records that they rarely made use of the supports available to them.

It was also clear from the analysis that students from both groups spoke about how they have been affected, both positively and negatively, by their interaction with mathematics teachers at 2nd level. We cannot draw any general conclusions from these interactions but we discuss this as a prelude to examining their interactions with mathematics teachers at third level.

4.3.2.1 Relationships and interactions with teaching staff

We examine the concept of relationships and interactions with teaching staff in this section. This concept is broken down into three parts: second level (4.3.2.1.1), third

level (4.3.2.1.2) and second level versus third level (4.3.2.1.3). Students in the 1st group rarely mentioned social interactions with teachers at third level whereas we show how the 2nd group used these interactions as a coping mechanism to help them deal with their difficulties with mathematics at third level.

4.3.2.1.1 Second level

In this section we examine social interactions with mathematics teachers at second level.

The main focus of the interview questions was on these students' experiences of mathematics at third level. However, we did ask them some questions about their experiences of mathematics at second level. These questions were general in nature (see Appendices A and B) and were brief in comparison to the section on third level. We also have no idea of what each student's engagement level with mathematics at second level was. What is clear was that their experiences with teachers at second level did have an affect on them.

Students in both groups had positive experiences with teachers or reflected upon those experiences in a mature manner. Jason (2nd group) had a mature, or perhaps diplomatic, view of the differing teaching styles he encountered in school:

> *There were different types of teachers, some were good and some weren't great. In my opinion. But every teacher has their own style. I found some of them more difficult than others. But I got through well so.*

That same attitude was shown by Adrian (2nd group), another mature student, who initially blamed his teacher for his perceived poor result at LC level:

> *I don't know, I used to always blame the teacher, but I don't know if it's fair to say he was entirely at fault. I mean, first of all, I think he was great at maths but he probably wasn't a great teacher.*

He then reflected on his own motivational difficulties at that time and the feeling that he had no one to ask for help:

> *But then again, the LC is a lot harder than the Junior Certificate (JC) and I did do the HL, perhaps mistakenly. I lost my motivation then, so whenever I*

would not do well with something, em, then I was less encouraged to try and solve it myself and I felt I didn't really have it in me, I felt I didn't really have any way to ask or any sort of procedure in place that I could get self help so to speak or, so I felt once it started going down, it was just likely to go down further.

The relationship with his teachers was important to Adrian and he emphasised that aspect of the teaching experience with a teacher earlier in secondary level:

He was a great guy, we had a very informal relationship and it was excellent. I would still say at the time I didn't fully understand maths as I alluded to earlier on in the question. But I certainly had a more enjoyable experience. Had I stayed in that school I probably would have had a much better experience of maths based on the teacher who would have taught HL at senior cycle.

Amy (1st group) had a good experience with her mathematics teacher at JC level and for LC HL mathematics but despite that she questioned whether her motivation to study the subject was there or not:

Well, what happened was, em, in LC then, I suppose my teacher, well she was lovely, and she, well not forced me but…I didn't want to do it because I wanted to put my efforts into everything else and I wanted to get good points and I knew that maths wouldn't have been my better subject.

Áine (2nd group) had a very positive experience with a teacher at second level. This teacher always encouraged her and she explicitly notes how the fact he seemed to care about how she was doing was important to her:

*I'd the same teacher from 1st year to just before my mocks in LC. Cause I did HL like. And he was brilliant like. He just kinda, I dunno, I just related to his teaching methods really well, I just picked up everything really easy when he was teaching it. He was really like, he actually gave a ****, you know what I mean like, I know it sounds ridiculous but I wanted to drop to pass at the beginning of LC we'll say. And he actually wouldn't let me drop until the mocks because he knew I was able for it.*

Sharon (2nd group) also had a very positive experience with her teacher for LC mathematics:

I had a very good teacher in 5th and 6th year, her way of teaching was fantastic and made you kind of think about stuff that you'd never have here, which was very different like. Maybe it was more babied, but I don't even know if it was that way. Like you could go into your class and you weren't

allowed write anything until the end of the class, so you had to be sitting there listening rather than writing down what's going on.

Janice (2nd group) had positive experiences of teachers at second level. Her JC mathematics teacher helped her regain her confidence and she was particularly affected by the perception that her teachers were putting in extra effort, going out of their way to help her. Her JC mathematics teacher would give her extra help at breaks:

Teachers probably made it even better, like I had a JC maths teacher and my confidence in maths was not great when I went into secondary school. But he used to, after the mocks, I didn't do well in the mocks and he kept me in at breaks. I chose to, he didn't make me stay in or anything but he took me in at breaks and did extra maths with me and kept on until I believed I could do it.

And her LC teacher ran extra classes after school:

And then my LC maths teacher was brilliant. She did after school closed on a Monday, which I didn't technically need to go to cause it was handy enough but it was revision. So they were all willing to put in the [effort]*, he'd didn't get paid for that and neither did she but they were willing to stay behind or do stuff at lunch.*

Students in both groups also had negative experiences with teachers at second level. Joe (1st group) liked his mathematics teacher but, in his opinion, she was not a good teacher:

Basically when I got to secondary school I was put in the worst maths class, well my parents went to the same school as I did, usually, the way it was run back then when they had the worst maths class would have the best maths teacher. You know who was able to make students comprehend. Where the teacher I got, she was lovely but she just wasn't a good teacher. (Joe)

Colm (1st group) respected the mathematics knowledge of his teacher but like Joe, in his opinion, the teacher was not a good mathematics teacher:

Well in secondary level, I suppose I had a maths teacher that was genius at maths but a terrible teacher if you know what I mean? (Colm)

Colm admits however that he always had a combative relationship with teachers at school:

Well, I think it probably had a lot to do with me as well, my whole life through school I was always warring with teachers you know so I think personal relationship with teacher took precedence over the subject they were teaching!

Ben (1st group) also had a negative experience with a teacher at second level and it affected his engagement with mathematics. When speaking about his teachers he said:

> *Some were good, some were very much a hindrance because they would get more angry than helpful. If you didn't get something right, if you didn't do it right, if you didn't understand* [it, you'd] *be, you know, kinda punished for it. Rather than help. LC then I had a problem. Em, we, again it became more of a if you kind of didn't know it and you end up becoming afraid to ask questions because you'd be afraid of....*

Jason (2nd group), a mature student, did not feel that his mathematics teachers in school encouraged him to excel:

> *Our teachers weren't great so. So there was never really a great push or a drive from them to actually do much about it. We were never offered honours maths or anything like that! So it was pretty desperate.*

Amy (1st group) also had a negative experience with a teacher at second level:

> *Then when I went down to pass eventually after my* [LC] *mocks, em, he* [the teacher] *was just terrible.*

Janice (2nd group) spoke in depth about her experiences of mathematics teaching in school. At primary level she had a very negative teaching experience in relation to mathematics:

> *Cause I struggled with maths in national school* [primary school] *in the beginning and my teacher, he wasn't very positive and he'd wallop you on the head with the roll book if you didn't get it right. So all I remember from NS maths wise is sitting at home with my mum, her trying to explain it to me.*

It is clear that students in this study had both positive and negative experiences with mathematics teachers at second level. Although in general the comments from the 1st group were more negative than those of the 2nd group we noted in the introduction to this section that it was difficult to draw any conclusions due to the general nature of the questions we asked and the lack of data about the engagement levels of students at second level. However, the analysis clearly shows that these students were affected by these experiences and that the issue of how second level mathematics experiences affect third level mathematics experiences is worthy of further investigation.

4.3.2.1.2 Third level

In this section we discuss the wide range of experiences that students from both groups had with teaching staff at NUIM. Our analysis of the interviews revealed that the 2nd group placed high value on their relationships and interactions with teaching staff at NUIM.

