Evaluating student engagement with mathematics support

This item was submitted to Loughborough University's Institutional Repository by the/an author.

Additional Information:

- A Doctoral Thesis. Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of Loughborough University.

Metadata Record: [https://dspace.lboro.ac.uk/2134/14435](https://dspace.lboro.ac.uk/2134/14435)

Publisher: © Ria Symonds

Please cite the published version.
This item was submitted to Loughborough University as a PhD thesis by the author and is made available in the Institutional Repository (https://dspace.lboro.ac.uk/) under the following Creative Commons Licence conditions.

You are free:

- to copy, distribute, display, and perform the work

Under the following conditions:

**Attribution.** You must attribute the work in the manner specified by the author or licensor.

**Noncommercial.** You may not use this work for commercial purposes.

**No Derivative Works.** You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

Your fair use and other rights are in no way affected by the above.

This is a human-readable summary of the Legal Code (the full license).

For the full text of this licence, please go to: http://creativecommons.org/licenses/by-nc-nd/2.5/
Evaluating Student Engagement with Mathematics Support

By

Ria Symonds

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of Loughborough University

June 2009

© by Ria Symonds, 2009
ABSTRACT

This thesis reports the findings of quantitative and qualitative research to evaluate the effectiveness of mathematics support and to examine the issue of student engagement in relation to its effectiveness. Usage data regarding Loughborough University’s Mathematics Learning Support Centre was analysed to understand which students make use of the support and the extent of that usage. It was found that the majority of students who need mathematics support were not accessing the resources. Rich contextual data were gathered by interviews and focus groups, which indicated that a number of barriers had prevented students from initially using the support. However, whilst some students overcame these barriers to become regular users of the support, other students (who were ‘at risk’ of failing the mathematical component of their courses) did not. Students who were ‘at risk’ and had not accessed the support lacked the motivation to engage with mathematics and the available support.

This thesis also evaluated the effectiveness of a proactive support initiative involving small group teaching. Despite encouraging students to engage with mathematics support, since they did not have to take the initiative themselves, it was revealed that a lack of student engagement had had a profound effect on the success of this support. Qualitative data was analysed to provide an insight as to why students had failed to engage with the initiative. Constructs of students’ attitudes towards mathematics and their learning approaches were investigated. In particular, it was found that students who engage with mathematics support are generally well-motivated and cognitively engaged. These students held generally positive attitudes towards mathematics and deployed metacognitive learning strategies by regularly monitoring and directing their learning in order to achieve their high educational aims.

This study has implications both for research and practice. From a practical perspective, it appears that mathematics support has moved from one of remedial support to one of enhancement. It is recommended that action should be taken to provide extrinsic motivation to encourage engagement with the support. However, from a research perspective, a more rigorous investigation of the students’ attitudes and learning approaches and how these constructs relate to their levels of engagement with mathematics support would be useful. Further information in this area could be used to provide further quantification of the efficacy of mathematics support.
ACKNOWLEDGEMENTS

I would like to extend my gratitude to a number of wonderful people who have helped support me whilst I have been working on this thesis. Without them I would not have gotten to the point where I am today. Although it is difficult to do proper justice to what they have meant to me, this is an attempt to acknowledge the various contributions.

It has been a real privilege to work under the supervision of Carol Robinson and Duncan Lawson. From the outset they have encouraged me to develop my own research and have gently offered appropriate suggestions and encouragement. They have given their time with extraordinary generosity, offering detailed and thoughtful feedback on ideas, data and eventually thesis drafts. Their support has made this experience enjoyable as well as educational.

I would also like to acknowledge the kindness and support of the MEC staff, particularly Tony Croft who has truly made me feel part of a family.

I am most grateful to the various students who have willingly given their time to my research and who have trusted me with open and honest accounts of their own experiences. Without their participation this research would not have been possible.

Finally, I am particularly grateful to the support of my family. Their encouragement and support have been invaluable in all my academic endeavors. My grandparents, Betty and Peter Gowen, have always believed in me and encouraged me to reach for the stars. My sister has been my best friend and offered her advice throughout. And finally, my mum, who has been my rock and has provided guidance and support during the highs and the lows. She has unconditionally given me everything to make my dreams come true, of which I am ever grateful.
RELATED PUBLICATIONS

The following papers were written prior to the submission of this thesis and report some of the work herein and other related activities.

Conference Contributions in published proceedings


Conference Contributions (awaiting publication)


Journal Papers


**GLOSSARY**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASI</td>
<td>Approaches to Studying Inventory</td>
</tr>
<tr>
<td>ATM</td>
<td>Attitudes Towards Mathematics</td>
</tr>
<tr>
<td>BTEC</td>
<td>Business and Technician Education Council</td>
</tr>
<tr>
<td>CAA</td>
<td>Computer Aided Assessment</td>
</tr>
<tr>
<td>CETL</td>
<td>Centre for Excellence in Teaching and Learning</td>
</tr>
<tr>
<td>DfEE</td>
<td>Department for Education and Employment</td>
</tr>
<tr>
<td>ESRC</td>
<td>Economic and Social Research Council</td>
</tr>
<tr>
<td>GCE</td>
<td>General Certificate of Education</td>
</tr>
<tr>
<td>GCSE</td>
<td>General Certificate of Secondary Education</td>
</tr>
<tr>
<td>GNVQ</td>
<td>General National Vocational Qualification</td>
</tr>
<tr>
<td>HEFCE</td>
<td>Higher Education Funding Council for England</td>
</tr>
<tr>
<td>HELM</td>
<td>Helping Engineers Learn Mathematics</td>
</tr>
<tr>
<td>IMA</td>
<td>Institute of Mathematics and its Applications</td>
</tr>
<tr>
<td>JCGQ</td>
<td>Joint Council for General Qualifications</td>
</tr>
<tr>
<td>LMS</td>
<td>London Mathematical Society</td>
</tr>
<tr>
<td>LTSN</td>
<td>Learning and Teaching Support Network</td>
</tr>
<tr>
<td>MSC</td>
<td>Mathematics Support Centre (at Coventry University)</td>
</tr>
<tr>
<td>MLSC</td>
<td>Mathematics Learning Support Centre (at Loughborough University)</td>
</tr>
<tr>
<td>NAO</td>
<td>National Audit Office</td>
</tr>
<tr>
<td>NSSE</td>
<td>National Survey of Student Engagement</td>
</tr>
<tr>
<td>OFSTED</td>
<td>Office for Standards in Education</td>
</tr>
<tr>
<td>PBL</td>
<td>Problem-based learning</td>
</tr>
<tr>
<td>PISA</td>
<td>Programme for International Student Assessment</td>
</tr>
<tr>
<td>ProDAIT</td>
<td>Professional Development for Academics Involved in Teaching</td>
</tr>
<tr>
<td>RSS</td>
<td>Royal Statistical Society</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
</tr>
<tr>
<td>SPQ</td>
<td>Study Process Questionnaire</td>
</tr>
</tbody>
</table>
# CONTENTS

ABSTRACT ................................................................................................................................. i
ACKNOWLEDGEMENTS ............................................................................................................... ii
RELATED PUBLICATIONS ............................................................................................................. iii
GLOSSARY ...................................................................................................................................... iv
CONTENTS .................................................................................................................................... vi

## CHAPTER 1 - INTRODUCTION ......................................................................................... 1

1. BACKGROUND ......................................................................................... 1
   1.1 Enhanced drop-in provision ........................................................................ 3
   1.2 Proactive support initiatives ........................................................................ 3

2. UNDERLYING THEME OF THE RESEARCH ..................................................... 4

3. RESEARCH QUESTIONS .................................................................................. 5

4. OUTLINE OF THESIS ...................................................................................... 6

## CHAPTER 2: LITERATURE REVIEW ........................................................................ 11

1. INTRODUCTION .......................................................................................... 11

2. THE MATHEMATICS PROBLEM ...................................................................... 12

3. MATHEMATICS SUPPORT ........................................................................... 15
   3.1 Streaming as a method of support .............................................................. 16
   3.2 Mathematics Support Centres ................................................................. 20
   3.2.1 UK provision ...................................................................................... 20
   3.2.2 International provision ........................................................................ 22
   3.3 Effectiveness of mathematics support ...................................................... 24

4. STUDENT ENGAGEMENT ........................................................................... 25
   4.1 Definition ............................................................................................... 26
   4.2 Engagement and Achievement .................................................................. 26
   4.3 Engagement at University ......................................................................... 27
   4.4 Engagement with Mathematics ................................................................ 28
   4.5 Engagement and approaches to learning .................................................. 30

5. STUDENT MOTIVATION .............................................................................. 32
   5.1 Definition ............................................................................................... 32
   5.2 Intrinsic and Extrinsic Motivation ............................................................. 32
   5.3 Motivational Theories ............................................................................. 33
   5.4 Motivation at University .......................................................................... 34
   5.5 Motivation and Mathematics .................................................................... 35
   5.6 Motivation and learning ........................................................................... 37

6. ATTITUDES AND LEARNING APPROACHES ............................................. 39
   6.1 Attitudes Towards Mathematics ................................................................ 39
   6.2 Learning Approaches to Mathematics ...................................................... 42

7. SUMMARY ..................................................................................................... 47

## CHAPTER 3: METHODOLOGY ................................................................................. 49

1. INTRODUCTION .......................................................................................... 49

2. QUALITATIVE “VERSUS” QUANTITATIVE RESEARCH .................................. 50

3. QUESTIONNAIRES ...................................................................................... 52
   3.1 OVERVIEW ............................................................................................ 52
   3.2 Design ..................................................................................................... 53
   3.2.1 Layout ............................................................................................... 53
   3.2.2 Question Wording ............................................................................ 54
   3.2.3 Types of Questions ............................................................................ 55
   3.3 Practicalities and Analysis ....................................................................... 56
   3.4 Advantages and Limitations ..................................................................... 58
   3.5 Conclusion ............................................................................................... 58

4. INTERVIEWS ................................................................................................. 59
   4.1 Overview ................................................................................................. 60
CHAPTER 4 - THE MATHEMATICS LEARNING SUPPORT CENTRE

1. INTRODUCTION
2. BACKGROUND
2.1 Loughborough University
3. ANALYSIS OF USAGE DATA
3.1 General usage of the MLSC
3.2 Analysis by STEM and non-STEM students
3.3 MLSC usage amongst first year STEM students
4. REGRESSION MODELS
4.1 Simple Linear models
4.2 Multiple Linear Regression Model
5. SUMMARY AND DISCUSSION

CHAPTER 5 - UNDERSTANDING WHY STUDENTS FAIL TO ENGAGE WITH MATHEMATICS SUPPORT

1. INTRODUCTION
2. NON-USERS OF MATHEMATICS SUPPORT
2.1 Methodology - Phase 1
2.2 Methodology - Phase 2
2.3 A note about sampling
2.4 Results
2.4.1 Lack of awareness of the MLSC's location and facilities
2.4.2 Lack of awareness of the need of mathematics support
2.4.3 Too many problems that need addressing
2.4.4 Embarrassment, Intimidation and demoralisation
2.4.5 Perceived to be not appropriate for non-STEM students
2.5 Summary
3. REGULAR USERS OF MATHEMATICS SUPPORT
3.1 Methodology
3.2 Results - Overcoming initial barriers
3.2.1 Lack of awareness of the MLSC's location and facilities
3.2.2 Lack of awareness of the need for help
3.2.3 Too many problems
3.2.4 Embarrassment, Intimidation and demoralisation
3.2.5 Perceived to be not appropriate for non-STEM students
3.3 Results - Student profile of regular users
CHAPTER 6 - PARALLEL CASE STUDIES OF PROACTIVE SUPPORT

1. INTRODUCTION ................................................................. 145
2. Loughborough University ................................................ 146
   2.1 Background ................................................................. 146
   2.2 The support initiative .................................................. 147
   2.3 Identifying the less well-prepared students .................... 148
   2.4 Implementation 2005/6 (Semester 1) ............................. 150
      2.4.1 Practical Problems ................................................. 150
      2.4.2 Attendance ............................................................ 151
      2.4.3 Comparison of Results ........................................... 152
         2.4.3.1 Composition of the groups ................................. 152
         2.4.3.2 Comparison of Pass/Failure rates in 2004/5 & 2005/6 153
         2.4.3.3 Comparison of Exam, Coursework and Module Marks in 2004/5 & 2005/6 155
      2.4.4 Failure Profile ....................................................... 156
   2.5 Implementation 2005/6 (Semester 2) ............................. 157
      2.5.1 Attendance ............................................................ 158
      2.5.2 Comparison of Results ........................................... 159
         2.5.2.1 Comparison of Pass/Failure rates in 2004/5 & 2005/6 (Semester 2) 159
   2.6 Implementation 2006/7 ................................................. 161
      2.6.1 Modifications of the support .................................... 161
      2.6.2 Comparison of 2004/5, 2005/6 and 2006/7 Cohorts .......... 162
         2.6.2.1 Composition of 2006-7 Cohort .......................... 162
         2.6.2.2 Comparison of the Pass/Failure rates in 2004/5, 2005/6 and 2006/7 ........ 163
         2.6.2.3 Comparison of Exam, Coursework and Module Marks in 2004/5, 2005/6 and 2006/7 165
      2.6.3 Attendance ............................................................ 166
      2.6.4 Failure Profile ....................................................... 168
   2.7 Conclusions ................................................................. 170
3. Coventry University ...................................................... 172
   3.1 Background ................................................................. 172
   3.2 The Support Initiative .................................................. 173
   3.3 Identifying the less well-prepared students .................... 175
   3.4 Implementation 2005/6 .................................................. 176
      3.4.1 Practical Problems ................................................. 176
      3.4.2 Comparison of Results ........................................... 177
         3.4.2.1 Composition of the groups ................................. 177
         3.4.2.2 Comparison of Pass/Failure rates in 2004/5 & 2005/6 178
         3.4.2.3 Comparison of Exam, Coursework and Module Marks in 2004/5 & 2005/6 180
   3.5 Implementation 2006/7 ................................................. 181
      3.5.1 Comparison of Results ........................................... 181
         3.5.1.1 Composition of the groups ................................. 182
         3.5.1.2 Comparison of the Pass/Failure rates in 2004/5, 2005/6 and 2006/7 183
         3.5.1.3 Comparison of Exam, Coursework and Module Marks in 2004/5 & 2005/6 184
      3.5.2 Attendance ............................................................ 185
   3.6 Conclusions ................................................................. 186
4. SUMMARY AND DISCUSSION ............................................. 187