Students in the 2nd group responded positively when they felt their mathematics teachers wanted to help them. All students in the 2nd group had something positive to say about a relationship with a lecturer or tutor. Áine talks about how approachable her tutor was:

> *You knew that you were being watched, not even that you were watched, that you were being helped. And there was someone you could go and talk to about certain problems…. My tutor…he was, I found him really good, he wasn't real pushy or annoying, he was kinda like "ah you'll be grand" kind of thing but you could tell he would actually help you. I know he sounds a bit blasé but he'd always come over and help you know that kind of way? I just felt more at ease.*

Shane, who was afraid of approaching lectures, had no issue going to his tutor:

> *Well I thought the tutors were great, definitely, big help. I definitely wouldn't have any problems going to the tutors with any problems I had.*

Janice talks about how nice the MSC tutors were and how that helped her overcome a fear of asking for help:

> *Well the tutors, in general, were really, really nice. And a couple of them in particular were really good at telling you in simple language what this meant… just the 1-1 help where you felt that you could ask and the fact that they never laughed at you. Cause that's always the big fear asking a question that they're gonna turn round and laugh at you and none of them ever looked at you to say you're stupid.*

Dónal mentioned how one of his lecturers had a very relaxed style and how it helped him re-focus his concentration in lectures:

> *What* [lecturer's name] *used to do, is he used to sort of take breaks during his lectures and give us a little story for a while. You know every twenty minutes or so. But that was quite good cause that sort of broke your concentration.*

Adrian expanded on this feeling and discussed the mature nature of these interactions:

> *The attitude that they have, not just with the mathematical content, but teachers in general in college, it's a much more mature relationship. I mean, it's more like a conversation between friends, that's how I perceive it like.*

This was echoed in David's comment:

> *I think the biggest thing about the MSC is the psychological effect. To know that somebody will help you, for me that was the biggest thing. It also, it tied in with the atmosphere that I had of the teacher wanting you to understand things and more like your friend explaining something to you rather than somebody just spouting the information.*

We can see that the attitude of staff and the atmosphere of a class can profoundly affect the engagement of students.

All students in the 2nd group had negative teaching experiences at NUIM as well. However, unlike the 1st group, these experiences did not put them off engaging in some other way. The most common form of negative teaching experience for the 2nd group was an issue with lecturers. Sharon did not see lecturers as being approachable:

> *I don't think the lecturers are as approachable as* [the tutors], *I dunno, I dunno maybe it's just the whole lecture hall, where as everything else is in a smaller* [environment].

And Jason mentioned how off putting it was when he had a negative teaching experience with a lecturer:

> *The main thing is your lecturer, if your lecturer is not a good lecturer it puts you off going to class. Like me, I had a bad lecturer this semester and it's put me off going to class. Cause I'm just lost in the class. Where if it's a good lecturer you're interested.*

We have seen that these negative experiences with teachers did not have a detrimental effect on the 2nd group but that was not the case for the 1st group.

Students in the 1st group also mentioned social interactions or relationships with mathematics teachers at third level although less frequently than the 2nd group. These students engaged less with the MSC and did not attend lectures and tutorials as frequently as the 2nd group. This may account for this difference. Comments from the 1st group about lecturers or tutors sometimes did not correspond with the actions and engagement levels of those students. For example, Darren never seriously engaged with mathematics during his time at NUIM (see Table 3.1) yet he said:

> *The tutors, the fact that you've got people that know the course like the back of their hand, guiding you through it and pointing out mistakes you've been making for months and kind of things, it's good.*

Ben, another student who never engaged to a serious extent with mathematics at NUIM, praised tutorials and tutors in his interview. However, he admitted not seeking help for his problems with mathematics, thereby directly contradicting himself:

> *Tutorials were very useful, I mean they were good size groups, the tutors were quite helpful, they were very open. Em, I mean they could just, I mean there wasn't any big problems with it.*

The same student compliments the MSC staff for not making him feel inadequate yet from our attendance records we can see that Ben only attended the MSC once during his time at NUIM:

> *No, I mean, it's just the how sort of really safe feeling it is. That you can go there and ask anything and that they'll help you, they won't think it's a stupid question or anything like that. I find it very helpful.*

Attendance records at the MSC are very accurate, the MSC has a receptionist who greets every student, issues them with an attendance form, and collects the form from the student when they leave. It is highly unlikely Ben could have attended the MSC and not had that attendance recorded. Therefore it seems possible that Ben gave an answer that he felt the interviewer wished to hear during the interview.

Majella (1st group), as mentioned previously, was a mature student and her motivations were unclear. She never seriously engaged with mathematics at NUIM yet continuously re-enrolled to repeat her first year of mathematics. She praised the interaction with her tutor:

> *Well you got your homework back, you got a feedback on where you were going wrong. And he would talk about other stuff like, it wasn't just the homework, it might be the pending homework or something you done in the past or the exams are coming up or, you know, interactionary* [sic]*, it's the interaction yeh.*

And praised how helpful and encouraging she found the teaching staff:

> *I did find that, you know they were dying to kind of keep you there and keep you going and make out that it wasn't as hard as you might think.*

In spite of this she never engaged to a proper extent with mathematics. Majella attended no tutorials, submitted no assignments and never attended the MSC in the academic year 2008/09. However, Majella had a previous attempt at first year mathematics in 2007/08 when she attended eighteen out of twenty tutorials and attended the MSC four times. When queried on this issue she quoted external factors:

> *Time management was one of my problems right? It still is. Cause I've a family…I was trying to get stuff organised for home so I could be here more but by doing that I seem to have left too much. Now I am still getting work done but when I was running out of time I wasn't, I probably wasn't here on the campus as much.*

Comments from the 1st group were, in general, quite positive. However, we know from their attendance records that students in this group rarely used the supports available to them. This is the reason why we believed that their comments may have been superficial in nature.

Sometimes students in the 1st group did alter their behaviour but were still unable to pass their first year mathematics. Joe admitted he did not engage with mathematics to a proper extent during his first attempt at first year. However, when interviewed during his repeat year he mentioned how the relationships he had formed with the MSC staff had helped him engage with mathematics:

> *I mentioned it before, he's* [MSC Manager] *gotten a certain set of staff on a regular basis there which means you know, they're familiar faces so you've no problems asking them…the staff are great craic, they're really helpful.*

Unfortunately, even after attending the MSC regularly, Joe was unable to overcome his difficulties with mathematics and dropped out of NUIM after completion of the interview. This highlights the incredibly complex nature of student engagement.

4.3.2.1.3 Second Level versus Third Level

In this section we examine the comparisons made by the students in the study of social interactions between mathematics teachers at second and third level.

One interesting aspect of this concept was how students commented on the difference between the actions of teaching staff at second and third level. Some had difficulty adjusting to the fact that at third level the onus was mainly on students to motivate themselves and there are no teachers in classroom settings consistently tracking their progress. Emily (1st group) explained:

> *Obviously it's all left to you, you have to do the work, most of it, there's not someone to give out to you every time you don't have your homework in or that sort of thing.*

Colm (1st group) went further and wondered if someone had approached him, would he then perhaps not have failed his first year of mathematics:

> *Maybe if I had a lecturer coming to me last year and just say, you're struggling, get your act together.*

Colm repeated first year and at the time of the interview had noted how after attending mentoring with the MSC Manager his attendance at the MSC had improved:

> *This year it's been, I really only kinda, basically it was just* [MSC Manager] *kinda got on my back a little bit and eh,* [inaudible] *first time going in, well I've gone a few times now just on the basis of him kind of poking me into doing it. And it's eh, a huge help.*

Two students in the 2nd group also contrasted second level to third level. Áine commented on how she found tutorials and the interactions with the tutor similar to school:

> *The small classrooms, you knew that you were being watched, not even that you were being watched, that you were being helped. And there was someone there that you could go and talk to about certain problems or you were stuck with a certain thing.*

Janice had difficulty with the transition from second level to third level. Her teacher in school would break everything down into small steps and when she came to third level she could not understand why her teachers there "skipped steps":

> *Well my specific tutor, I found her very hard to understand. She used the same language as the lecturers used. She couldn't break it down into simple terms. Just break it down and say, right, basically! It was the same language which was used in lectures.*

It is obvious that the transition from second level to third level was difficult for students in both groups. Students in the 1st group in particular seemed to have difficulty with not having a teacher there to push them and motivate them. The Department of Mathematics and Statistics subsequently introduced a monitoring scheme based on the data from this project and this is discussed in more detail in Chapter 6.