CHAPTER 7 - STUDENTS’ ATTITUDES TO MATHEMATICS

1. INTRODUCTION ................................................................. 191
2. Attitudes of the 2005/6 physics students ......................... 192
   2.1 Questionnaire .............................................................. 192
      2.1.1 Methodology .......................................................... 192
      2.1.2 Results ................................................................. 194
         2.1.2.1 Attitudes towards mathematics prior to / whilst at university 194
         2.1.2.2 Feelings towards the module and the exam assessment 196
   2.2 Follow-up interviews .................................................... 198
      2.2.1 Methodology .......................................................... 198
      2.2.2 Results ................................................................. 200
         2.2.2.1 Previous mathematics experience .......................... 200
         2.2.2.2 University Mathematics ......................................... 201
         2.2.2.3 Mathematics module assessment .......................... 203
TABLES

Table 2.1: Sample Items, by factor, of Tapia and Marsh’s ATM scale ................................................. 40
Table 2.2: Attitudinal factors and their defining characteristics ............................................................ 42
Table 3.1: Characteristics of quantitative and qualitative research methods ........................................ 51
Table 4.1: Number of students and visits to the MLSC grouped by STEM and non-STEM departments .......................................................................................................................................................... 88
Table 4.2: Comparison of the number of visits and the proportion of visits made by STEM/Non-STEM students ................................................................................................................................................................ 89
Table 4.3: Breakdown of first year MLSC visits by STEM students ....................................................... 91
Table 4.4: Breakdown of first year mathematics modules by department ............................................. 92
Table 4.5: Frequency of visits to the MLSC by module and grade ......................................................... 95
Table 4.6: Frequency of visits to the MLSC by grade ............................................................................ 96
Table 4.7: Multiple regression model of engineering students’ performance in a first year mathematics module .................................................................................................................................................. 107
Table 5.1: Non-user student profiles .................................................................................................... 115
Table 5.2: Reasons given for non-use of the MLSC ............................................................................... 121
Table 5.3: Responses given by regular users of the MLSC ................................................................. 130
Table 6.1: Average lecture and tutorial attendance of the main and ‘supported’ groups ..................... 151
Table 6.2: Distribution of attendance rates for the ‘supported’ group .................................................. 152
Table 6.3: Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 ........................................................................................ 154
Table 6.4: Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 ........................................................................ 156
Table 6.5: Failure Profile of students who had failed the module in 2005/6 ........................................... 157
Table 6.6: Failure Profile of students who had failed the module in 2004/5 .......................................... 157
Table 6.7: Comparison of Semester 1 and Semester 2 attendance for the main group and the supported group ......................................................................................................................................................... 159
Table 6.8: Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 (Semester 2) .......................................................... 159
Table 6.9: Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 (Semester 2) .......................................................... 160
Table 6.10: Comparison of the less well-prepared students from 2004/5 (Semester 1) with the less well-prepared students who received support and the main group in 2005/6 and 2006/7 (Semester 1). .......................................................................................................................................................................................................................... 164
Table 6.11. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 and 2006/7 .................................................. 165
Table 6.12. Average lecture and tutorial attendance of the 'supported' groups in 2005/6 and 20006/7 (semester 1) ................................................................................................................. 167
Table 6.13. Failure Profile of students who had failed the module in 2006/7 ............................................ 169
Table 6.14. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support in 2005/6 ...................................................................................... 179
Table 6.15. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 .............................................................. 180
Table 6.16. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support in 2005/6 and 2006/7 ........................................................................... 183
Table 6.17. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 and 2006/7 ...................................................... 184
Table 7.1: Students' responses in relation to their attitudes to mathematics before and during university. ................................................................................................................................. 195
Table 7.2: Students responses in relation to how they felt about the first semester mathematics module and the exam assessment ........................................................................................................ 197
Table 7.3: Previous mathematics qualifications of the respondents to the first distribution of the questionnaire ................................................................................................................................................. 209
Table 7.4: Breakdown of responses with regards to Self-Concept of Ability (1st distribution) .................. 215
Table 7.5: Breakdown of responses with regards to Self-Concept of Ability (2nd distribution) .......... 216
Table 7.6: Breakdown of responses with regards to Enjoyment (1st distribution) ...................................................... 217
Table 7.7: Breakdown of responses with regards to Enjoyment (2nd distribution) ........................................ 219
Table 7.8: Breakdown of responses with regards to Motivation (1st distribution) .............................................. 220
Table 7.9: Breakdown of responses with regards to Motivation (2nd distribution) ........................................ 221
Table 7.10: Breakdown of responses with regards to Teaching (1st distribution) ........................................ 222
Table 7.11: Breakdown of responses with regards to Teaching (2nd distribution) ........................................ 223
Table 7.12: Breakdown of responses with regards to Value/Worth (1st distribution) ................................. 224
Table 7.13: Breakdown of responses with regards to Value/Worth (2nd distribution) ................................. 225
Table 8.1: Breakdown of students into the four learning approaches (prior to university) ......................... 243
Table 8.2: Breakdown of the less well-prepared and well-prepared students into the four learning approaches (prior to university) ................................................................. 244
Table 8.3: Breakdown of students into the four learning approaches (at university) ........................................ 245
Table 8.4: Breakdown of the less well-prepared and well-prepared students into the four learning approaches (at university) .......................................................................................... 246
Table 8.5: Breakdown of students in terms of preparedness, attendance and module result and learning approach .......................................................................................................................... 252

FIGURES

Figure 2.1: Learning approaches and their defining characteristics ............................................................ 45
Figure 4.1: Comparison of the number of students and visits to the MLSC in 2006-07, 2005-06 and 2004-05 ................................................................. 83
Figure 4.2: Frequency of visits to the MLSC by module ............................................................................... 93
CHAPTER 1 – INTRODUCTION

This thesis seeks to examine the effectiveness of mathematics support within Higher Education. In particular, it will examine the issue of student engagement and how this may impact upon the effectiveness of the support. In this chapter an introduction to the present study will be given by locating this research within broader and ongoing concerns about the mathematical preparedness of undergraduates. It will first give a brief background to the research at hand before outlining the main research questions that the author wishes to address. The final section will provide an outline of the thesis by providing brief description of each of the main chapters.

1. BACKGROUND

The decline in the mathematical preparedness of students entering university has been the subject of close scrutiny over recent years. Commonly known as the “Mathematics Problem”, many reports (for example Sutherland and Pozzi (1995) and LMS, IMA & RSS (1995)) have documented the deteriorating situation and the resulting complications for universities. The situation appears to be a result of the changes in the structuring teaching and assessment of A-levels and widening access to higher education for students with diverse educational backgrounds, amongst other factors (a more detailed discussion is presented in Chapter 2).

Consequently, many Science, Technology, Engineering and Mathematics (STEM) courses suffer from a high proportion of course failure and poor retention rates. The Higher Education Funding Council for England (HEFCE) produces performance indicators for non-continuation following year of entry. These show that for young entrants (aged 18-25) in engineering and technology, non-continuation figures are the highest amongst all subjects, HEFCE (2003). Similarly in a report published by the National Audit Office (NAO) (2007), statistics indicated that

‘When science, technology, engineering and mathematics students are considered together, they are less likely to continue to a second year of study than students following other subjects.’ NAO (2007) p 24.
For example, 88.1% of Mathematics and Computer Science students progressed to their second year in 2004-5 compared to a continuation rate of 91.7% amongst Law students, NAO (2007). Indeed, research suggests that high failure rates and poor retention rates during the first two years of undergraduate programmes are primarily caused by the difficulties students experience acquiring crucial mathematics skills (QAA Subject Overview Electronic and Electrical Engineering, cited in Croft (2003)).

In response to this problem many universities now offer some form of mathematics support, MathsTEAM (2003c). For example, several institutions have established some form of mathematics support centre. These centres offer a wide-range of support facilities to students, which is additional to that provided by their routine lectures or tutorials. In addition, some institutions have introduced innovative ways of teaching, such as project-based learning, in an attempt to build students’ mathematics skills and confidence. However, the level of support offered by universities varies enormously and there is a shortage of evidence indicating how effective these mathematics support systems are in supporting students.

At Loughborough and Coventry Universities, sigma, a joint Centre for Excellence in Teaching and Learning (CETL), has funded a number of mathematics support initiatives in order to improve the mathematical learning experience of students. This has been made possible by the considerable funding that the CETL award brings. The funding has been allocated to various support initiatives in order to enhance the current mathematics and statistics support at Loughborough and Coventry Universities, including:

- Enhanced drop-in provision
- Proactive support initiatives
- Support for students with additional needs
- Innovative uses of technology

In terms of the research presented in this thesis, two particular methods of support are examined in detail, namely drop-in provision and proactive support. Therefore, further details of these initiatives are given below.
1.1 ENHANCED DROP-IN PROVISION

Support facilities have been extended at both universities. At Loughborough University, new support facilities have been developed via a new centre that is located at the centre of the university campus. Previously, the only centre was located on the edge of the campus, amongst the Mathematics, Engineering, and Physics departments. The location of the additional centre is more conveniently located for students from Social Sciences, Human Sciences, Business and Economics departments.

At Coventry University, the drop-in centre has been relocated to newly refurbished premises, which has nearly doubled the capacity of their mathematics support centre. Since its opening in September 2005, there has been a significant increase in the uptake of support with an increase of over 100% in the number of visits recorded.

As well as extending and improving the drop-in centre environments, both centres have also increased the variety of resources, improved online support material and increased staff time dedicated to the support centres. However, this form of support is reactive in that students are required to take the initiative in accessing the support available.

1.2 PROACTIVE SUPPORT INITIATIVES

Proactive support initiatives have been implemented within various departments at both universities, in the anticipation that the initiatives will help support students who lacked the motivation to seek 'drop-in' support. A number of approaches have been implemented including supplementary or alternative teaching and department-specific drop-in sessions. For some departments, students who are recognised as being mathematically less well-prepared than their peers receive separate small group teaching for their mathematics module(s) and may also receive additional teaching hours. In other departments, specific drop-in sessions are offered to all students who have no timetabled classes.
The structure and level of support of the proactive initiatives differ depending upon the module and students who require support. To illustrate, further details of some of the support initiatives are given:

**Separate small group teaching (Coventry)**

A small group of mathematically less well-prepared students are taught separately from the main group for the entirety of their mathematics module. Diagnostic test marks are used to allocate students to an appropriate group. The small group are taught using a classroom approach rather than the traditional lecture/tutorial format (a full evaluation of this support is provided in Chapter 6).

**Separate small group teaching (Loughborough)**

This initiative is similar to that of the small group teaching at Coventry. A small group of mathematically less well-prepared students are taught separately from the main group for the entirety of their mathematics module. However, previous mathematics qualifications are used to determine the students' preparedness. Students with a grade D or E in Mathematics A-level or non-traditional qualifications are deemed as being less well-prepared. Students were taught using a 'classroom' approach using different teaching materials than that of the main group. (A full evaluation of this support is provided in Chapter 6).

**2. UNDERLYING THEME OF THE RESEARCH**

It was anticipated that the initiatives outlined above would enhance students' learning, improve retention and increase pass rates. However, some of these initiatives have had limited success (as will be discussed in Chapter 6). A critical issue that has impacted upon their success is that of student engagement. Whilst some manner of disengagement may be expected with regards to reactive support initiatives (such as the 'drop-in' facility) perhaps more surprisingly this is also the case with regards to proactive support initiatives. Consequently, if students fail to engage with the support offered then they cannot benefit from it and, moreover, the support cannot be deemed to be successful.
However engagement with mathematics support is not as straightforward as labelling a student who uses mathematics support as being ‘engaged’. There are many issues that are connected to this construct, such as the extent to which the student is engaged on a behavioural and cognitive level, as well as considering the factors that may influence the level of that engagement. It should also be considered that student engagement may influence profoundly issues such as retention, success of teaching approaches and students’ approaches to learning. In addition, stronger engagement has the potential to deliver a more enjoyable teaching and learning experience for staff and students.

In this thesis, the construct of student engagement will be used to depict the extent to which a student participates in and values learning activities. It will be considered in terms of two components, the first as a behavioural component and the second as a cognitive component. In terms of behaviour, ‘engagement’ will be used to depict the extent to which a student actively participates in educational practices (such as attendance at lectures). In terms of cognition, ‘engagement’ will be used to depict the extent to which a student identifies with, believes in and values educational practices. This is linked to motivated behaviour, in that a student will exhibit persistence and self-regulation in learning mathematics.

The purpose for this study is to explore the issue of student engagement and how this impacts upon the success of proactive and reactive mathematics support mechanisms. The research questions directly address the purpose of the study. These will now be presented.

3. RESEARCH QUESTIONS

The motivation of this research project was primarily to evaluate the effectiveness of some mathematics support initiatives for undergraduate students. However, during the initial stage of this research it was evident that student engagement was of particular concern and played a pivotal role in the success of the various support initiatives. Therefore, the research project aims to examine the issue of student engagement with mathematics support and how this impacts upon the effectiveness of the support.
In undertaking this research, the following research questions act as the core of this study:

1. Which students use mathematics support? Which of these fall into the ‘at risk’ category?

2. To what extent do students engage with mathematics support? Is there a difference in the level of engagement of ‘at risk’ students compared to other students?

3. Why do some students avail themselves of mathematics support whilst other do not?

4. Is there a significant difference in the success rate of ‘at risk’ students prior to CETL initiatives compared to ‘at risk’ students who take part in CETL initiatives.

5. How effective are different methods of support in aiding ‘at risk’ students?

6. What is the student perspective on their knowledge/ lack of knowledge in mathematics and how has it affected their university studies and engagement with mathematics/mathematics support?

Encompassed within these research questions are a number of constructs, which will be considered, in respect of mathematics support, particularly student engagement. This research will consider how students interact and engage with mathematics support and how this may impact upon the effectiveness of that support. This will include examining students’ attitudes and their approaches to learning mathematics. The research will investigate these constructs to help understand how and the extent to which students engage with mathematics support.

4. Outline of Thesis

This chapter has provided a brief orientation of the key features of the present research study. The study has been located within broader and ongoing concerns about the mathematical preparedness of undergraduates and the context within which the study took place has been introduced. Most importantly, the research questions have
been described, and a stance adopted with respect to the general purposes of such research. The structure of this thesis is briefly outlined in what follows.

Chapter 2 provides a review of the relevant literature, and describes in detail the theoretical framework related to the research. It begins by discussing the relevant literature with regards to the "Mathematics Problem" as evidence for the need for mathematics support at the tertiary level. It then highlights the current literature in the area of mathematics support, in particular that of 'streaming' and mathematics support centres. The constructs of student engagement and motivation are explored including how these constructs relate to higher education and to the discipline of mathematics. The chapter also examines the constructs of attitudes towards mathematics and approaches to learning and focuses on how these relate to engagement and motivation in mathematics.

An overview of the methodology used in this research is given in Chapter 3. This includes a discussion of the debate surrounding the use of quantitative versus qualitative research methods and how this relates to the present study. It proceeds to discuss three paradigms that were most influential on this study, namely questionnaires, interviews and focus groups, and highlights those elements that were most useful. This chapter also draws upon some ethical concerns and also theoretical issues of the research methods used, in particular with regard to sampling.

The subsequent five chapters present a discussion and analysis of the research conducted for this thesis. Within Chapter 4-8, two particular support mechanisms are discussed, namely a reactive support initiative and a proactive support initiative. The issue of engagement is considered throughout these chapters and is presented in two strands by considering quantitative and qualitative data. Namely;

- **Reactive support initiative: Mathematics Support Centre**

  Chapter 4 will consider engagement as a *behavioral* component by analysing quantitative data such as usage data to depict the extent to which students avail themselves of ‘drop-in’ support.
Chapter 5 will consider engagement as a cognitive component by analysing qualitative data taken from student interviews and focus groups.

- Proactive support initiative: Small group teaching

Chapter 6 will consider engagement as a behavioral component by analysing quantitative data such as attendance data to depict the extent to which a student participates in lectures/tutorials.

Chapters 7 and 8 will consider engagement as a cognitive component by examining students' attitudes and learning approaches to mathematics (using qualitative data).

Chapter 4 evaluates a reactive support initiative in the form of Loughborough University's Mathematics Learning Support Centre (MLSC). Usage statistics over a three-year period (from 2004-5 to 2006-7) are analysed and compared to evaluate the success and effectiveness of the support. In particular, it examines the extent to which students use the centre, in terms of Science, Technology, Engineering and Mathematics (STEM) and non-STEM disciplines. Moreover, mathematics module marks of first year students taking STEM courses are analysed and compared against centre usage. These findings are used to examine the extent to which students, who failed a mathematics module, used the centre and compares them with students who passed the module. A deeper investigation of the relationship between student engagement, mathematics support and mathematics performance is carried out in the final section of this chapter. In particular, linear and multiple linear regression models are considered. Such models were constructed to establish if a student's performance in a mathematics module could be predicted and, particularly, whether there is a relationship between student engagement with the MLSC and mathematics performance.

A key issue that emerges from Chapter 4 is that many students who had failed a mathematics module failed to engage with mathematics support via the MLSC. Chapter 5 examines this further by analysing qualitative data (from interviews and focus groups) to investigate the reasons why students failed to engage with
mathematics support. The views of non-users of the support and also the views of regular users of the support were considered. In particular, it describes the perceived barriers that have prevented students from engaging with this method of support. The perceptions of the regular users are then discussed to give an insight into how non-users may be encouraged to engage with the mathematics support. This chapter provides a detailed discussion of student engagement in terms of cognition, to investigate the extent to which the students themselves felt they were motivated and engaged with mathematics and their university courses and how this may have influenced their engagement with mathematics support.

Chapter 6 evaluates two proactive support initiatives implemented at both Loughborough and Coventry Universities. The support implemented involved small group teaching of mathematically less-well prepared students over two consecutive years (although the groups of students changed over the two years). Details of the support at Loughborough University with Physics students are presented first. In particular, it describes the implementation of the support initiative, including practical problems and attendance figures. A comparison is made of the module results for the less well-prepared students who received support in 2005/6 and 2006/7 with results for the less well-prepared students (who were not supported) in 2004/5. A similar examination of the support initiative at Coventry University with Engineering students is then given. The chapter compares the support initiatives at both institutions and comments upon their effectiveness with regards to improving retention and progression amongst the mathematically less well-prepared students. In particular, it discusses the issue of student engagement with proactive support.

Findings from Chapter 6 indicate a lack of student engagement with the support, despite being proactive in that it encourages students to engage with mathematics support since they do not have to take the initiative themselves. Chapter 7 and Chapter 8 analyse and discuss qualitative data (from questionnaires and interviews with Loughborough University Physics students) to provide an insight as to why students had failed to engage with the initiative. In particular, the constructs of students’ attitudes towards mathematics and learning approaches are considered (in Chapter 7 and Chapter 8 respectively).
At the start of Chapter 7, details of a questionnaire, which sought to collect preliminary data with regards to the 2005/6 cohort of Physics students, are given. This is followed by a discussion of the findings from a number of follow-up interviews. In particular, the issue of students' mathematics confidence and their ability to adapt to learning at university is discussed. The chapter then presents a deeper investigation of students' attitudes by analysing data from a qualitative questionnaire administered to the 2006/7 cohort of Physics students. It examines a number of attitudinal factors that have influenced the students' attitudes, including self-concept of ability, enjoyment and motivation. In particular, it investigates whether the students' attitudes have changed since being at university. It compares the responses of the well-prepared students and less well-prepared students and also discusses how this may affect their engagement with and performance in mathematics at university.

Chapter 8 extends the analysis presented in Chapter 7. It uses data from the same qualitative questionnaire to examine students' learning approaches to mathematics. The construct of learning approaches is presented with reference to four pre-identified categories, namely: Surface, Procedural, Deep and Strategic learning approaches. It discusses how these approaches relate to the learning of mathematics and also examines the issue of cognitive engagement in relation to these approaches. Comparisons are made between the well-prepared and less well-prepared students throughout. Chapter 8 also analyses data taken from a number of interviews designed to investigate these issues further. In particular, it examines a number of issues associated with a lack of student engagement, including student motivation, the 'pass culture', 'university culture', and learning at university.

Finally Chapter 9 draws together the findings of the research project and gives a reflection on the implications of these findings. In particular, it discusses how this relates to higher education in a broader sense. Suggestions of possible future work are also given.
CHAPTER 2: LITERATURE REVIEW

1. INTRODUCTION

This chapter will discuss the present literature in the area of mathematics support and related issues for the field of mathematics education. The broad aim of the present study is to investigate the effectiveness of a range of mathematics support mechanisms in Higher Education. In order to examine successfully the effectiveness of mathematics support, a qualitative investigation into the theoretical and social constructs associated with the support is needed. In particular, this research is interested in how students engage with mathematics support and the impacts this may have on the effectiveness of the support. The constructs and the research questions associated with these constructs, which were outlined in the previous chapter, address the current knowledge and theoretical issues in relation to Higher Education and mathematics education literature. Such constructs that will be focussed on are student engagement, student motivation, attitudes towards mathematics and approaches to learning, which were formulated following an initial exploration of the research context and exploration of the relevant literature in this area.

In particular, a key issue of concern for the research presented in this thesis was that of incoming university students' abilities in mathematics. This has become known in the literature as “The Mathematics Problem”, in that many students lack the necessary mathematical skills on entry to university, and so this was taken as a basis for the review. Subsequently, a review of the literature regarding mathematics support was deemed appropriate as the next key issue. Undoubtedly, understanding what is meant by mathematics support and how this relates to the Mathematics Problem is vital for this thesis, especially in evaluating the effectiveness of such mechanisms. Also fundamental to this research are the social constructs surrounding mathematics support mechanisms. Therefore, when evaluating the effectiveness of this support it is essential to consider the construct of student engagement, since if students fail to interact and use the support then it cannot be deemed as successful, or be evaluated appropriately. Directly associated to this is the construct of student motivation, since...
this is closely linked to engagement. To be academically engaged requires some form of motivation on behalf of the student, yet the relationship between the two is not always simple and requires further investigation to examine this further. However, motivation and engagement are based upon affective variables of student behaviour within the construct of students' attitudes. Students' attitudes and the way these affect their behaviour can impact upon how mathematics support is used, and consequently upon the effectiveness of the support. Finally, an additional construct central to understanding the way students engage with mathematics support is that of approaches to learning. Mathematics support mechanisms are provided for students to help build upon the skills and techniques, and consequently their learning of mathematics. Therefore, the way in which students approach their learning of mathematics will determine how they interact with the support.

Considering the areas of interest as stated above, this chapter will begin by providing some background information on the 'Mathematics Problem'. A discussion of the relevant literature in this area will provide evidence of the need for mathematics support at the tertiary level. The subsequent section will then review the current literature with regards to mathematics support mechanisms, in particular that of ability grouping or 'streaming' and Mathematics Support Centres. The chapter will then progress by discussing the issues of student engagement and student motivation and how these relate to studying in Higher Education and to the discipline of mathematics. Finally, the constructs of attitudes towards mathematics and approaches to learning will be examined, including the origin and formulation of these constructs and the way in which these have been used in education research. In particular, this will focus on the linkage with engagement and motivation in the context of these constructs.

This discussion is used to provide crucial evidence that supports the present research study and to acknowledge the need for further research in this area, particularly that of evaluating mathematics support in Higher Education.

2. THE MATHEMATICS PROBLEM

Over the past 30 years, the Mathematics curriculum in the UK has undergone some radical modifications. Numerous changes, coupled with the emergence of so-called
‘sexy’ subjects, primarily at A-level, have contributed to the decline of the popularity of mathematics. According to the report “Making Mathematics Count”, Smith (2004), since 1999 less than 10% of GCSE students in England continue with Mathematics post-16, and less than 10% of those who do continue go on to take a Mathematics degree. Indeed, this translates to a decline of approximately 40% in the number of students taking A-level mathematics compared to the early 1980s, Porkess (2001).

In 1988, The Education Reform Act was introduced in England, Wales and Northern Ireland. This brought about the introduction of a centrally directed National Curriculum. Mathematics was named as a ‘core’ subject that was to be taught to every child between the ages of 5-16. A core subject is defined, by the National Curriculum, to be one “...without which other learning cannot take place effectively”, Eurydice (2007), indicating that competency in Mathematics is a fundamental basis of the curriculum and for all aspects of adult life.

In terms of studying Mathematics and other subjects beyond the age of 16, the qualification of A-levels were first introduced in the early 1950s. Initially, the A-level was used and controlled by universities to measure academic achievement as a selection tool. However, a transfer of control of the A-level curriculum brought about changes to the syllabi. The 1970s brought about the first major changes to the A-level curriculum, whereby statistics was introduced as an option. This meant that students entering sixth form could choose a course comprising of either pure mathematics and applied mathematics or pure mathematics and statistics. This became a much discussed topic amongst academics since it was felt that this change had undermined the development of important skills amongst students. In particular, Kitchen et. al (1997) believe that mechanics plays a key role in mathematics at A-level since, unlike statistics, mechanics “... helps to motivate and reinforce the various pure mathematical skills.” In the late 1980s A-level Mathematics was modularised, and it is believed that this too contributed to a decline in basic mathematical skills since it has led to students entering higher education with wider variation in subject knowledge, Roberts (2002). In particular, an effect of modularisation is to compartmentalise knowledge and it can also lead students to ‘forget’ topics that they study in the first module since they do not take a final exam. In 1988 the GCE O-level was replaced by the GCSE, which spurred a new discussion since it was believed that
the new syllabus change "... brought a decline in students concepts of proof... ", Hawkes and Savage (2000). In 2000, the A-level was revised once more with the introduction of the Advanced Subsidiary level (AS-level), which accounts for 50% of an A-level and meant that a student could achieve the qualification of 'half' of an A-level after just one year. Many concerns have been raised with regards to the impact of 'Curriculum 2000', in particular the high AS-level mathematics failure rate, James (2002) and Porkess (2001). Indeed, the first year of Curriculum 2000 saw a high failure rate (28.7%, JCGQ (2001)) in the Mathematics AS-level, and the Mathematics results stood out of line with other subjects. Of the subjects listed in the JCGQ data, the vast majority had failure rates less than 16%. Subsequently, there was a large drop in the number of students taking A-level Mathematics, as a result of poor AS results.

Repercussions of the numerous changes to the curriculum, and other factors such as Widening Participation schemes, first appeared in the mid 90s, with universities across the country reporting a serious decline in students' mathematical preparedness on entry to their degree courses. In particular, many Mathematics, Engineering and Science departments across the country have reported that their students possess inadequate mathematical preparation, Hawkes and Savage (2000). However, it should be noted that a problem had been recognised as early as the 1960s. For example, Thwaites (1972), in the 1962-3 report, found that it was desired by many universities that "... their future pupils be better prepared for university-type mathematics" and Baker et al. (1973) reported that "Many students of science subjects arrive at university with little facility and less interest in mathematics". However, as the awareness of this problem increased, a number of reports were published by and on behalf of learned societies (for example, Sutherland & Pozzi (1995) and LMS, IMA & RSS (1995)), which comment upon what is now known as "The Mathematics Problem". These reports highlighted the extent of the problem. In particular, the report "Tackling the Mathematics Problem", LMS, IMA & RSS (1995) pointed out that:

"There is unprecedented concern amongst mathematicians, scientists and engineers in higher education about the mathematical preparedness of new undergraduates."

"Recent changes in school mathematics have not laid the necessary foundations to maintain the quantity and quality of mathematically competent school leavers and have greatly disadvantaged those who need to continue their mathematical training beyond school level."
Although the numerous changes to the national curriculum have led to an apparent lack of mathematics competence amongst students with A-level mathematics, there have also been publications reporting on the lack of mathematical preparedness of students with non-traditional mathematics qualifications. Lawson (2000) analysed the results from a mathematics diagnostic test taken by a group of engineering students on commencement of their degree courses. His results indicated that "... A-level students, of all grades, have better basic mathematical skills than those from the vocational route."

To date, the literature provides no simple solution to "The Mathematics Problem". However, Hawkes and Savage (2000) have suggested that all students embarking on mathematics-based degree courses should have a diagnostic test on entry in an attempt to identify students lacking mathematical preparedness. In addition, it was recommended that "Prompt and effective support should be available to students whose mathematical background is found wanting by the [diagnostic] tests." At the time of this recommendation, several universities were already implementing diagnostic testing within their Engineering, Science and Mathematics departments in order to assess the mathematical competency of their students. However, following this report, more universities were encouraged to introduce diagnostic testing on a large scale. In addition, the increased use of diagnostic testing caused many universities to devise new strategies, in the form of mathematics support initiatives, to support students with differing attainments.