In this section we have demonstrated how positive teaching experiences helped the 2nd group engage with mathematics and negative teaching experiences did not detrimentally affect their engagement. The 2nd group always had some coping mechanism to get by. The 1st group however, rarely speak about teaching experiences at NUIM.

4.3.2.2 Influence of friends or peers on engagement

In this section we demonstrate how the *influence of friends or peers* was an important concept to emerge from the analysis. We show how the 2nd group generally utilised the support of friends and peers to help overcome difficulties with mathematics at third level. We contrast that against the actions of the 1st group, who rarely mentioned interacting with friends or peers in relation to mathematics.

Firstly we discuss how the 1st group made brief references to working with friends or peers in relation to mathematics but it was clear from the analysis that these interactions did not form a part of a coherent plan to seek help. They were also reluctant to admit to themselves or others that they were struggling with mathematics and it is possible that this was a contributing factor to the lack of social interactions related by them during their interviews.

Only two of the 1st group mentioned working with others on mathematics and it did not appear to be of particular help to them:

> *I mean you'd be going to your friends and stuff like that and they still wouldn't have an idea. Or you'd be stuck together. But you just got more and more down about it and you just don't care.* (Ben)

> *I asked my mates at the time, you know, what's the story with the thing, how's it going? And yeh, they offered to help, like they helped me a few times, but again, they got their own stuff to do*. (Joe)

Darren, Emily and Colm rarely mentioned friends or peers in relation to mathematics at NUIM. Emily was asked had she ever discussed the MSC or heard about it from friends who were studying mathematics with her and she said that it was not mentioned. Darren was sometimes encouraged to go along to lectures or the MSC by friends but never seemed interested in engaging:

> *Ah, I'd go to a few if friends were going* [to lectures], *nothing else to do maybe, waiting for a bus kind of thing. But, em, it was, no, it was never, I was never paying attention, I was always doodling and stuff so….I had*

> *mates who went there* [MSC] *and I'll be like, I'd just shrug it off like, it cant be that helpful like, it's always busy and stuff.*

And Colm mentioned how he was distracted by chatting to friends in lectures:

> *I had a tendency to sit towards the back. Eh but you know, was probably my own fault really but I got, I dunno, I'd be talking and trying to take notes at the same time. And then the notes that I'd taken down, when I looked back on them later on they'd be half of each section.*

Amy never mentioned interacting with friends or peers in relation to mathematics but it was clear from her interview that she had difficulties with asking for help. In these quotations she discussed how embarrassed she was admitting to peers she had to repeat her first year of university twice and how expectations placed upon her from her schooldays also caused her embarrassment:

> *But the funniest, I was talking to a girl last week, she, I went to school with her. And she was like "how's college going?" and I'm like "grand"* [sounds embarrassed]*... they're* [her school friends] *all in 3rd year and some have got their degrees and everything and are working.*
>
> [Her friend said]:*"You never failed an exam in school, oh my god it makes me feel so much better". And I was like "oh my god, I'm gonna cry".* (Amy, relaying the reaction of her friend)

Finally, Majella mentioned attending the MSC on the advice of a friend and working there with friends:

> *Yeh, a friend told me about it* [MSC] *and em, I went in. And there was other matures* [mature students] *so to speak with me. And we often went in at different times depending on the times of our lectures.*

However, as mentioned previously, Majella never seriously engaged with mathematics for reasons that were unclear from the interview.

Most of the students in our 2nd group noted that their decision to attend the MSC was affected by friends or peers. Two of our nine students explicitly mentioned how they were fearful of attending the MSC but a recommendation by someone they trusted swayed them:

> *But one of the girls who lived downstairs, you know we'd go to lectures together. And she was living with two other girls who* [did] *3rd or 4th year maths and they were telling us how helpful the MSC was. You know when you hear about something and you're like 'ugh'. But then the second week we went and it was such a lifeline like.* (Áine)

> *Yeh, one of my friends, I heard it from* [a friend] *and I was kinda like "I don't know", all these help things. But someone actually really went and it's actually really good.* (Lisa)

Students in the 2nd group all worked in groups, either inside or outside the MSC. Eight of out of nine students in the 2nd group worked in groups in the MSC. These students all utilised group work as part of their strategy of engagement. Jason (2nd group) spoke about the benefits of group work:

> *I found group work the best. I dunno, you could just ask somebody, bounce an idea off somebody or somebody would ask you, "what do you think?" and you're less reliant on the tutors as well then.*

Áine (2nd group) talked about how she felt embarrassed going to the MSC on her own but that changed when she had even one friend to work with:

> *I just felt like a tool. Like no, even if I had just one more person with me I'd be fine.*

Not all students in the 2nd group were comfortable working in groups in the MSC. Janice (2nd group) expressed her fears of holding others back:

> *Well just the whole you don't want to stick up your hand cause you'd feel embarrassed if you were keeping everyone back.*

She sought help from trusted friends instead:

> *Every week about five of us got round the table, one was an expert at maths, the other was good at maths, between the two of them they'd work it out and then they'd help me and a couple of the others who were really struggling…To be honest I don't think I'd have passed if I hadn't* [gotten help from friends].

It was clear from the analysis that the 2nd group used the social interactions outlined as a method of seeking help. When the 1st group made efforts to seek help from friends or staff it did not seem to have a significant impact on their engagement levels. Sometimes they made positive comments about staff or friends but we know from attendance records that they rarely made use of the supports available to them. There were motivational issues at play here and in Section 4.3.3 we discuss the category of motivation. This category overlaps with both the fear and social interactions categories and centres on the question: why were some students motivated to engage with mathematics and others were not?

4.3.3 Motivation

In this section we discuss the behaviour of the students in our study within the goal orientation theory framework of motivation. We demonstrate how we found examples of both mastery and performance goal orientations but that the analysis suggests that this dichotomous model is insufficient to fully explain what motivation the 2nd group appeared to have that the first did not**.**

4.3.3.1 Mastery goal orientations

We discuss the emergence of mastery goal orientations from the analysis in this section. As outlined in Section 2.5.1 students with *mastery goal* orientation attempt academic tasks for the purpose of developing competency. Students with this goal orientation focus on learning, understanding, developing skills and mastering information.