3. MATHEMATICS SUPPORT

The literature indicates that over recent years there has been an increased awareness within all university institutions that there are students who have not had the opportunity to fully develop the mathematical skills required for their courses and who need additional help in their mathematics modules. Consequently, many universities now offer some form of mathematics support to their students in order to tackle this problem, Perkin & Croft (2004).

As a method of promoting mathematics support at the tertiary level, the LTSN (Learning and Teaching Support Network) MathsTEAM has published a collection of
three reports consisting of case studies from universities across the UK, in the areas of Diagnostic Testing (MathsTEAM (2003a)), Maths for Engineering (MathsTEAM (2003b)) and Science and Maths Support for Students (MathsTEAM (2003c)). The third report documents a number of case studies that describe a variety of mathematics support mechanisms and, in addition, recommends how other institutions can implement this support. The differing methods of support include mathematics drop-in centres, summer schools, computer-based support and paper-based support. There are also examples of proactive support within Engineering and Physics departments. For example, the University of Manchester Institute of Science and Technology (UMIST), the University of Liverpool and the University of Leeds have all adopted the method of ‘streaming’, whereby students are split into two or more broadly homogeneous groups, dependent upon their mathematical preparedness, and are taught accordingly. Since this form of support is of particular interest to this present study, the subsequent section will provide a more detailed review of ‘streaming’ as a support mechanism. This will be followed by a detailed review of the literature pertaining to Mathematics Support Centres, which is also of general interest to the research presented in this thesis.

3.1 STREAMING AS A METHOD OF SUPPORT

It is common practice amongst schools in the UK to group students by their ‘ability’. This practice is commonly referred to as ‘ability-grouping’ or ‘streaming’. In particular, mathematics students are traditionally streamed into ‘ability-groups’ so that students are exposed to content that matches their levels of understanding. An OFSTED survey in 1996 reported that 96% of schools taught mathematics to ‘setted’ groups in upper secondary years, Guardian (1996). One reason why streaming in mathematics remains a popular choice is due to its hierarchical structure, whereby concepts and skills build upon each other, Ruthven (1987). If it is perceived that students have a fixed level of ability within this hierarchy then these students need to be taught accordingly.

The advantages and disadvantages of grouping students in this way have been debated by researchers and educators over many years. The 1960s gave rise to a growing awareness of the inadequacies of streamed systems. In a study investigating child-
centered education within junior schools, Jackson (1964), it was revealed that low streams were overrepresented by working-class students and, furthermore, teachers with fewer qualifications were allocated to teach such groups. Similar findings were reported in studies by Hargreaves (1967) and Lacey (1970); both linked the method of 'streaming' to underachievement amongst the working-class. Consequently, some subject departments abandoned grouping students by ability. However, mathematics has remained faithful to the practice of streaming. In fact the proportion of secondary schools grouping students has never dropped below 90%, William & Bartholomew (2004).

Since these initial reports, a number of studies have investigated the impact of streaming on students' academic achievement. Relatively few British studies have explicitly examined the attainment of students in different streamed sets, whereas research in the USA provides a rich source of evidence relating achievement to ability groups. This has given rise to a number of literature reviews by American researchers. Slavin (1987, 1990) compared ability group classes against heterogeneously grouped classes in studies from 14 elementary schools (1987) and 29 secondary schools (1990). Data from standardized or teacher-made tests were analysed and it was found that ability-grouping had little effect on overall academic achievement. Kulik and Kulik (1992) report similar, non-significant findings in their review. They concluded that generally there did not appear to be any negative effects on the achievement levels of middle or low groups. In a large-scale study in middle schools by Hoffer (1992), it was found that the effects of ability grouping are not the same for all students. In his study, the method of streaming increased achievement amongst the high attainers at the expense of the lower attainers. Similar findings were found in an earlier study by Kerckhoff (1986), whereby streaming gave slight benefit to students in high streams at the expense of significant loss to students in the low streams.

Although research in this area is less well-developed in the UK, a similar mixture of results has arisen amongst British studies. Boaler et al (2000) investigated the ways in which students' attitudes and achievement in mathematics are affected by ability grouping. Students from six schools, moving from year 8 to year 9, were traced with four of the six schools moving from mixed-ability grouping to homogeneous ability-groups. This study found that students from across the spectrum of setted groups were
at a disadvantage. In particular, students in the high ability groups were disadvantaged due to high expectations and a pressure to succeed, and students in the low ability groups were at a disadvantage due to low expectations and limited opportunities. Consequently, ability-grouping had a negative effect upon the overall academic achievement, since the majority of students achieved well below their potential. More recent studies have found similar findings, for example Ireson et al. (2005). In this study, statistical analysis of 6000 students in British secondary schools found that setting had no significant effect on average GCSE attainment in a school. However, setting could have a profound effect on the attainment of individual students of the same ability who were placed in high or low sets. On average, the effect for an individual of being placed in a top set, rather than a low set, in mathematics, could result in the difference of almost one whole GCSE grade.

Such research findings about the effects of grouping students by ability have not given consistent messages and reflect great variety in practice in different schools and in different countries. In an attempt to address the general effects of ability grouping, a number of comprehensive reviews have been conducted in the UK over recent years, Hallam and Toutounji (1997); Sukhnandan and Lee (1998); Ireson and Hallam (1999). The general consensus from these reviews report that ability-grouping has a limited effect on pupil achievement and there is no conclusive evidence to dispute or support the practice of streaming. However, since there has been limited research conducted within the UK on ability grouping, it is suggested that more research in this area should be conducted.

A review of the literature has revealed that ability-grouping is widespread amongst primary and secondary schools in the UK, primarily in response to government policy and the introduction of competitive pressures such as performance tables. However, limited research (consisting of only a handful of publications) has been conducted into ability-grouping in further and higher education. This is largely due to the fact that once the study of mathematics is no longer compulsory, it is expected that students furthering their education in this subject should be at a similar, high level of ability. However, since the reported decline in students' mathematical preparedness on entry to university a possible solution could be to stream students, dependent upon their mathematical preparedness, as a method of mathematics support. To date, 'streaming'
has been implemented in a small number of UK universities, as briefly discussed above. Steele (1997) & (2000) reports on the “Three Stream System” at UMIST. This support system was implemented amongst a group of engineering students, whereby the students were streamed into three groups dependent upon their mathematical ability. This provided extra assistance to the mathematically less well-prepared students, whilst average students could progress separately from those who required the support and the well-prepared students were able to learn more. Through the use of questionnaires it was found that staff and students found the support method useful and effective.

A similar method of supporting first year Physics students at the University of Leeds has been reported on by Savage & Roper, MathsTeam (2003b). Whereas streaming is used within schools as a way of facilitating learning, in the context of higher education streaming was used as an effective support mechanism. In particular, ‘Booster Classes’ were implemented for students in the ‘lower’ stream in order to provide additional mathematics support to those who need it most and are considered to be ‘at risk’. This method of support proved successful, in particular drop out and failure rates were notably reduced.

However, whilst these reports comment upon the relative success and limitations of the streaming as a support mechanism, they do not provide an extensive review of the effectiveness of the support, particularly its effect on student achievement. Since there is little precedence concerned with the streaming of undergraduates and the effect of streaming on undergraduate achievement, it is clear that research is needed in this area. Indeed, this will be addressed in Chapter 6 of this thesis. An evaluation of the use of streaming as a support mechanism with undergraduates students, implemented at Loughborough and Coventry Universities, will be undertaken. In particular it will examine the effect of streaming on academic achievement of mathematically less well-prepared students.
3.2 MATHEMATICS SUPPORT CENTRES

Whilst a limited number of Universities have implemented streaming as a form of mathematics support, Mathematics Support Centres have been adopted by a growing number of institutions. Since the research presented in this thesis will examine the effectiveness of mathematics support provided by a Mathematics Support Centre at Loughborough University (Chapter 4), this section will review the literature in this area to provide a background to this support and to examine the extent of what is already known about the effectiveness of such support.

3.2.1 UK PROVISION

Mathematics Support Centres are becoming a popular strategy of supporting undergraduate students since they encompass a wide range of support facilities. This method of learning support is offered to students in addition to that provided by their routine lectures and usually requires students to take the initiative to use it. Lawson et al (2001), in a LTSN-funded study to investigate the extent of mathematics support amongst UK universities in 2000, reported on the existing provision. It was found that, out of the 95 universities questioned, 46 indicated that they offered some form of mathematics support. This study was then up-dated in 2004 by Perkin and Croft (2004), by which time 66 out of 106 universities provided mathematics support. It was also found that the aspect of this provision valued most, by the students, was the availability of one-to-one support.

Whilst this method of mathematics support appears to be an increasingly popular choice amongst institutions, very little has been documented about individual institutions’ experience of their implementation. The majority of the literature in this area pertains to Loughborough University’s Mathematics Learning Support Centre (MLSC) and Coventry University’s Mathematics Support Centre (MSC), for example Lawson et al (2001), Lawson & Reed (2002), Croft (2002) and Perkin et al (2007). These articles describe good practice of mathematics support provision and, as such, much of the remaining literature uses Loughborough and Coventry Universities’ experience as a benchmark for their own Support Centres.
A detailed examination of Loughborough University's Mathematics Learning Support Centre is given in Chapter 4, and so specifics will not be given in this section. However, it is useful for this research to examine other universities’ experience and thoughts surrounding this method of support. In particular, the University of Newcastle Upon Tyne, Nottingham Trent University and Hull University provide mathematics support through some form of Support Centre, albeit each Centre has its own unique focus.

In a similar manner to Loughborough University's MLSC and Coventry University's MSC, the Maths-Aid Centre at the University of Newcastle Upon Tyne provides mathematics support to all three of its Faculties, with a focus of supplying discipline-specific support where possible. As such, the Centre has strong links with the different departments and schools across campus and the support provided by Maths-Aid is committed to complementing and reinforcing any existing support provided by the teaching staff within the various disciplines, Foster (2005).

At the University of Hull, their Study Advice Services (SAS) provides mathematics support via an appointment only service. In delivery of this support there is a strong emphasis on encouraging student confidence amongst students. In particular, their experience has shown that in some cases students are actually just unconvinced of their mathematical ability and require reassurance, Ireland (2006). Others need support in the offer of direction, so that they are aware of when they are doing things correctly or incorrectly.

Following the model of the MLSC and MSC, provision offered by Nottingham Trent University's Mathematics Support Centre “...enables students to bridge the gap between school and university learning in mathematics, and support students' learning outside the classroom”, Woodhouse (2004). However, a unique feature of their Centre is the use of peer mentoring. In addition to one-to-one tuition and a drop-in facility, ‘maths mentors’ in the form of mathematics undergraduate students, are available as an alternative form of support for students experiencing mathematics difficulties. In particular, students who have never used the centre and are identified as being ‘at risk’ are targeted and offered mathematics support.
Whilst the publications as referred to above describes the different foci pertaining to this method of support, interestingly they all highlight the issue of student engagement and motivation in some way. Woodhouse (2004) reports that their attendance is largely assessment driven with only 13% of targeted first years using the support. Of particular concern were uncommitted students who rarely attended lectures and did not respond to personal contact. Indeed, "The students who made best use of maths support were those who were confident in themselves (although not necessarily with maths), well motivated and well organised." The majority of such were mature students. A similar issue that has been broached by Ireland (2006). She reports that a disproportionately large number of mature students use the support supplied by the SAS, although it is unclear whether this is because such students are generally more motivated or because their time away from study has made them feel insecure. However, reaching students is a major concern for the SAS; "Unfortunately it is the case that there are more students out there who need help than are prepared to come and seek that help", Ireland (2006), and this too is an issue echoed by Foster (2005). In particular, and from experience, Foster states that students will avoid help if it is not integrated into their course and it is difficult to motivate students, with significant mathematical problems (as opposed to basic numeracy deficiencies), to seek help.

However, whilst such publications draw upon the issues surrounding student engagement with mathematics, none have attempted to investigate the issue further. The research presented in this thesis will specifically address the issue of student engagement with mathematics support by examining student usage to ascertain the type of students who engage regularly with the support and the type of students who fail to engage with the support. This will be addressed on a quantitative level in Chapter 4 and on a qualitative level in Chapter 5. In particular it will provide a detailed discussion of the perceived barriers preventing students from availing themselves of the support.

3.2.2 INTERNATIONAL PROVISION

From an international perspective, the concept of a Mathematics Support Centre is less well established within Higher Education institutions. Indeed, very little literature exists documenting international support offered via a Centre of some kind. Perhaps this is because some countries are not faced with a decline in students' mathematics
abilities or that similar issues have not been tackled to the extent that has been seen in the UK. Undoubtedly, similar provision of mathematics support does exist outside of the UK. However, it appears that there has been little research conducted with regards to this. Recently, a number of reports have begun to document international provision, such as “An Audit of Mathematics Support Provision in Irish Third Level Institutions” produced by Regional Centre for Excellence in Mathematics teaching and Learning (unpublished), and MacGillivray (2008), which documents support in Australia.

The small amount of literature that does exist stems from Australia. Secondary-tertiary transition and mathematics under-preparedness for tertiary studies have long been the focus of educational interest in Australia, Jourdan et al (2007). Indeed, in the 1990s there was a proliferation of ‘Learning Support’ centres containing numeracy/mathematics experts to help address this problem, with a reported 46% of universities offering ‘drop-in’ support by the end of the decade, Atkins (1994) cited in Taylor (1999). The extent of such support differs between universities (much like the UK) yet their essence is the same. Such provision aims to create opportunities to increase positive outcomes in student learning and to develop and provide academic programmes and resources to enhance learner independence. Taylor (1999) expresses that the provision of support aims to do more than just “...fixing students up with the required knowledge to do sums” and that mathematics support should “…try to help students grow from being problem solvers to problem posers moving well away from the deficit model of learning to a developmental one.”

A similar view is expressed by Dalby (2001). Dalby emphasises that Mathematics Learning Centres should help students gain confidence by overcoming anxieties in learning mathematics and that providing support should involve helping students to become autonomous learners. Indeed, there is a strong advocation that mathematics support should be student-centred and that a learning outcome for the student should be to build up “…students’ sense of control over their own work, giving them opportunities to experience responsibility for their own learning and helping them to develop self-management skills”, Brown & Atkins cited in Dalby (2001).