Only three students in our study, all of them from the 2nd group, showed any serious inclination towards mastery goal orientations with respect to mathematics. Two of the students were mature students and the third did not come directly from school to university. All these students displayed a greater sense of maturity than the other students interviewed. All three students came to university with a very fixed idea of what they wanted to study (not necessarily mathematics) as opposed to the majority of students in our study whose choice of course was made without much research or who did not receive an offer for their first choice course. All three spoke about a desire to understand mathematics. Every one of our students used the word understanding at

some point in relation to mathematics. However these three students were the only ones who demonstrated that it was a deep understanding of the subject they desired as opposed to something shallower. Student Jason (2nd group) discussed how he learns mathematics:

> *Eh, I need to, I need to have a good understanding of anything before I can say I know it, you know that sort of way? I really need to know what's going on.*

Adrian (2nd group) exhibited the strongest tendency towards mastery goals and when asked about his experience of mathematics in his first year at university he responded:

> *Now, there were times in the past where I would get the right answer. But I never really felt I understood the subject at all. And for the first time I felt I understood what was happening. And to my own satisfaction, rather than just answering questions, em, looking at two methods, maybe in an example question, looking at the question before me, an unsolved question and then just transplanting one method onto the other. I actually felt I understood what the questions were asking.*

Dónal (2nd group) also demonstrated that he had a mastery goal orientation. When discussing tutorial structure he said:

> *Yeh, cause I think a lot of people come from school, not engaging just writing down things and expected to just regurgitate and not really engage with the material. You know, if you're coming into an environment that's similar to school well they're going to act like they were in school. There needs to be a change.*

It should be noted that these three students had other goal orientations as well (This is not uncommon and is to be expected as noted in the literature review). They all admitted to being motivated by the marks on continuous assessment. The responses to why Adrian and Dónal submitted assignments are indicative of this motivation:

> *Why did I hand them in? Cause they're worth points.* (Adrian)

> *Well, pretty obviously it was to get my grade, get the free marks or the CA marks available.* (Dónal)

Jason admitted that good marks in his assignments were part of the reason he returned to the MSC for example:

> *Yeh, a good experience* [attending the MSC] *and I started getting decent enough results in assignments and that so.*

Here Dónal admitted to abandoning attempts to fully understand or master specific parts of a module coming up to the exams:

> *There were a few sort of issues in maths where I sort of said, I didn't seek to understand it completely. So I sort of memorised it, I memorised the answers, how to apply.*

It was clear from the analysis that these students wished to do well in the subject and in university in general, in addition to displaying a desire for mastering the subject. It seems reasonable that these students have other goal orientations apart from mastery goal orientation. This would correspond with results from other authors (see Section 2.5.1).

In summary, only three students in our study, all from the 2nd group, displayed any serious inclination towards mastery goal orientations. In the next section we discuss the prevalence of performance goal orientations in the analysis.

4.3.3.2 Performance goal orientations

In this section we look at the emergence of performance goal orientations from the analysis. As outlined in Section 2.5.1, *performance goal* orientated students attempt academic tasks for the purpose of demonstrating competency. They focus on the impression others have of their ability while attempting to give the impression of high ability and avoiding an impression of low ability.

We did not see any concrete examples of performance approach goals in this study. However, we did have clear indication of performance avoidance goals in a small number of cases. Kaplan and Maehr (2007) defined *performance avoidance goals* to be the desire to avoid the demonstration of low ability. They noted how students with performance avoidance goals focus on the possibility of failure and that these goals were associated with anxiety. Students in both groups were concerned with avoiding demonstrating low ability. As we noted in Section 4.3.1.1 this was closely related to a fear of showing a lack of knowledge or ability and this makes sense if we consider the

findings from Kaplan and Maehr (2007) above. Two quotes from the 1st group illustrate the attempts to avoid showing a lack of knowledge:

> *Never! I did in one, in accounting, but that's because I was comfortable with it and I knew what I was talking about and I corrected the lecturer and I asked a question. So, I was comfortable with that.* (Amy (1st group), on why she would not ask a question in a mathematics lecture.)

> *Yeh, that's where you feel like a bit of a dumb-ass saying I'm kind of struggling on your basic calculus here, do you mind going back a few steps.* (Joe (1st group), speaking about tutorials)

Four students in our 2nd group demonstrated explicit performance avoidance goals. Excluding our three mature students who did not appear to be worried about the opinions of others, the remaining six students all worried about how their actions in relation to mathematics were perceived. However, only four of the six explicitly showed performance avoidance goals. One of those students, Áine, discussed pretending to her tutor that she understood:

> *No, I'd ask the question and then they'd explain it and then I'd be like, "I don't really understand" and then they'd keep trying to explain and then I'd kinda go, "aww yeh, I got it" and like I'd have no idea what they just kinda said.*

Janice mentioned how she found the idea of approaching a lecturer daunting because she felt that her queries to them would be viewed as trivial:

> *You know, you'd be afraid to go into a lecturer, they're doing this for ages and they've got their PhDs and whatever and you're going in and asking them about the domain and the range and you're as confused as* [inaudible] *and they're looking at you as if to say, "Ah come on now, we did this* [in the] *first lecture!"*

However, as we recall from Section 4.2.3.1 (critical events for the 2nd group), these performance avoidance goals were not detrimental to their engagement and these students persisted and looked for help:

> *Ah still sometimes I do feel like awkward, oh my god, I probably should know this but I don't, you know what I mean? There's no point, I know myself there's no point, if you don't ask you're gonna be even more lost.* (Lisa)

Áine rarely attended the MSC on her own out of a fear of looking stupid:

I just never went by myself in the first place. I went once by myself and I actually didn't really like cause I felt like I was being stupid.

However, she attended the MSC in the safety of a group and got help that way.

From the limited number of examples of mastery and goal orientations we have observed, it is clear that a more general model of approach and avoidance motivation fits our data. Students in the 2nd group were motivated to approach their difficulties with mathematics whereas students in the 1st group avoided facing such difficulties.

4.4 Conclusion

In this chapter we have presented the main findings of the analysis of the interview data. We have shown how after encountering similar difficulties with mathematics the students experience a number of critical events. The reactions to these critical events were vital in determining the future engagement of these students. The 2nd group generally approached their difficulties with mathematics whereas the 1st group avoided facing up to those problems.

We also showed that there were three main influences on the behaviour of these students: fear, social interactions; and motivation. We observed how the 1st group allowed their fears to prevent them from engaging with mathematics whereas the 2nd group's engagement was not detrimentally affected by fear. We showed how social interactions were utilised by the 2nd group as a means of engaging with mathematics and how the 1st group rarely mentioned social interactions in relation to mathematics. Finally, we discussed motivation and noted that while we had some limited examples of mastery and performance approach goals, a more general model of approach and avoidance motivation best fits our data.

In the next chapter we will discuss these results and how they match up with the relevant literature.

Chapter 5 – Discussion

In this chapter we discuss the main results of the thesis. We see how these results fit in with the relevant literature and highlight any further research questions that they have raised.

5.1 Similar Tactics

In this section we discuss the main findings related to the similar tactics deployed by both groups at the beginning of their first semester of mathematics at NUIM.

Our analysis showed that fourteen out of sixteen students initially engaged with mathematics at the beginning of their first semester at NUIM. Some of the motivations for this engagement were noted as students feeling obliged to attend lectures or tutorials and students being motivated by continuous assessment grades. These students began to experience difficulties with mathematics within the first few weeks of the first semester. Research from Williams (2003) has shown that resilience (ability to overcome setbacks) is not necessarily correlated with high grades and we saw this when some students in this study with high grades in their LC examination did not engage with supports when they needed help while others with low grades did.

This along with the homogenous behaviour of the students at the beginning of the first semester highlights the difficulty in predicting which students will struggle once they experience difficulties with mathematics. The SEUM study (see Section 2.7) had similar difficulties identifying students who would struggle, with hindsight they discovered that struggling students had very similar mathematical backgrounds to students who were not struggling, and hence it was difficult to predict pre-university who would struggle upon entry to third level. In the next section we discuss the results from the Similar Difficulties sections.

5.2 Similar Difficulties

In this section we look at the main findings about the similar difficulties these students encountered at the beginning of their first semester of mathematics. We note how difficult the transition from second to third level can be for students.