However, such reports do not appear to document the extent of student engagement with such learning centres. It seems that very little is known as to the extent to which
students do or do not engage with this method of support and that there is a need for such research in order to carry out a successful evaluation of the effectiveness of mathematics support. Indeed, if no students use the support then it cannot be deemed to be successful. Therefore, the research presented in Chapter 4 and Chapter 5 will be useful on a UK and international perspective.

3.3 Effectiveness of Mathematics Support

Section 3.2 has shown that that many universities have adopted some form of support in order to tackle “The Mathematics Problem” within their departments. However, since the publication of such reports by the LMS, IMA and RSS (1995) and Hawkes & Savage (2000), there have been few publications with regards to the effectiveness of mathematics support. At present the success of Mathematics Support Centres, in particular, has only been assessed to a limited extent by individual institutions, through methods such as student feedback questionnaires, usage data and informal student feedback. The report by Lawson et al (2001) provides some details of such assessments. In this report, it was found that many students, who were interviewed from eight institutions, highly valued their Mathematics Support Centre. A detailed account of the relevant methods used to evaluate the success of the eight Support Centres can be found in this report. Each centre recognised this as a difficult task and as such a variety of methods were used. The most commonly used were that of student feedback (via questionnaires or comment cards), attendance levels, external reports, reduced failure rates and staff comments.

In addition, a few other reports exist that investigate the effectiveness of other support methods. For example, as indicated in Section 3.1, some data has been collected and analysed to examine the effectiveness of the “Three Stream System” at UMIST, whereby engineering students are streamed into three groups dependent upon their mathematical ability, Steele (1997), (2000). Through the use of questionnaires it was found that staff and students found the support method useful and effective.

Whilst some of the reports, as discussed above, provide useful data on usage statistics and comments from feedback forms, they do not provide a detailed evaluation of the support mechanism in question. Such data can merely give an insight into how the
support has been received by the students and staff members. Indeed, in a paper presented at the University Mathematics Teaching Conference (UMTC) in 2004 by Challis et al, it was recognised that there is a need for a detailed evaluation of mathematics support, which is missing at present. However, since this date, there have been no published articles which explicitly measure the effectiveness of mathematics support in the detailed manner which was suggested at UMTC. A reason as to why this gap in the literature remains unfilled is suggested by Challis et al in their report, namely “...evaluating the benefits is not straightforward...this is potentially an extremely large project”. Indeed, for an effective evaluation the report suggests that data should be gathered in six areas, namely Baseline information, Output measures, Process measures, Student responses, Staff and expert opinion and Other data. These guidelines will be followed when evaluating the effectiveness of mathematics support in this thesis, in order to provide depth to the evaluation of mathematics support mechanisms.

A review of the literature provides evidence that further research in this area is needed. Furthermore, since the implementation and form of mathematics support will vary between institutions, it is particularly important that the different forms of support are evaluated and the findings disseminated to produce ‘best practice’ for mathematics support provision. In particular, and as suggested by the literature so far, student engagement with mathematics support is a real concern amongst institutions. In particular, a comprehensive evaluation of mathematics support cannot be carried out successfully if students are failing to engage with it. The subsequent sections will investigate this issue further by examining the literature surrounding student engagement and student motivation.

4. STUDENT ENGAGEMENT

This section will examine the issue of student engagement. It will begin by identifying how this term is defined within the literature, before examining the issue of student engagement within a number of contexts. In particular, it will consider engagement and its effect on student achievement, engagement at university, engagement with mathematics and the relationship between engagement and learning approaches.
4.1 Definition

There appears to be no general consensus amongst researchers as to how to define the term 'student engagement', Farmer-Dougan et al (date unknown). However, the term is commonly used to depict the extent to which a student identifies with, values and participates in educational practices. Its definition usually comprises a psychological component pertaining to a student's sense of belonging and a behavioural component pertaining to the participation of the student, Willms (2003).

Much of the research in this area has shown that student engagement overlaps with, but is not reducible to, student motivation, Sharan et al (1999). However, it is important to distinguish between the two concepts, since it is possible for a student to be motivated but disengaged. The Australian Government Department of Education, Science and Training defines engagement as “…energy in action, the connection between person and activity” and motivation as “…energy and direction, the reasons for behaviour, why we do what we do”, Russell et al (2005). Much of the literature discusses students' academic motivation when reporting upon student engagement, since motivation is often inferred from student's engagement in learning activities.

4.2 Engagement and Achievement

Researchers increasingly conceptualize poor educational performance as the outcome of a process of disengagement and lack of motivation, although it is recognised that other variables may contribute to performance, Kelly (1989); Merchant (1987); Natriello (1984). According to this model, students who do not identify, participate, and succeed in school activities become increasingly at risk of academic failure and dropout. However, the literature suggests that it has not always been easy to demonstrate how engagement influences learning and achievement. In particular, the relationship between engagement and achievement will differ depending upon the definition used. Russell et al (2005) report that in studies where engagement is defined as a sense of 'belonging', a weak relationship to achievement has been found. However, when engagement is defined as attitudes to and interest in, then engagement can be a strong predictor of achievement. Nevertheless, much of the research in this area provides evidence to suggest that engagement is a strong predictor of academic achievement, Finn (1993); Kuh (2001), (2003); Pascarella and Terenzini (2005).
The most recent large-scale evidence of the relationship between engagement and success comes from an Australian study conducted by the Programme for International Student Assessment (PISA). They have published several reports that present results from a number of international studies of fifteen year old students. In PISA 2000, results showed that a student’s engagement in reading was a strong predictor of literacy achievement. In 2003, PISA reported on several measures relating to motivation and engagement in mathematics, which included mathematics self-efficacy (cognitive judgment of one’s capabilities), mathematics anxiety and mathematics self-concept (cognitive response to one’s self, influenced by social comparison). Their report found that students with positive self-efficacy and positive self-concept in mathematics had higher mathematics literacy. Evidence from such studies show that student engagement is particularly important in promoting successful educational outcomes.

4.3 ENGAGEMENT AT UNIVERSITY

Much of the literature pertaining to student engagement is centred on the school level, specifically students aged 11-16 years. However, some researchers have examined the issue of engagement amongst undergraduates; the majority of which are American and Australian studies. Such literature underpins student engagement in higher education within two research strands. The first strand relates engagement with transition and retention, McInnis (2003); Tinto (2005); Yorke (2000); Zepke, Leach & Prebble (2003). Such reports comment upon the difficulty of academically engaging first year undergraduates amidst the storm of their adjustments to university life. Factors such as a lack of peer support and an inability to cope with the demands of their courses can affect student engagement and retention. Pargetter et al (1999) report that some students’ motivation to attend university is ‘external’, for example, a student’s choice to attend university may be overly influenced by parental expectations and pressure. Such factors, amongst others, can contribute to a lack of engagement amongst first year undergraduates.

The second strand relates to disengagement with university life in general and with university study, Kuh (2003); Marklein (2005); McInnis (2003). In particular, it is reported that many students are under financial pressure, which promotes high levels
of part-time employment (McInnis 2003). In the United States, Marklein (2005) documents the problem of student disengagement caused by student transfers between institutions. Indeed, it is reported that students who take classes at multiple institutions, as a way of achieving their bachelor’s degree, participate in fewer educationally enriching activities, indicating a lack of engagement.

Much of the American literature pertaining to student engagement at the tertiary level, reports on results from the National Survey of Student Engagement (NSSE). The NSSE is an annual survey that is distributed to first year and senior university students in the US, with more than 850 different four-year colleges having used it more than once since 2000, Carini et al (2006). Results from the NSSE provide an estimate of how undergraduates spend their time and what they gain from university so that changes in policies and practices can be made to improve undergraduate education. The report “What we’re learning about student engagement from NSSE”, Kuh (2003), summarises the engagement pattern of different groups of students according to the results from the NSSE. In particular, it reports that students who are studying full-time and live on campus are, on average, more engaged. Results also show that female students tend to be more engaged than male students.

In recent years, the literature has tended to focus on student engagement amongst first year university students. Perhaps not surprisingly, the issue of engagement of first year students is a much discussed topic at present since the transitional period to university often results in disengagement. Not only are students faced with the difficulty of establishing an identity within a new community of practice but many are unprepared for the amount of work and self-motivation that is required at university. In particular, Hu & Kuh’s (2001) analysis of data from a College Student Experiences Questionnaire shows that “Sophomores, juniors, and seniors were less likely to be disengaged compared with first-year students.” (pg 563).

4.4 ENGAGEMENT WITH MATHEMATICS

Educational practice is necessarily based on the assumption that students are willing to engage in educational activities. However, when a student becomes disengaged then this can have an effect on a student’s academic achievement and can influence
their decision to further their education in a particular subject. This is of particular concern for mathematics, since mathematics is generally perceived as a subject for all, the skills of which are fundamental to the National Curriculum in England.

The literature concerning student engagement with mathematics remains comparatively small, with only a handful of publications to date. However, there is a growing recognition that there is a lack of student engagement with mathematics at all stages of education within the UK. In particular, the report of the post-14 mathematics enquiry, "Making Mathematics Count", Smith (2004), identified the urgent need to improve and sustain engagement with mathematics at every level and at every age. There are also alarming statistics that indicate an increasing lack of engagement with mathematics within Higher Education. Data from the National Audit Office (NAO) report (2007) shows that there has been a twenty-five percent decrease in the number of students accepting university places on mathematics courses between 2002 and 2006. In addition, Mathematics degrees have the lowest continuation rates amongst undergraduates, with only 88.1% of first years continuing their course to the second year (compared to say Physical Sciences with a continuation rate of 93%) NAO (2007). There have been repercussions on other degree programs, since the number of students choosing to study some degree courses that rely heavily on mathematics, such as Engineering, has dropped increasingly. According to the DfEE (2000) one of the principal reasons for a decline in the number of students taking an Engineering degree was due to the decline in the number of students studying mathematics at A-level.

In terms of engagement with mathematics, PISA’s 2003 report is perhaps the largest study that has investigated this issue. As stated in the previous section, PISA’s results suggest that achievement in mathematics is influenced by a student’s level of engagement, in terms of their attitudes and interest. However, it should be noted that the relationship between student engagement in mathematics and mathematics achievement is complex and could be regarded as circular. For example, are high motivation and confidence the causes of strong performance or by-products of doing well in mathematics? Regardless, the strong link between student engagement in mathematics and mathematics performance suggests that high motivation and self-confidence are important in terms of engagement and achievement in mathematics.
The more students succeed in mathematics the more likely they are to believe that they can succeed; the more students believe they can succeed the more engaged they will become with learning mathematics.

4.5 ENGAGEMENT AND APPROACHES TO LEARNING

A review of higher educational research literature indicates that students frequently enter their degree programmes with expectations of what it means to study at university, which may not be met, Bowl (2003). These expectations are shaped by their sense of themselves as learners, Weil (1986) drawing on their learning experiences within a classroom context. Perhaps not surprisingly a number of studies have investigated the relationship between student engagement and student learning, Ainley (1993); Connell (1990); Meece, Blumenfield & Hoyle (1998); Pintrich & Schrauben (1992). Results from these studies suggest that the construct of cognitive engagement (referring to intrinsic motivation and an investment in learning) is closely related to student approaches to learning.

In particular, Pintrich and De Groot (1990) use learning strategies to define engagement. In their report student engagement is viewed as motivated behaviour that can be indexed by the kind of cognitive learning strategies that students use. That is, a student who engages cognitively will be likely to use self-regulated learning strategies that promote deep understanding and expertise. In particular, cognitive surface strategies (such as rehearsal) indicate superficial engagement whereas cognitive deep strategies (such as persistence and elaboration) indicate active task engagement. Similarly, Weinstein and Mayer (1986) report that students who use deep strategies are more cognitively engaged; they exert more mental effort, create more connection among ideas, and achieve greater understanding of ideas.

More recently, Yorke (2006) has studied engagement in a broad socio-cultural context by linking a student's learning approach to their level of engagement. In particular, student engagement can be influenced by the way in which a student perceives their educational aims when undertaking a degree. Yorke suggests that a deeply engaged student will focus on 'learning goals' (desire to learn) as opposed to 'performance goals' (passing the test) and, consequently, will exhibit characteristics of 'Deep'
learners (engaging with subject matter and going 'above and beyond'). Conversely a student may superficially engage with the subject due to external motivators, such as a strong desire to pass a test. However, often students will only manage to grasp the crucial concept and techniques since they are learning on a 'Surface' level. Hence they are engaging on a different level to that of 'Deep' learners

Since there is evidence which supports the notion of this relationship between student engagement and learning approaches, there is perhaps an obvious need to examine these concepts further with a view to developing methods which will help stimulate and engage students in higher orders of learning at university. By fostering the linkages between engagement and learning it is expected that this will lead to academic achievement and contribute to a students' cognitive and social development, Finn (1993).

It is clear from the literature that there is a growing interest with regards to the issue of student engagement. In particular, many educational institutions are faced with the problem of student disengagement, predominantly amongst undergraduate students and particularly those within the disciplines of science, such as mathematics.

Despite the fact that there are a number of publications which have reported on the various issues surrounding student engagement (such as linkages between engagement and achievement or learning approaches) there has been a limited number of published reports concerning the conceptualisation of engagement within mathematics, especially within the UK. Indeed, much of the literature stems from American and Australian studies. Moreover, disengagement in mathematics is a particularly important issue since this issue can lead to serious implications for industry and education, notably a lack of mathematics teachers. Thus, there is a pressing need to investigate the issue of student engagement further, particularly within a higher education context.

The issues surrounding student engagement are crucial for the research presented in this thesis and to examine this effectively, the construct of student motivation should be considered. The next section will review the literature surrounding this area.
5. **Student Motivation**

5.1 **Definition**

From a review of the literature pertaining to student engagement it is evident that there are strong links between engagement and motivation, although the two terms have very different meanings. Whereas engagement relates to the connection between a person and an activity, the term ‘motivation’ can be defined as the internal drive directing behaviour towards some end. In the educational research domain this behaviour will relate to the learning process, as defined by Bomia et al (1997):

"[motivation] refers to a student's willingness, need, desire and compulsion to participate in, and be successful in, the learning process" (p. 1).

However, it should be noted that 'motivation to learn' has a slightly different meaning from that of just motivation in an educational context. It is defined by one author as "the meaningfulness, value, and benefits of academic tasks to the learner--regardless of whether or not they are intrinsically interesting", Marshall (1987, pg 135). According to Marshall a student may be motivated to partake in the learning process as long there is some internal or external drive. In terms of the literature this is defined as Intrinsic or Extrinsic types of motivation, respectively.

5.2 **Intrinsic and Extrinsic Motivation**

According to Deci & Ryan (1985) there are two distinguishable types of motivation, which are based on the different reasons or goals that give rise to an action. A student can be described as intrinsically motivated when he or she is motivated from within. Intrinsically motivated students will undertake an activity "for its own sake, for the enjoyment it provides, the learning it permits, or the feelings of accomplishment it evokes" Lepper (1988). Such students actively engage themselves in learning out of curiosity, interest, or enjoyment, or in order to achieve their own intellectual and personal goals. Entwistle & Wilson (1977) suggest that intrinsic motivation refers to learning for its own sake (i.e. striving to understand), which is directly linked to a cognitive drive.

On the other hand, extrinsic motivation describes the process of satisfying a need which is related to the learning activity. A student can be described as extrinsically...
motivated when he or she engages in learning "in order to obtain some reward or avoid some punishment external to the activity itself", Lepper (1988). Extrinsically oriented students are inclined to put forth the minimal amount of effort necessary to get the maximal reward.

While it may be regarded that any motivation is preferable to none, there is compelling evidence to suggest that intrinsically motivated students will fare better than extrinsically motivated students (for example Brooks et al (1998), Brophy (1983) and Lumsden (1994)). Such reports indicate that intrinsically motivated students will earn higher grades, will be better personally adjusted to school and will be more likely to feel confident about their ability to learn new material.

It should be noted that not all researchers use the terms intrinsic and extrinsic to describe student motivation, since all motivation ultimately derives from some intrinsic need. Moreover, there are many complex and interrelated factors that can influence students' motivation and it is usual that students will be motivated by both internal and external factors. However, in terms of the research presented in this thesis, External and Internal motivation will be regarded as two separate constructs.

5.3 MOTIVATIONAL THEORIES

A comprehensive review of the literature on student motivation reveals that many researchers have developed motivational theories in an attempt to explain and predict student behaviour. There is currently no universal theory to explain motivational behaviour but most explanations combine elements of Fritz Heider's attribution theory, Bandura's work on self-efficacy and other studies relating to locus of control and goal orientation, Bandura (1965).

Some of the motivational theories used within the literature are listed below:

- Self-efficacy Theory
- Interest Development Model
- Self-determination Theory
• Achievement Goal Theory
• Expectancy Value Theory
• Theories of Self
• Epistemological Identity
• Self-Concordance Model

In an attempt to generalise such theories, the basic perspective can be modelled as:

![Needs → Behaviour → Satisfaction Diagram]

In other words, a student will have certain needs or wants (for example a student wants to pass the exam), and this causes the student to do certain things (behaviour), which satisfy those needs or wants (satisfaction). This can then change which needs/wants are primary (either intensifying certain ones, or allowing you to move on to other ones), Borgatti (1996).

5.4 MOTIVATION AT UNIVERSITY

Whilst much of the literature regarding motivation is related to school studies there is a growing body of research pertaining to higher education. To date, there are only a handful of longitudinal studies conducted with university students, e.g. Fazey & Fazey (1998), so there is relatively little known about the development and conditions of motivational variables in this context. However, motivation amongst undergraduate students is of particular interest since it is believed that poor retention rates are associated with a lack of motivation amongst students. At the National Conference on Student Retention in 2003, Anderson stated

"The best predictor of student retention is motivation - retention services need to clarify and build on motivation and address motivation-reducing issues. Most students drop out because of reduced motivation" (Anderson, San Diego (2003), cited in Stephen Powell (2007)).

Although Anderson’s research is taken from US Higher Education the premise can be regarded as much the same as to that in the UK and similarities can be made between the two.
Since students in Higher Education have autonomously chosen their subjects or course, which they want to study, we expect high levels of intrinsic motivation due to a natural desire or personal interest to study. Indeed, Fazey & Fazey’s results showed a higher level of intrinsic motivation and identification with education goals, compared to extrinsic motivation. Only very few students were demotivated. Research in a Higher Education context has often assessed students’ motivation from a goal-oriented perspective, with a number of studies having indicated that unsuccessful students entered university for ‘extrinsic’ reasons (such as parental pressure) rather than out of ‘intrinsic interest’ in a particular discipline, Hopkins et al. (1958); Wankowski (1970).

However, it appears that there has been limited published research that addresses the issue of de-motivation amongst undergraduates. Whilst many academics and researchers agree that there has been a decline in students’ levels of motivation to study at university, very little is known as to what has caused this decline and how it can be improved. Perhaps this is because, compared to school, undergraduate student motivation is more complex and must be conceptualised in terms of the interrelationship between a number of theoretical dimensions, which include but are not exhausted by the student’s perceptions of the purpose of university education.

5.5 MOTIVATION AND MATHEMATICS

A lack of student motivation has proven to be a problem in high schools across the US for many years, particularly within mathematics, Kloosterman (1997). Indeed, studies have shown that there is a strong correlation between lack of student motivation and the rising number of “at risk” students in mathematics, Kasten & Howe (1988).

It is recognised amongst researchers in the US that motivation in mathematics classrooms is imperative for success, Carr (1996). According to the National Research Council (2001) mathematically motivated students are those who will be proficient in mathematics; thus, they will be likely to be able to fully function as productive citizens of society. However, implementing successful strategies to encourage motivation in mathematics is problematic. Kloosterman (1998) concludes that
motivation is "multi-dimensional" and adds, "... there are no magic answers to motivating students in high school mathematics" (p.16). Brophy (1986) concurs that implementing effective teaching strategies to stimulate student motivation to learn "may be much more difficult in mathematics classes and this difficulty (and not just the difficulty of the subject matter) may be an important reason why many students dislike mathematics" (p. 344).

Within the UK, it appears that the construct of motivation in mathematics is a less well-established area of research. However, published studies in mathematics education have been primarily descriptive and inadequately conceptualised (by way of lacking exploration and interpretation of the effect of motivation), the majority of which have reported low motivation amongst mathematics undergraduates, Hall (1982) cited in Kahn & Hoyles (1997).

Often motivation has been examined secondary to other variables or issues regarding mathematics. Studies that have examined student motivation have often done so by focussing on other factors, such as mathematics achievement, and the effect motivation has on these factors. However, even here, affective and motivational variables as factors in mathematics achievement have received only modest attention, Seegers (1993). Fennema (1984, 1985) and Fennema & Leder (1990) found that affective variables, including motivation, can help explain gender differences in mathematics. In these studies more traditional measures of motivation and affect were used, by assessing student characteristics in the context of mathematics at a particular point in time. However, although such trait measures of motivation provide an insight into the impact of affective variables on mathematics achievement, they do not examine the effect of motivation and affect on the learning process itself, Boekaerts (1987); Nenniger (1988).

Since the research indicates that motivation in mathematics can affect achievement, fostering student motivation is an important issue. Lepper (1988) suggests that relevance and contextualising can promote motivation, in that students see how skills can be applied in the real world. Indeed, there are a few recently published papers documenting student-centred instructional methods, which are claimed to significantly enhance motivation and engagement. These include the use of Problem-based learning.
(PBL) and Inquiry based learning. There is an extensive body of research that has examined the effectiveness of such methods in motivating students in their studies since they encourage learning through practical experience. The majority of the literature in this area relates to medical and gifted students, Hmelo-Silver (2004). However, there are a substantial number of reports that provide innovative descriptions of using PBL in various settings, including educational administration, business, educational psychology, engineering, chemistry and various undergraduate disciplines, Boud and Felletti (1991); Bridges (1992); DaCosta et al (2003); Hmelo et al. (1995); Ram (1999); Stepiein and Gallagher (1993). In terms of Mathematics there have been relatively few published reports in the effects of using PBL or Inquiry based learning. Pedersen (2003) found significantly higher intrinsic learner motivation amongst science students taught using PBL than for students taught using traditional methods and Crabtree (2004) reported that undergraduate students, who had been taught using an inquiry-based approach, commented specifically on the extent to which understanding had been improved as a result of inquiry-based discussions. Although these studies are relevant to the present research, the literature is limited in the context of mathematics in Higher Education and undoubtedly there are issues pertaining to this that require further investigation.

5.6 MOTIVATION AND LEARNING

As with student engagement, a number of publications recognise an interaction between motivation type and approach to learning. In the literature, motivation is conceptualised by motivational phenomena, referred as 'orientations'. For example, Entwistle & Ramsden (1983) distinguish the 'reproducing orientation', which they found to be associated with a surface approach to learning, and a 'meaning orientation', which was found to be associated with a deep approach to learning. Similarly Taylor (1983) (cited in Breen & Lindsay (1999)) suggests that there are four study orientations: vocational, academic, personal and social, which can be associated with students' motivation. Taylor's study orientations reflect the students' reasons for studying and describe how their resulting feelings of success or failure in achieving personal aims underlie motivation in higher education.
Much of the literature that examines the effect of motivation on the learning process discusses the importance of a student’s fear of failure and its effects on student motivation. The concept of the ‘fear of failure’ was developed within attribution theory approaches to student motivation;

'Attribution theory approaches concentrate on success or failure outcomes and [students'] attributions to perceived causes' Brophy (1983, p. 201).

There is sufficient evidence to prove that there is a strong connection between a student’s self-concept of their abilities and their motivation and academic performance in school (for example Covington (2005); Elliot & Dweck (2005); Hansford & Hattie (1982)). Theories from such studies emphasise the student's expectancies of success or failure as determinants of the extent to which motivation is positive or negative. Depending on the student’s perspective, failure can be a motivator or a barrier to success. For example, failures that are attributed to a lack of ability evoke feelings of shame, while failure ascribed to a lack of effort evoke feelings of guilt, Covington (2005). Therefore students may try to work harder to reduce guilt. However this can be an endless spiral for a student with low self-esteem since those who exert more effort and still fail are left with a feeling of a lack of control over their success or failure Fontaine (1974).

"Failure dampens motivation and a lack of motivation makes continuing failure a near certainty", Levine (2002, p. 263)

On the other hand, students who are driven by a ‘hope for success’ (in that they attribute failure to a lack of effort and hence will consciously increase their readiness to make an effort, Valsiner & Voss (1996)) expect to succeed and have been allocated to an 'achievement motivation' type, Breen & Lindsay (1999). This theory contends that academic success is achievable as students attempt to maintain a positive image of their own ability. Consequently, feelings of self-competence breeds self-motivation.

At present, the construct of student motivation in mathematics is especially relevant to mathematics education in the light of recurring questions about how to encourage more students to be involved with the subject, especially within higher education. Much of the literature regarding student motivation has centred on the school level. However, we would expect that students in Higher Education should have much
higher levels of motivation, since they have chosen to study their discipline further. Therefore, there are qualitatively different issues that need to be explored in an attempt to examine student engagement with mathematics and mathematics support at university. This will be carried out within this thesis, particularly within Chapter 5 and Chapter 7. Student engagement and motivation will be a recurrent theme within this thesis and, consequently, will be considered when evaluating mathematics support.

In particular, the literature indicates that students' attitudes will affect their behaviour, such as how they engage with mathematics. Therefore, this research will examine students' attitudes and how this may affect their engagement at university, particularly with mathematics support, since such constructs are considered crucial in examining the effectiveness of the support mechanisms. In addition, the literature suggests that a student's level of engagement and motivation will contribute to the way in which they approach their learning of mathematics. Since mathematics support mechanisms are provided for students to help build upon the skills and techniques, and consequently their learning of mathematics, it is important that approaches to learning are considered for this research. Therefore, a brief introduction to these constructs will now be given.

6. ATTITUDES AND LEARNING APPROACHES

6.1 ATTITUDES TOWARDS MATHEMATICS

Since Feierabend's "Review of Research of Psychological Problems in Mathematics Education" (1960), an increasing number of published articles that examine the effects of students' attitudes and beliefs in mathematics has emerged. Aiken (1976) organised an inventory of survey items, known as the Attitudes Towards Mathematics scale (ATM), to measure attitudes of students towards mathematics. The inventory is divided into a number of scales, which measure different attitudes that contribute to a students' general attitude towards mathematics. For example, one scale may measure a student's anxiety towards mathematics whilst another scale may measure a student's motivation towards mathematics. This scale has been widely accepted by researchers who study attitudes towards mathematics, because it is an instrument that measures only the attitude towards the subject itself, disregarding the teacher's performance or the type of mathematical activity proposed. A more recent ATM scale, designed by
Tapia & Marsh (2004), is a shorter instrument with a straightforward factor structure designed to investigate the underlying dimensions of attitudes toward mathematics. Such instruments contain a number of question items per scale, with half stated positively and half stated negatively, and five Likert-type response alternatives (strongly agree, agree, undecided, disagree, strongly disagree), which have a score from 1-5 (scoring for negative statements is reversed). The responses are used to determine a cumulative total for an individual, where a lower score equates to a more negative individual mathematics attitude and a higher score equates to a more positive individual mathematics attitude. Table 2.1 shows sample items from each of the factors in Tapia and Marsh’s instrument. Using such instruments, the studies above have found that positive attitudes towards mathematics are associated with high performance in the subject.