In fact, as we have seen, both groups suffer difficulties with mathematics early on in their first semester at university. All but one student (Jason, 2nd group) encountered problems with understanding lecture material or difficulties in attempting assignments. These difficulties are perhaps to be expected when we consider the fact that twelve out of sixteen students came directly to university from second level. Clarke and Lovric (2009) note how this transition is considered a "rite of passage" and can lead to cognitive conflict.

We seen in our study that students had difficulty with the mathematical language used at third level, they had a general lack of understanding of the nature of mathematics, and generally struggled with mathematics from the beginning of their first semester. Hourigan and O'Donoghue (2007) offer a possible explanation for these issues. They explained how an emphasis on rote learning in second level mathematics classes in Ireland was not preparing students for the higher expectations of third level mathematics.

These students experienced difficulties which emerged as critical events in the analysis of the interview data. Their reaction to these critical events defined their engagement and we tie these reactions or lack of reactions to the literature in the next section.

5.3 Critical Events

In Chapter 4 we outlined that there were several critical events for the students in both groups. Their reactions to these critical events were crucial to determining their future engagement and in this section we summarise the main results in relations to critical events.

We defined a critical event to be: an event that emerged from the analysis as being important in determining the future engagement of a student, whether they were consciously aware of its critical nature or not. The 1st group immediately began to

struggle with mathematics upon entry to university, similar to failing students from the SEUM study (see Section 2.7). However, our 2nd group struggled as well, eight of nine students attended the MSC after having difficulty with an assignment early in their first semester. As we have seen, they were not always comfortable asking for help in some scenarios but they were always able to adapt their behaviour to get the help they needed from teachers or peers. The 1st group experienced three types of critical events: struggling with material in lectures; difficulties with assignments; and fear or embarrassment of attending tutorials. The 1st group seemed not to be aware of the importance of these events nor did they seriously attempt to seek help. This decision impacted negatively on their future engagement. Macrae et al. (2003a, 2003b) showed that even when students are aware they are struggling, they often have no idea how to extract themselves from that situation and seek help.

The key difference between the two groups of students in this study was their reactions to these critical events. This reaction is tied in with a decision to avoid or approach one's problems, referred to as the "critical juncture" by Ryan et al. (2001). The 2nd group were immediately aware of their need for assistance and were motivated to seek help or change their behaviour in a positive way, while the 1st group seemed to drift into a pattern of non-engagement without making a conscious decision about their behaviour. We did not find much evidence of the purposeful self-handicapping described by Urdan and Midgely (2001), as the inaction of the students in the 1st group did not appear to be a deliberate effort to create an excuse for failure.

We have seen how critical events occur for both groups and that their reactions or lack of reactions to these events led to a decision to approach or avoid dealing with difficulties with mathematics. In the next section we examine the main points of approach and avoidance behaviour.

5.4 Approach versus Avoidance

In this section we summarise how students in the 2nd group seemed to be motivated to approach their difficulties with mathematics and students in the 1st group appeared to be motivated to avoid seeking help with their problems with mathematics.

The 2nd group all sought to confront their difficulties head on. They appeared to not have an issue admitting to themselves they were having problems and would seek help from a source they felt comfortable with, either a lecturer, tutor, or a peer. The 1st group never faced up to their issues and avoided seeking help. A study similar to our own which dealt with pure mathematics students (Macrae et al., 2003a) showed that failing students withdrew from engagement when faced with a lack of success. A follow up paper, Brown and Rodd (2004) showed that successful students in the same study showed persistence when dealing with issues with mathematics that struggling students did not. It is not possible to conclude that these students were displaying approach and avoidance behaviours as we have defined them in our study. However, it is clear that there is a similarity between the types of behaviours displayed by those students in the SEUM study and the students in our study in relation to difficulties with mathematics.

As described in the literature review, the idea of a student approaching an academic task to achieve success and another avoiding a task to escape failure is well documented in the literature. Elliot (1999) in his survey of approach and avoidance motivation literature notes that in the area of achievement goal theory, approach and avoidance motivation has traditionally been considered part of the dichotomous model of mastery and performance goals. He states that in other areas of achievement motivation, approach and avoidance motivation has been considered as an independent framework. However, what has emerged from our study was that this basic approach and avoidance model seems to best describe the motivational behaviour of the students. We discuss this in conjunction with other models of motivation in Section 5.7.

We have seen how the 2nd group approached their difficulties with mathematics and the 1st group avoided facing up to these difficulties. In the next three sections we summarise, in conjunction with the relevant literature, the three influences on behaviour that emerged from our study: fear; social interactions; and motivation.

5.5 Fear

In this section we look at how our results on the fear these students experienced ties in with the literature.

Hannula (2006) and Ryan et al. (2001) have found that the fear of showing a lack of knowledge or ability negatively affects students' willingness to ask questions. Furthermore, Ryan et al. (2001) showed that students displaying such behaviour were more likely to avoid seeking help, giving further evidence for the link between fear and avoidance behaviour. For six of the seven students in the 1st group, we found that fear was the dominant reason they did not engage with the subject.

This category of fear was broken down into four concepts: fear of showing a lack of ability/knowledge; fear of the unknown; fear of being singled out and; fear of failure. We concluded that this fear was an obstacle for engagement for the 1st group. The 2nd group did encounter some of the same fears as the 1st group but as we have outlined in Chapter 4, they had a number of coping mechanisms for dealing with these fears.

We found that fear of the unknown presented an obstacle for students in the first group engaging with mathematical supports. Symonds (2008) found similarly. In contrast to this, we noted evidence of the 2nd group using fear of failure as a motivation for engagement. This concurs with Symonds (2008) who found that for five students who overcame fear or embarrassment to attend the MLSC at Loughborough, fear of failure was more important than the embarrassment of seeking help.

It was not clear from this study what exactly was the cause of the high levels of fear or embarrassment which the 1st group in particular reported. Metje et al. (2007) noted that for novice learners, major triggers of fear included: starting the lectures at too high a level for the student; and difficulties with mathematical language. These two issues were frequently commented upon by students in this study. Students in both groups have negative experiences of mathematics from second level and it is possible that these students suffered from mathematics anxiety. Research has shown that mathematics anxiety can have physiological effects on students (Hopko et al., 1998). If it is true that students had high levels of mathematics anxiety, then the work of Hopko et al. (1998) implies that they would not able to block out distractions to the same degree as students with low levels of mathematical anxiety. Thus fear might have led to low levels of concentration and engagement.

We have examined how fear is a barrier for engagement for the 1st group and while the 2nd group also experienced issues with fear, it rarely prevented them from seeking help. Some students in the 2nd group used fear as a motivating factor and this has been seen in Symonds (2008) as well.

5.6 Social Interactions

In this section we summarise the main results in relation to the social interactions category.

This category contained the concepts of relationships and interactions with teaching staff, and influence of friends or peers on engagement. The 1st group rarely mentioned social interactions in relation to working on mathematics. If they did mention social interactions it did not seem to, as described in Section 4.3.2, significantly improve their levels of engagement. It is also possible that the 1st group were isolated socially in a mathematical sense, very few of them mentioned friends or peers when discussing dealing with their difficulties with mathematics.

The 2nd group utilise a combination of relationships with teachers, group work and the advice and experiences of their peers to help with their engagement with mathematics. Hannula (2006) concluded that students are possibly motivated by a desire to contribute to group work and for the 2nd group, our data agrees with this. It was clear from the analysis that these interactions were a method of learning from peers and when students commented on working in groups there was evidence of Lave and Wenger's (1991) communities of practice and Solomon et al. (2010) had previously shown how communities of practice have emerged in mathematics supports centres in the UK. Inglis et al. (2011) considered students who attended lectures and the MLSC at Loughborough University. They showed that there was a correlation between these face-to-face teaching methods and better grades. In our study, although impossible to prove a causal link, it is clear that the 2nd group use social interactions to help them to achieve better grades.