<table>
<thead>
<tr>
<th>Question #</th>
<th>Factor</th>
<th>Statement</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Value</td>
<td>Mathematics is important in everyday life.</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Value</td>
<td>Mathematics is one of the most important subjects for people to study.</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Value</td>
<td>High school math courses would be very helpful no matter what I decide to study.</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td>Self-confidence</td>
<td>Studying mathematics makes me feel nervous.</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>Self-confidence</td>
<td>I am always under a terrible strain in a math class.</td>
<td>-</td>
</tr>
<tr>
<td>19</td>
<td>Self-confidence</td>
<td>I am able to solve mathematics problems without too much difficulty.</td>
<td>+</td>
</tr>
<tr>
<td>25</td>
<td>Enjoyment</td>
<td>I have usually enjoyed studying mathematics in school.</td>
<td>+</td>
</tr>
<tr>
<td>26</td>
<td>Enjoyment</td>
<td>Mathematics is dull and boring.</td>
<td>-</td>
</tr>
<tr>
<td>31</td>
<td>Enjoyment</td>
<td>I am happier in a math class than in any other class.</td>
<td>+</td>
</tr>
</tbody>
</table>

*Scoring: Each positive item receives a score 1-5 (1=strongly disagree, 5=strongly agree)
Each negative item receives a score 1-5 (1=strongly agree, 5=strongly disagree)

Table 2.1: Sample Items, by factor, of Tapia and Marsh’s ATM scale

Other researchers have found similar findings through the use of interviews and questionnaires in conjunction with an ATM scale (for example Ma (1997)). Generally, the literature indicates that factors which contribute to a student’s mathematics attitude can be predictive of performance in that subject.
A review of the literature in this area shows that there are a number of attitudinal factors, which are associated to a student's general mathematics attitude, that have been researched in detail. For example, Aiken's (1974) original ATM was constructed to reflect attitudes toward mathematics on two basic dimensions, enjoyment and value. This study found that enjoyment is related to ability and interest in mathematics, while value was related to verbal and general-scholastic ability. The Fennema-Sherman Mathematics Attitude Scales (1976) is one of the most popular instruments to be used in research investigating attitudes towards mathematics, Meyer and Koehler (1990). In particular, these scales assess attitudes relating to confidence, motivation, anxiety and usefulness of mathematics. There has also been much research into teacher-related variables in relation to the development of attitudes towards mathematics. Midgley et al (1989), in a study investigating the transition of adolescents to middle school, found that a lack of nurturing qualities in a teacher correspond to a decline in academic motivation and achievement. Fennema and Sherman (1995) found that students of teachers who were well-organised, achievement-oriented and enthusiastic tended to have a more positive mathematics attitude.

Table 2.2 lists a number of attitudinal factors that can be identified amongst students. According to the literature, attitudes towards mathematics take a positive or negative disposition. For example, Ajzen's definition of attitude: "...a disposition to respond favourably or unfavourably to an object, person, institution or event." (1988, pg. 4). Therefore, the table describes the characteristics of each attitudinal factor and how this relates to a negative or positive disposition or attitude. For example, if a student feels able and confident in mathematics this will contribute to a positive mathematics attitude. These factors relate to attitudes that have been investigated by other researchers and have been used in existing ATM scales (see literature review above).
<table>
<thead>
<tr>
<th>Positive ATM</th>
<th>Negative ATM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-concept of ability</strong></td>
<td><strong>Student feels able and confident with mathematics</strong></td>
</tr>
<tr>
<td><strong>Enjoyment</strong></td>
<td><strong>Student expresses a fondness towards mathematics and enjoys studying the subject.</strong></td>
</tr>
<tr>
<td><strong>Motivation</strong></td>
<td><strong>Student is interested in mathematics and has a desire to pursue it further.</strong></td>
</tr>
<tr>
<td><strong>Experience of Teaching</strong></td>
<td><strong>The teaching style / materials have contributed to a positive experience of mathematics.</strong></td>
</tr>
<tr>
<td><strong>Value / Worth</strong></td>
<td><strong>Student believes mathematics is useful and relevant to the 'real world'.</strong> <strong>Student feels that mathematics will be useful for his/her future.</strong> <strong>Student feels he/she obtains value for effort (i.e. student values the mathematics learnt)</strong></td>
</tr>
</tbody>
</table>

Table 2.2: Attitudinal factors and their defining characteristics

For the research presented in this thesis, considering students’ attitudes in this multi-dimensional form will be useful in understanding how students engage with mathematics support and the impact this has on their achievements in mathematics. In Chapter 5 and Chapter 7 affective variables such as confidence and enjoyment of mathematics will be examined. In particular, Chapter 7 will use data from a questionnaire and interviews to understand how students’ attitudes may differ, depending upon the mathematical preparedness, and how this affects their behaviour in engaging with mathematics and mathematics support. The construct of students’ learning approaches will now be considered.

**6.2 LEARNING APPROACHES TO MATHEMATICS**

The transition from school to university is often a difficult one for students and this issue has been of great concern in the field of mathematics education, Hoyles et al. (2001). Entering a new community of practice where the global goals and aims are not yet fully understood by the student can lead to failure. Since students’ may be unaware of the need or unsure of how to adapt their learning approach to ensure
success in the new community of practice, many students are faced with a poor education outcome. At the tertiary level, students are required to take responsibility for their own learning. However, students entering university come from a wide range of social and educational backgrounds, which in turn has shaped these students as learners. Each student will adopt his/her own learning approach in an attempt to achieve his or her educational goals.

The construct of ‘approaches to learning’ encompasses a large body of research (see Richardson (1994) for a review), which can be traced back to a series of groundbreaking studies conducted by Marton and Saljo. In their first study (Marton & Saljo (1976)), they set out to investigate how university students processed information. Students were asked to read an article and subsequently asked questions about the text. Their results revealed that the students used two qualitatively different levels of processing. Students using a Deep-level of processing aimed to grasp an underlying meaning of the text, whereas students using a Surface-level of processing concentrated on memorising large chunks of the text. Subsequently, Marton and Saljo adopted the broader term ‘approach to learning’ as a generic term for any discipline.

Students who adopt a Deep or Surface approach to their learning can be identified by a number of characteristics. Those who adopt a “Deep” approach will become actively involved with the subject and will seek to understand the subject knowledge by making connections between concepts and applying theory. These students will express an intrinsic interest in the subject and will derive enjoyment from studying. On the other hand, students who adopt a “Surface” approach do not have a primary intention of understanding or engaging with the subject. Their goals are short term, and will involve memorizing facts and rote learning. These students will treat parts of the subject as separate entities, failing to integrate topics into a coherent whole.

A further review of the literature reveals that students’ learning approaches cannot always be clearly categorised as Surface or Deep and that sometimes there is a “middle” approach, which may combine features of Deep and Surface learners. For example, in 1978, Biggs created a 42-item inventory known as the “Study Process Questionnaire” (SPQ). Using this inventory Biggs identified a third level of processing which he called the Strategic (or achieving) approach. Students who adopt
the Strategic approach wish to achieve positive outcomes and will do this through effective time management and study methods in relation to the assessment process. To achieve these goals, students will elect to use a mix of Deep and Surface learning methods.

In a more recent study, Case & Marshal (2004) identified a ‘Procedural’ approach to learning amongst engineering students. Their paper draws on work from two separate studies that both identified a middle approach, which falls between the Deep and Surface poles, and involves a strategy aimed at problem solving. Students using this approach will have an intention to develop some understanding of the subject, at an undefined point in the future, through familiarity. This means that their initial strategy is to practice problems in the belief that this will lead to an understanding. It should be noted that none of the above cases were directly related to the learning of mathematics.

Figure 2.1 summarises the defining characteristics of the three learning approaches, Deep, Surface and Strategic as described by Entwistle (1987), and the Procedural approach as described by Case and Marshall (2004). Although learners may be classified using these approaches, a student may adopt different approaches to learning in different courses or possibly even at different times within the same course. For example a student may generally adopt a Deep approach but find one particular topic very difficult to comprehend and so take a Surface approach to it.

Continued research in this area has seen major developments in our understanding of how students in higher education approach their learning. For example, Gibbs (1994) reported on the effect of Deep and Surface learning approaches on the quality of learning. Gibbs argued that not only is a Surface approach very prevalent in Higher Education courses, but also that it nearly always leads to poorer quality outcomes. In another study by Crawford et al (1998), results from a modified version of Biggs’ (1987) Study Process Questionnaire (SPQ) revealed a relationship between mathematics students’ understanding of mathematics, the approach they take to learning mathematics, and the quality of their learning outcomes. Namely, that a fragmented conception of mathematics is associated with a Surface learning approach.
and a cohesive conception of mathematics is associated with a Deep learning approach.

<table>
<thead>
<tr>
<th>Strategic</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intention to obtain highest possible grades</td>
<td>Intention to complete task requirements</td>
</tr>
<tr>
<td>Organise time and distribute effort to greatest effect</td>
<td>Memorize information needed for assessments</td>
</tr>
<tr>
<td>Vigorous interaction with content</td>
<td>Failure to distinguish principles from examples</td>
</tr>
<tr>
<td>Use previous exam papers to predict questions</td>
<td>Treat task as an external imposition</td>
</tr>
<tr>
<td>Be alert to cues about marking schemes</td>
<td>Focus on discrete elements without integration</td>
</tr>
<tr>
<td>Relate new ideas to previous knowledge</td>
<td>Unreflectiveness about purpose or strategies</td>
</tr>
<tr>
<td>Relate concepts to everyday experience</td>
<td></td>
</tr>
<tr>
<td>Relate evidence to conclusions</td>
<td></td>
</tr>
<tr>
<td>Examine the logic of the argument</td>
<td></td>
</tr>
</tbody>
</table>

**Procedural**

<table>
<thead>
<tr>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain understanding through familiarity</td>
</tr>
<tr>
<td>Practice numerous problems to learn methods</td>
</tr>
<tr>
<td>Relate formulae to each other</td>
</tr>
<tr>
<td>No relation to underlying concepts or theories</td>
</tr>
</tbody>
</table>

**Deep**

- Intention to understand
- Vigorous interaction with content
- Relate new ideas to previous knowledge
- Relate concepts to everyday experience
- Relate evidence to conclusions
- Examine the logic of the argument

**Surface**

- Intention to complete task requirements
- Memorize information needed for assessments
- Failure to distinguish principles from examples
- Treat task as an external imposition
- Focus on discrete elements without integration
- Unreflectiveness about purpose or strategies

Figure 2.1: Learning approaches and their defining characteristics.

Although research into students' learning approaches in general is well developed, there are still areas of interest that require further research. In particular, there is speculation amongst researchers that the relationship between learning approaches and learning outcomes differ between disciplines. For example Meyer and Eley (1999, p.198) argue

"...individual students might well adopt differentiated patterns of learning behaviors that are attributable to the learning contexts shaped by different subjects."

There are a small number of studies which have attempted to contextualise students' learning process in mathematics, for example Meyer (1991) and Crawford et al
(1998). However, these studies have used instruments that were essentially versions of Biggs' SPQ and Entwistle and Ramsden's (1983) Approaches to Studying Inventory (ASI) but minimally altered to reflect learning in mathematics. Therefore, this work does not indicate the contextual variations in the discipline of mathematics. The nature of mathematics means that the 'normal' characteristics of Deep, Surface, Procedural and Strategic learning approaches may not always apply so precisely. For example, mathematics requires the development of some fundamental skills and to acquire these skills requires an amount of practice is essential, no matter which learning approach is adopted. This may be compared with the learning of music, in that students will need to practice scales before they are able to progress and learn more complicated musical compositions.

It is clear that more research is needed in specific subject disciplines, particularly in order to distinguish contextual features of learning approaches for such subjects. In particular, it is recognised that there are perhaps qualitative differences between learning approaches in the arts and learning approaches in the sciences. This is evident in specific disciplinary studies. For example, Watters and Watters (2007) have investigated the learning approaches of first year undergraduate Biological Science students (comprising of Biological Chemistry, Biochemistry and Statistics and Computing). Using a version of Biggs' SPQ and interviews with the students, they found that these students mostly adopted surface strategies such as rote learning and memorisation and that very few attempted to learn on a 'deeper' level (i.e. by seeking clarification or challenging ideas). In particular Statistics and Computing students scored high on the Surface Strategy response. In comparison, Skogsberg & Clump (2003) administered Biggs' SPQ with students taking Psychology majors. These students scored high on the subscales of Deep Approach, Deep Motive and Deep strategy, indicating that such students are likely to adopt Deep approach techniques when studying. Interestingly, they reported no significant differences in learning styles amongst 'upper' and 'lower' level students.

However, a review of the literature suggests that generally the way in which students approach their learning can affect their academic performance. Chapter 7 will investigate if the mathematical preparedness of the student affects the way in which they adapt to learning at university. The outcomes discussed in Chapter 7 will extend
earlier descriptions of student learning approaches (see above), as it seeks to extend and contribute to the debate surrounding students' learning approaches towards mathematics, and specifically at the tertiary level.

It should be noted that the literature regarding attitudes and learning approaches to mathematics have generally been investigated using quantitative data from questionnaires (i.e. ATM scales, see Table 2.1 above), with very few using qualitative data (such as interview data). Although research involving ATM scales provides a descriptive approach to classifying/measuring attitudes and affect, they do not provide a deeper understanding into how attitudes develop over time. For example, when students are reflecting on their past experiences, an attitude scale cannot determine which experiences the students are relating to. However, a qualitative response from a student can provide more information on how their attitude has developed at various points in time and to what extent. Therefore the present research will examine these constructs using qualitative data with the view of providing a basis for further understanding in order to develop existing theories in this field, or at least with the intention of supporting prior research findings.

7. SUMMARY

In this chapter an extensive review of the literature surrounding a number of key issues and constructs, which were considered vital for the present research, has been given. This was presented by firstly examining the “Mathematics Problem” and the concept of mathematics support. In particular, the literature pertaining to ‘streaming’ and Mathematics Support Centres was examined. It was identified that little has been documented with regards to the effectiveness of these methods of support in a Higher Education context, hence the need for research in this area.

This was followed by examining a number of constructs related to the learning of mathematics at university. The first of these constructs was that of student engagement followed by the second construct of student motivation. It had been identified from the literature that a lack of engagement is a key issue regarding university mathematics and that student motivation may affect this. It appears that students who are highly motivated will be more likely to engage at university, which
in turn can have a positive affect on their achievement. In particular, the literature indicates that more research is needed to investigate how and why students engage with mathematics and mathematics support at university.

Within the literature itself, and also from the original aims of this research, the constructs of student attitudes and approaches to learning are vital when examining student engagement and motivation. In the course of the chapter the relationships between these concepts have been outlined to provide a framework for the research presented in this study. Indeed, the definition of the term engagement will be examined on two levels in the present research. The first will consider engagement as a *behavioural* component and the second will consider engagement as a *cognitive* component. In terms of cognition, the students’ attitudes are of particular importance. Therefore, examining the affective variables that contribute to their attitudes is of particular concern. It has also been recognised that student engagement is closely related to approaches to learning. Although studies have investigated these constructs in a number of ways, the most popular is by considering how students learn on a ‘Surface’ or ‘Deep’ level. In particular, students who are recognised as Deep learners will be actively engaged with the subject. This again may have implications for the way in which students approach their learning of mathematics at university and their engagement with mathematics support.