Another interesting aspect of the analysis was the effect social interactions with mathematics teachers at second level had on the students in both groups. We showed how positive and negative experiences with teachers were described in detail by students. It is possible that students appreciated teachers who they felt cared or were interested in their progress. The students mainly discussed the personalities of teachers, very few mentioned teaching methods. However, the aim of this study was not to examine the second level mathematics experiences of these students and we have no information about the engagement levels of these students at second level. This area requires further research.

Students commented frequently on the difference between their social interactions with teachers at second and third level. Students commented on the fact that, in contrast to second level, at third level they felt that no one was watching over them or pushing them to do well. This agrees with the findings of Clarke and Lovric (2009) who discussed the culture shock that students experience upon arrival at third level. This highlights the importance of the transition from second level to third level and the effects it can have on student motivation and engagement. The importance of good relationships with teaching staff at third level were emphasised by the final report of the SEUM study (Brown & Macrae, 2003). Friendly and approachable staff were highly valued by students. However, successful students seemed to flourish no matter what type of teachers they had. Failing students seemed hampered by teachers who were not enthusiastic, friendly or approachable. This would seem to correspond with our findings that social interactions with teachers are an important piece of the puzzle in terms of determining future engagement. While also reinforcing the idea that the 2nd group have some motivation to succeed that the 1st group do not.

We have seen how the main finding from this section was that the 2nd group utilised social interactions with teachers and peers to help themselves engage. The 1st group rarely mentioned social interactions in relation to mathematics. In the next section we link our results on motivation to Dweck's (1986) model of mastery and performance goals.

5.7 Motivation

In this section we analyse the data that emerged from our study on motivation. In particular we look at examples of mastery and performance goals that we observed and discuss, in conjunction with the literature, whether this model fits the data we observed.

Our analysis of how our data matched up with the mastery/performance framework revealed that this framework was not sufficient to explain our results. However, it should be noted that we did not ask specific questions about goal orientations. Our study did find solid evidence of three students having mastery performance goals. The three students who expressed mastery goal orientations with respect to mathematics were all mature students who had come to university with a fixed idea of what they wanted to study and gain from the experience. All three of these students worked on mathematics effectively in conjunction with others which seems to agree with Hannula (2012), who noted how authors have linked mastery goal orientations with having a positive effect on inter-personal relationships in the classroom.

We found no concrete examples of performance approach goal orientations. It was very difficult to ascertain from the transcripts if students were motivated by "demonstrating competence". Students would often comment about the desire to achieve good marks in assignments or exams but it was never clear that these students were interested in demonstrating those achievements to their peers. We did see a limited number of examples of performance avoidance goals. We mentioned how this overlaps with the issue of students having a fear of showing a lack of knowledge or ability. This fear or embarrassment was a possible reason for students adopting performance avoidance goals. However, three students from the 2nd group also demonstrated performance avoidance goals and suffered from fear or embarrassment in relation to showing a lack of ability, yet they still engaged with mathematics. This highlights the immense complexity of the motivation issue amongst these students.

Levy et al. (2004) linked mastery goal orientated students with having little concern for social status in the classroom and they cooperated with other students if they perceived it would contribute to their learning. Performance goal orientated students were much more concerned about social status. Our results show that our three mastery goal

students were not fearful about working in groups and engaged in group work eagerly. However, these three students only trusted certain friends to study mathematics or attend the MSC with. Students who demonstrated performance avoidance goals were more wary of social interactions. In the case of the two students in the 1st group who displayed performance avoidance goals this involved not interacting socially to any significant extent in relation to mathematics.

Whilst we did not find evidence of overlapping goal orientations like Hannula (2006) or O'Shea, Cleary & Breen (2010), the three students who had mastery goals were also motivated by achieving high grades and doing well in assignments and not only by understanding the material.

The difficulty with a lack of concrete examples of performance goals seems to correspond with Elliot (1999) who, upon surveying the literature, concluded that hypotheses regarding mastery goals are reliably supported by empirical studies whereas hypotheses related to performance goals produce less concrete results. When we take into account the fact that it is also generally accepted by psychologists that the mastery and performance goal dichotomy is only a basic working model of achievement motivation (Kaplan & Maehr, 2007; Elliot, 1999), it is clear that the issue is quite complex.

While goal orientations play an important part in the motivational issues that emerged from this study it is apparent that a more general approach and avoidance model of motivation, as discussed in Section 5.4, best suits our data.

Chapter 6 – Conclusion

In this section we first present a summary of the main findings of this project, we discuss the implications and limitations of this study and finally suggest ideas for future work in this area.

6.1 Summary of Findings

We have seen how both groups of students initially displayed similar behaviour at the beginning of their first semester and that it was only when difficulties with mathematics arose that a divergence occurred. An analysis of the 2nd group led us to observe that they had reacted to the critical event of struggling with an early assignment by seeking help. When we examined the first group to look for critical events in their engagement it emerged that problems with assignments, tutorials and understanding material in lectures were followed by a lack of reaction that proved detrimental to their engagement. In summary, the 2nd group approached their difficulties head on but the 1st group avoided facing up to their problems and were rarely aware of the critical nature of their difficulties.

While Symonds (2008) found that issues like a lack of awareness of the location and type of service available were given as reasons for non-engagement by students, we found that deeper issues like fear, social interactions and motivation were much more important in analysing the reasons for engagement.

We examined the main influences on behaviour that emerged from the study and saw how fear was evident in both groups. The 1st group's fears were a barrier to engagement and we noted how this was closely related to avoidance behaviour. Six students in the 2nd group also suffered from fear but they altered their engagement to deal with their problems. Interestingly, students in both groups had difficulties with mathematics in school and it is clear that this affects their views of mathematics and perhaps contributes to fear and anxiety in relation to mathematics.

The 2nd group also utilised social interactions in relation to mathematics in order to seek help. All students in the 2nd group participated in group work. The 1st group rarely

mentioned such interactions in a meaningful way and rarely sought help from friends or peers.

We noted how three students in the 2nd group had mastery goal orientations and how students from both groups had showed signs of being motivated by performance avoidance goals. However, we outlined our arguments for why this model of motivation does not explain the behaviour of the students in this study. The 2nd group had some motivation to approach their difficulties whereas the 1st group were motivated to avoid their difficulties with mathematics.

6.2 Implications of this study

Students in this study commented on how, in contrast to their experiences at second level, at third level they felt that no one was observing them or pushing them to do well.

Principally as a result of these finding the Mathematics and Statistics Department at NUIM initiated three separate programmes. The first was a mentoring programme carried out by the MSC manager (Mac an Bhaird, 2011) in the academic year 2009/10. The eighteen students who responded to our initial call for participants in this study (see Section 3.2) were invited to participate in a mentoring scheme with the MSC Manager. Fourteen students agreed to participate and arrangements to meet on a one-to-one basis in the MSC Manager's office for every fortnight were made; two of these students subsequently decided not to engage with the scheme. Discussion of mathematics was kept to a minimum but students were given advice on study methods, time management and using available resources effectively. Although it is difficult to draw concrete conclusions about the effectiveness of such a scheme, the majority of students who engaged appropriately with the study showed improvement in their engagement with mathematics and nine out of the twelve students who participated progressed into second year.

As a result of the positive outcomes of this mentoring scheme and feedback from students involved in my research project, a peer-mentoring scheme was launched for first year 'at-risk' undergraduate students at NUIM in September 2011 (Burke, Mac an Bhaird & O'Shea, 2012b). The two supervisors applied for and were awarded a

Teaching and Learning Fellowship from NUIM to establish this pilot scheme. Thirty eight students participated in the scheme and were mentored by 24 second or third year students who themselves had been categorised as 'at-risk' but had all engaged with mathematics and passed their first year mathematics exams. The mentoring took place in groups and was similar in style to the scheme described above in that mathematics did not form part of the meetings. The majority of students engaged with the mentoring process (25 out of 34) and their engagement increased relative to previous cohorts. However, final exam grades did not improve. Qualitative results from the study showed that both the mentees and mentors found the scheme worthwhile (Burke et al., 2012b).

The third scheme involved the monitoring of students' tutorial attendance, assignment submission rates and usage of an online mathematical proficiency course (Burke, Mac an Bhaird & O'Shea, 2012a, 2013). Again this scheme was introduced as a result of the findings of this project. A tutor was employed in September 2010 to monitor tutorial attendance, assignment submission rates and usage of an online course for students who failed a diagnostic test. In previous years, students' tutorial attendance had been loosely monitored. At the end of semester one, students who missed three or more tutorials (out of a total of ten) received a letter from the head of department reminding students that it was important that they maintain a high level of tutorial attendance.

In the scheme described by Burke et al. (2012a, 2013), students were contacted by email if their engagement was not deemed sufficient. Students who continued to not engage were contacted again by email and asked to meet with their mathematics course co-ordinator to discuss their non-engagement. Burke et al. (2012a, 2013) found that the monitoring scheme had a positive effect on engagement with these supports. Engagement with the online course was also found to have a positive effect on students' final module grades. The authors intend to expand the scheme, noting both the positive feedback and the cost effectiveness of the scheme.

These three proactive schemes were a direct consequence of the findings of this project. It should be noted that Symonds' (2008) examination of a similar proactive small group teaching scheme at Loughborough found that, after initial successes, the scheme had little effect on students' final exam grades even though students spoke positively about the scheme itself.

6.3 Limitations of this study

In this section we will discuss some of the limitations of this study.

The numbers of students in each group was small, but not unusually so for a study of this kind. The time constraints of collecting and analysing qualitative data are balanced against the potential richness of such data and in the case of this study we consider the interview data to have been of a high quality.

Although some examples of mastery and performance avoidance goal orientations emerged from the study we did not ask specific questions on goal orientations. This might explain why we saw no examples of performance approach goal orientations and we did not explicitly see many of the social goal orientations explored by Dowson and McInerney (2003). Students spoke in depth about motivation and social interactions and further study in this area is needed. A follow up study, currently being conducted at NUIM, interviewed a further 25 students and incorporated more questions about motivation and social interactions. Analysis of these interviews has not been conducted yet but results may shed further insight into these issues.

We interviewed students who had failed first year mathematics and students who had passed and engaged to a significant extent with mathematical supports. However, we did not interview students who had passed their first year of mathematics but had not availed of support and it is possible this group of students may have some insights that are different to either of the groups in our study. This is discussed in more detail in Section 3.6. The follow up study mentioned above incorporated students from this cohort.

6.4 Future Work

From the interview analysis it is clear that several other categories of influence on engagement also exist within the data. These include understanding the nature of the subject of mathematics, awareness of services and supports, awareness of their own learning style, and influence of external factors upon engagement. It is highly likely that

these categories are important in providing evidence for why students engage or do not engage with mathematics.

While we could not conclude much from our study about the self efficacy levels of the students in the 1st group, we know that they were unwilling or unable to seek help. Caraway et al. (2003) linked fear of failure to low self efficacy and it is possible that a further study could investigate how low levels of self efficacy contributes to the fear suffered by students similar to those in the 1st group.

Solomon et al. (2010) noted how half the students in their study were dissatisfied with mathematical teaching styles at university and Macrae et al. (2003a) found that the failing students in their study showed a lack of academic preparedness and were unable to adapt to different learning styles at university. They noted how other studies had shown that school students in the UK were more 'spoon-fed' in comparison to those at university. Both groups in our study displayed some limited examples of this but we did not focus in this study on the contrast between learning styles at second and third level. Further studies could analyse the effects this has on engagement of service mathematics undergraduate students.

Our study seemed to suggest that the 1st group were socially isolated with respect to mathematics whereas the 2nd group utilised group work to help them succeed at mathematics. As part of the SEUM study, Macrae et al. (2003a, 2003b), found that struggling students seemed to socialise with students who were also struggling. While Brown and Rodd (2004), as part of the same study, found that successful students had social interactions within the mathematical community. The final report on the SEUM study (Brown & Macrae, 2003) highlighted the importance of a good social network to a student succeeding at mathematics in university and therefore it would be interesting to expand on our investigations to include considerations of social interactions in general, and perhaps confirm or contradict the findings of the SEUM study.

Students also frequently commented on difficulties with mathematical language. This seems related both to the transition from second to third level mathematics and the fact that the literature has shown that this issue can generate fear in novice learners. Further investigation of this issue may is required.

It was clear from the analysis that students were affected strongly by their experience of mathematics at second level. However, we have no knowledge of the engagement levels of these students at second level and therefore it is hard to draw solid conclusions from what they said. Further examination is needed on how experiences of second level mathematics affect the issues at third level that emerged from this study (fear, social interactions and motivation).

As mentioned in Section 6.3 a follow up study of 25 students is underway. The interview format was adapted to include questions on the issues that emerged from this study and further cohorts of students were added to gain insight into a more complete cross section of the student body. Analysis on this study has not begun but the interview and transcription process has been completed.

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Appendices

Appendix A – Interview Format for the 1st group

Intro (General Chat) (where are you from, live in Maynooth? Like Maynooth, social Life etc.)

What are you studying? Arts? Finance? Science?

Modules repeating?

What other subjects? Chemistry? Physics, etc,?

Were the difficulties with Maths similar to difficulties in other subjects?

Did you realise the extent of Maths content in your course?

What was your experience of Mathematics before University?

Did you enjoy maths in primary/secondary school?

How did your teachers affect your experience of maths?

Difficult/Easy?

How did you fare in the Leaving Cert?

What was your experience of 1st year Mathematics?

How was it different from school?

(compare to points above??)

Did you attend any Mathematics lectures?

How many lectures did you attend? (All, most, once a week, rarely, never)

Attended regularly:

Why did you attend regularly?

Did you find them useful?

Attended rarely or never:

Why did you not attend on regular basis?

Comment on lecture structure in general, anything that should be changed?

Did you attend any Mathematics tutorials?

How many tutorials did you attend? (20, in total, all, most, less than 10, less than 5)

Attended regularly:

Why did you attend regularly?

Did you find them useful?

Attended rarely or never:

Why did you not attend on regular basis?

Comment on tutorial structure in general, anything that should be changed?

Did you hand in any Mathematics assignments?

How many assignments did you hand in? (20, in total, all, most, less than 10, less than 5)

Handed in most:

Why? Did they help with your understanding? Did you find them difficult/easy?

Rarely/never:

Why? Did you attempt the assignments? What would you say is the main reason you did not submit?

Comment on assignment structure in general, anything that should be changed?

Did you attend the Mathematics Support Centre (MSC)?

How many times did you attend? (never, once, >5, >10)

Attended regularly:

Why? What was helpful about the MSC? (atmosphere, tutors, etc?) Why did you return regularly?

Attended once or twice:

Why? Why did you not return? Was it helpful/unhelpful? Reasons?

Never attended:

Why? Were you aware of it? What stopped you from coming? Did you feel you didn't need to come?

Comment on MSC structure in general, anything that should be changed?

When did you realise you were having problems with maths?

What did you do when you realised this?

Unaware needed help? Aware but unsure how to get help? Aware but embarrassed or intimidated?

Do you think there is anything else you could have done to improve your grade?

Do you think there is anything we (NUIM\Mathematics Department) could have done to help you improve your grade or make your study experience here better?

If you could advise a current first year maths student, in a similar situation to your own, to do one thing that would help improve that situation, what would it be?

Did you complete and hand in the anonymous questionnaire?

Any other general comments or things you would like to suggest?

Appendix B – Interview format for the 2nd group

Intro (General Chat) (where are you from, live in Maynooth? Like Maynooth, social Life etc.)

What are you studying? Arts? Finance? Science?

Modules Doing?

What other subjects? Chemistry? Physics,etc,?

- Did you realise the extent of Maths content in your course?
- Why did you choose Maths?
- Are you still studying Maths?
  Yes/No
  - Why? Was it enforced or by choice?
  - If not enforced would you choose differently?

What was your experience of Mathematics before University?

Did you enjoy maths in primary/secondary school?

How did your teachers affect your experience of maths?

Difficult/Easy?

How did you fare in the Leaving Cert?

What was your experience of 1st year Mathematics?

How was it different from school?

(compare to points above??)

Did you attend many Mathematics lectures?

How many lectures did you attend? (All, most, once a week, rarely, never)

Attended regularly:

Why did you attend regularly?

Did you find them useful?

Attended rarely or never:

Why did you not attend on regular basis?
Comment on lecture structure in general, anything that should be changed \positive aspects of Lectures?

Did you attend many Mathematics tutorials?

How many tutorials did you attend? (20, in total, all, most, less than 10, less than 5)

Attended regularly:

Why did you attend regularly?

Did you find them useful?

Attended rarely or never:

Why did you not attend on regular basis?
Comment on lecture structure in general, anything that should be changed \positive aspects of tutorials?

Did you hand in many Mathematics assignments?

How many assignments did you hand in? (20, in total, all, most, less than 10, less than 5)

Handed in most:

Why? Did they help with your understanding? Did you find them difficult/easy?

Rarely/never:

Why? Did you attempt the assignments? What would you say is the main reason you did not submit?

Comment on assignment structure in general, anything that should be changed \positive aspects of assignments??

Did you attend the Mathematics Support Centre (MSC)?

How many times did you attend? (never, once, >5, >10)

Attended regularly:

Why? What was helpful about the MSC? (atmosphere, tutors, etc?) Why did you return regularly?

Attended once or twice:

Why? Why did you not return? Was it helpful/unhelpful? Reasons?

Never attended:

Why? Were you aware of it? What stopped you from coming? Did you feel you didn't need to come?

Comment on MSC structure in general, anything that should be changed \positive aspects of MSC?

What aspects of the MSC services did you use most? Why\why not etc

Ask them to comment on group work/1-1 help. Did they find them useful? Good points/bad points? Any suggestions on how this service could be improved?

Did they use the handouts/books at all? Why\Why not? Did they find them useful? Good points/bad points? Any suggestions on how this service could be improved?

Did they use any of the online courses on moodle? (Maths Proficiency/Foundation?) Why\Why not? Did they find them useful? Good points/bad points? Any suggestions on how this service could be improved?
Did they avail of the follow up workshops? (Maths Proficiency/Foundation/First Science Workshop?) Why\Why not? Did they find them useful? Good points/bad points? Any suggestions on how this service could be improved?
Did they access any other online resources? Why\Why not? Did they find them useful? Good points/bad points? Any suggestions on how this service could be improved?

Would you say that you have problems with maths?

What do you do when you have problems with Mathematics?

Unaware\aware needed help? Aware but unsure how to get help? Aware but embarrassed or intimidated? Comment on importance of seeking help\asking questions etc.

Do you think there is anything else you could have done to improve your grade? What do you think was the main factor for you achieving your grade?

Do you think there is anything we (NUIM\Mathematics Department) could have done to help you improve your grade or make your study experience here better?

If you could advise a current first year maths student, coming to NUIM in a similar situation to your own, to do one thing that would help improve that situation, what would it be?

Did you complete and hand in the anonymous questionnaire?

Any other general comments or things you would like to suggest?

Appendix C – Completed Grid

Fear	**Social**	**Motivation**	
Fear of the unknown: p3	*Relationships/Interactions with teaching staff: P1, p3, p6, p8, p11, p12 x2 , p13*	*Mastery Goals:P5*	**Understanding of maths: P2, p4, P5**
Fear of showing a lack of knowledge/ability: P2, p8	*Influence of friends/peers on engagement:P4, p5 x2, p14*	*Approach Goals: P2?P6*	**Awareness/lack of awareness: P1, p2, p4, P5 x2, p8, p9, p10, p12, p13, p14, p15, p16**
Fear of being singled out: P2, p9x2		*Avoidance Goals: P5, p7, p8, p9, p12, p14, p15*	**Moment of Realisation/Fight or flight, etc,: p5, p8, p9, p11, p12, p13, p14, p16?**
Fear of failure:p6		*Other motivation: p6 Didn't want to fail*	**Other: p1, p5 Environment, influence teaching style, p3 environment, p4,p5, p6, p13 Intervention p11, p14, p16**

Strategies	**Fear**	**Motivation**	**Social**	**Other**
	P2 fear of maths, fear of being asked questions on maths, p3, p4, p4 fear as a motivation, p5 fear of asking a question in lecture, p5, p8, p9, p15 Anti-fear of approaching lectures p1 Fear of large class? P6 Anti-fear of asking questions p6, p7, p13 Fear of feedback p9 Anti-fear p12	**P2, p4 fear, p5, p6, p11, p12 Choice of course on a whim P2 Marks mot p10 Bad experience in MSC off putting p12 Right answer mot p13**	**P6, p7, p13, p14**	**History of struggle with maths p2 x2, p3. p14 x2 Learned lesson p10, p12, p13, end Excuses p5, p8, p9, p12**

Appendix D – Consent Form

Informed Consent Form

I. Research Study Title
An investigation of the effectiveness of mathematics support initiatives.

II. Researcher: Mr Martin Grehan, Department of Mathematics, NUI Maynooth. Tel:7083915.

III. Supervisors: Dr Ann O'Shea, NUI Maynooth. Tel: 7083766. Dr Ciarán Mac an Bhaird, NUI Maynooth. Tel: 7083992.

IV. Purpose of the Research
This study will investigate students' experiences of Mathematics and Mathematics Support at NUI Maynooth. The project also aims to explore the reasons why students have difficulties with Mathematics at Third Level and what the Department of Mathematics at NUI Maynooth can do to help resolve these problems.

V. Dissemination of Study Results
Results will be presented in Martin Grehan's MSc thesis which he hopes to complete before the end of 2011. It is hoped that the results will also be presented as conference papers and journal articles following the analysis of data and completion of the project (summer 2010 onwards). Interested participants will be offered an electronic copy of the completed thesis.

VI. Requirements of Participation in Research Study
Participation in the study will involve the student taking part in audio-taped semi-structured interviews of 30 minutes duration.

VII. Arrangements to Protect Confidentiality of Data
The study will be anonymous. All identifying information for participating students will be removed from all reports of the findings of the study. Also, every effort will be made not to report results using small subgroups of participants which might lead to the identities of those concerned being inadvertently revealed. All data will be stored securely at NUI Maynooth. Data will be available to subjects at their discretion.

VIII. Confirmation that involvement in the Research Study is voluntary
I am aware that if I agree to take part in this study, I can withdraw from participation at any stage. There will be no penalty for withdrawing before all stages of the Research Study have been completed.

IX. Signature:

I have read and understood the information in this form. The researchers have answered my questions and concerns, and I have a copy of this consent form. Therefore, I consent to take part in this research project

Participant's Signature:

Name in Block Capitals:

Witness: **Date:**