Hence, this chapter has provided an insight into the extent to which the current knowledge relates to the research presented in this thesis. Through an extensive review of the literature, it has been recognised that little is known about the effectiveness of mathematics support at university or of undergraduate student engagement with such support. Therefore, this study will provide a basis for further understanding in this context.
CHAPTER 3: METHODOLOGY

1. INTRODUCTION

The purpose of this chapter is to explain the methodology chosen for data collection and to provide a justification for the choice of these research methods. The research questions, as outlined in Chapter 1, provide a starting point for the choice of research methods used in the present study. The broad aim of this research study was to investigate the issue of engagement with mathematics and mathematics support. Since this is a complex task that must be examined on many levels, a variety of quantitative and qualitative research methods have been used to answer the associated research questions. For example, one aim of the research is to investigate the effectiveness of a mathematics support system. This was done by analysing module marks and attendance data using quantitative methods (See Chapter 6 for details). Given that a further aim was to explore issues such as attitudes towards mathematics and approaches to learning, and that little is known about these constructs in the context of mathematics in Higher Education, a qualitative methodology was chosen.

In the present study, the researcher has used a mixed methods approach drawn from the quantitative and qualitative paradigms, chosen and combined for the particular purposes of addressing the research questions. This chapter will discuss the paradigms that were most influential on this study, and highlight those elements that were most useful. In particular, it will briefly discuss the debate surrounding the use of quantitative versus qualitative research methods and how this relates to the present study. Subsequent sections of this chapter will discuss three research methods that were used in this study, namely questionnaires, interviews and focus groups, and will justify them as methods of data collection for this research. Finally, this chapter will draw upon some of the important theoretical and ethical issues of the research methods. The practicalities of how the research was conducted in the present study are described within the subsequent individual chapters of the thesis.
2. Qualitative “versus” Quantitative Research

The qualitative-quantitative debate is a much-discussed topic amongst researchers, Trochim (2006), since each paradigm boasts a number of advantages over the other. However, since the debate’s height in the 1970s and 80s, the argument between quantitative and qualitative researchers has been essentially unproductive, Miles & Huberman (1994). Much of the debate stems from the fact that the two paradigms are based upon very different epistemological assumptions. The quantitative paradigm is based upon positivism, whereby science is seen as the way to get at truth, Krauss (2005), and the data and its analysis are objective and value-free (i.e. the researcher does not intervene in the phenomenon of interest and tests theories using objective generalisations). Quantitative researchers are often detached from the research study and the research methods are based upon statistics, McNabb (2004). Conversely, qualitative research is based upon constructivism, whereby the task of the researcher is to understand the multiple social constructions of meaning and knowledge, Robson (2002). Qualitative researchers will often be immersed and actively involved in the research in an attempt to learn more about a situation. Consequently, data and its analysis will be largely descriptive.

Although some researchers believe that qualitative and quantitative methodologies cannot be combined, according to Carey (1993) quantitative and qualitative techniques are merely tools and so integrating them allows the researcher to answer questions of substantial importance. Generally, researchers agree that the two methods need each other more often than not and, consequently, a mixed-method approach is becoming an increasingly popular choice in research studies. As long as the methodology employed matches the particular phenomenon of interest then there is no need to commit to a particular paradigm.

By mixing quantitative and qualitative research methods, the researcher is able to use the strengths of each paradigm to complement the study. Although this does not necessarily mean validity is enhanced, when different approaches are used to focus on the same phenomena and they provide the same result, then the researcher will have superior evidence of that result. Since mixed methodology draws upon the strengths and minimises the weaknesses of both paradigms, it was felt that this third paradigm
would be ideal to answer the research questions of this study. In this thesis quantitative research is used to provide concrete facts, for example, attendance data have been analysed to examine student engagement (considering the construct as a behavioural component) with a mathematics module. Whilst such statistics measure to what extent students were attending their timetabled sessions, they do not provide any further details as to why students were or were not engaging. Therefore, qualitative research methods were used to collect such data. By using interview and questionnaire methodologies, a more descriptive analysis was undertaken to provide a deeper examination of the underlying issues surrounding the quantitative facts.

However, in order to mix research methods in an effective manner, it is necessary to consider all of the relevant characteristics of quantitative and qualitative research and the methodologies associated with those paradigms. Table 3.1 describes the general characteristics of each paradigm and the methodologies associated with these. It should be noted that the methods do not lie exclusively in one section or the other.

The following sections will discuss the methodologies chosen for this research and highlight the aspects of such methods that were appropriate in answering the research questions. The first that will be considered is that of Questionnaires.

<table>
<thead>
<tr>
<th>Quantitative Research</th>
<th>Qualitative Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic scientific investigation of phenomena</td>
<td>In-depth understanding of human-behaviour</td>
</tr>
<tr>
<td>What Where and When of decision-making</td>
<td>Why and How of decision-making</td>
</tr>
<tr>
<td>Large random samples needed</td>
<td>Small more-focused samples</td>
</tr>
<tr>
<td>Findings are conclusive</td>
<td>Exploratory and descriptive findings</td>
</tr>
</tbody>
</table>

**Methods**
- Any method, which deals with numbers.
- Counting and measuring -- the result leads to a number or series of numbers.
- Face-to-face, paper-based, online, telephone questionnaires can be used to collect such data.

**Methods**
- Interactive interviewing / focus groups -- participant verbally describes their experience
- Written descriptions by participants -- questionnaires can be used to collect such data.
- Observation -- descriptive observation of non-verbal or verbal behaviour.

Table 3.1: Characteristics of quantitative and qualitative research methods.
3. Questionnaires

By way of answering some of the research questions presented in this thesis, the researcher chose to use the method of questionnaires to collect data. This method was deemed appropriate since it would yield a substantial amount of information reasonably quickly and easily. In particular the research questions that were addressed using this method were:

What is the student perspective on their knowledge/ lack of knowledge in mathematics and how has it affected their university studies?

How do students approach their learning of mathematics and what effect does this have on their performance at university?

This method was primarily used as a way of gathering initial ideas and emerging issues (such as reasons for disengagement that are examined in Chapter 7), which could be examined more extensively using other research methods, such as interviews. Examples of a questionnaire used to gather preliminary data within this research can be found in Appendix A. A detailed examination of this method and how it was implemented in the context of the present research will now be discussed.

3.1 Overview

The use of questionnaires (or surveys) as a research method has continued to be a popular choice in educational and social research since they are highly adaptable and versatile in their design. This method offers an objective means of collecting information about people's knowledge, beliefs, attitudes, and behaviour, Oppenheim (1992).

Within this section a number of areas, concerned with the research methodology of using questionnaires, will be discussed. This will include the purpose of questionnaires, sampling, their design (including question wording and ordering), advantages and disadvantages as a research method and analysis of the data.
3.2 DESIGN

Since questionnaires often incur a low response rate, the researcher considered a number of design issues when producing questionnaires for the present research. In particular, if the questionnaire itself looks uninviting, boring or difficult then it is less likely that somebody will send time completing it. Some of these issues and how they were avoided will now be discussed.

3.2.1 LAYOUT

The opening of the questionnaire is extremely important. When designing questionnaires for this research, the researcher stuck to the KISS principle; Keep It Short and Simple, National EMSC (date unknown). This not only encourages the respondents to complete the questionnaire but it also ensures that unnecessary questions are not included so that analysis is kept to a minimum. The researcher was particularly mindful to consider the structure of the questionnaire, especially the sequence of questions, as suggested by Cohen et al (2000):

- **i.** Commence with unthreatening factual questions
- **ii.** Move to closed questions or questions giving statements, eliciting responses that require opinions, attitudes, perceptions and views.
- **iii.** Move to more open-ended questions that seek responses on opinions, attitudes, perceptions and views together with reasons for these responses.

This layout was chosen since it helps to build a rapport with the respondent in order to elicit as much information as possible.

The close of the questionnaire was also important when designing questionnaires for the research presented in this thesis. Where possible, respondents were given the opportunity to comment and were thanked for participation. This ensured that the respondent felt valued and allowed for casual remarks that could uncover issues which the researcher may not have thought about.
3.2.2 **QUESTION WORDING**

When determining the question wording the researcher must understand who the audience of the questionnaire will be. An important issue that was considered was how respondents may respond to particular words and phrases. For example, how would the respondent define the word ‘used’ if asked, “How often have you used the Mathematic Support Centre?”. Crucially, the language should be understandable and unambiguous.

When considering question wording for this research, a number of styles were avoided, as highlighted by Bell (1999). These include, Hypothetical questions, such as “If you fail your first year mathematics module, will this be due to a lack of mathematical preparedness?” and Double questions, such as “Do you enjoy and feel you are good at mathematics?”. Responses to such questions may confuse the respondent and will not provide clear and consistent data.

Other situations that should be avoided have been outlined by Fowler (2002). These include:

- **i.** Direct questions on sensitive issues
- **ii.** Unnecessary detail
- **iii.** Creating opinions
- **iv.** Questions involving knowledge or memory

By avoiding such issues, it was more likely that a true reflection of the respondent’s opinions was obtained. Sensitive questions should be avoided at all times, but when necessary these were included near the end of the questionnaire. By then a rapport will have been built up with the respondent making it more likely to elicit such information. The researcher was also careful not to include too much detail in the question wording, since this could confuse respondents.

When considering question wording in the design of the questionnaire the researcher ensured that the respondent was not forced into creating an opinion. The question should not favour one answer choice over another and should avoid negative
connotations, such as "Do you hate mathematics at university?". The researcher also provided a "don't know" or neutral option since otherwise the respondent may have felt they were being coerced into giving an answer they did not want to give or that they honestly did not have an opinion on.

3.2.3 **TYPES OF QUESTIONS**

As well as paying attention to question wording, it is also important that the researcher uses the most effective type of questions. The question type will depend on what kind of information is required from the respondent. There are three basic types of questions that are more generally used in questionnaire design and were used in this research. These are open-ended, closed-ended and rating scales.

**i. Open-ended Questions**

Open-ended questions provide no answer choices, and so were especially useful when the researcher was uncertain of how a respondent would respond. This was particularly important when gathering data with regards to students' attitudes and learning approaches (see Appendix B). The response rate to such questions was sometimes lower since the blank space can be demanding and intimidating. However, responses were illuminating and yielded much useful information.

**ii. Close-ended Questions**

Closed-ended questions provide specific answer choices although on occasion an "other" value with brief space for adding an additional value was included. However, with this type of question, the researcher was aware of the possibility that the right response may not be offered and valuable information will not be gathered.

**iii. Rating Scales**

Rating scales give a numerical value to some kind of judgement, Oppenheim (1992). This type of question is often popular in questionnaire design since ratings can be applied to almost anything – individuals, objects, abstractions and ourselves. Most scales use five points, as was used in this research. More points can be used but
respondents can be discouraged by too many choices and often don’t use the whole scale, Gillham (2000). The researcher provided a ‘neutral’ response to avoid forcing the respondent into choosing an option that did not necessarily reflect their true opinion. However, whatever response was given, the researcher had no information as to why without additional data.

An additional issue that was considered by the researcher was that of habituation, which can often occur when the respondent is faced with a series of questions that all have the same answer choices. When faced with too many similar questions the respondent may start to give the same answer, without really considering it. Therefore the researcher used such questions sparingly.

3.3 PRACTICALITIES AND ANALYSIS

When administering the questionnaire, there are a number of issues that were considered prior to the analysis stage. These included, careful planning of distribution, follow-up procedure, piloting and data collection.

The researcher took careful consideration in the planning process of the distribution, in order to eliminate a number of problems that could arise. For example, timing of the administration of the questionnaire was an issue. Fowler (2002) suggests that busy periods are to be avoided at all costs. However, if the questionnaire was distributed by hand to a group of students, then leading up to Christmas may be the ideal time to gather information before they leave for their Christmas break. This is true of the research presented in this study. A questionnaire was distributed to students prior to their University holidays since this would ensure a higher response rate. If the distribution was carried out during their long holiday break (four weeks at Christmas and Easter and even longer over the summer) then it is possible that many students would fail to complete the questionnaire because they had forgotten about it.

Due to the perceived problems relating to the low response rate of questionnaires it is usual to administer follow-up procedures. This may include a promoting letter to remind the respondent of the questionnaire and a further copy of the questionnaire 'in
case they did not receive or mislaid the original one', Gillham (2000). In terms of the present research, respondents were e-mailed to encourage response.

Piloting the questionnaire is of equal importance with regards to the practical issues. Indeed, Oppenheim (1976, pg 25) stresses

"...pilot work can help us with the actual wording of questions, but it can also help with such procedural matters as design of a letter of introduction, the ordering of question sequences, and the reduction of non-response rates."

Piloting the questionnaire will help the researcher understand the meaning of the questions to the respondents and may uncover issues which the researcher may not have initially thought about. A pilot of a questionnaire used for data collection in this study (see Appendix C which may be compared with Appendix B) revealed that a number of the questions needed re-wording in order to avoid ambiguity, as discussed in Chapter 7.

The last issue to consider is the collection of the data and its subsequent analysis. The researcher monitored all actions regarding the questionnaire, including dates of when the questionnaire and follow ups were administered and a record of how many replies have been received at a given time. In particular, returned questionnaires were checked and stored immediately they were received. Not only did this save time on analysis later but also if errors had been made then it was possible to contact the respondent to resolve the problem, Robson (2002).

The analysis stage can vary depending on the type of questions used and the desired outcome of the research. Numerical data that require quantitative analysis is considerably easier to store and review than written passages. Invariably a number of statistical techniques can be applied to quantitative data, including means, standard deviations, t-tests, f-tests etc. So for example, statistics in this study will be used to:

- Describe the mathematical background of respondents
- Describe what factors have prevented students from engaging with mathematics support
With regards to qualitative data, it is advised by Robson (2000) to code answers into a limited number of categories. This was done by pasting all the responses, to a particular question, on a sheet of paper and then developing a small number of categories (for example eight to ten) in which these responses could be sorted. A more detailed report on the analysis of such data can be found in Hatch (2002) and will be provided in later chapters of this thesis when used.

### 3.4 ADVANTAGES AND LIMITATIONS

Questionnaires are a relatively low cost way to reach a large number of people. For this research, this method was chosen since the process could be done relatively quickly so that data analysis could begin right away. The questionnaire method also avoided interviewer bias, guiding, and cues (if well written) that could potentially affect the validity and reliability of the data collection. There was also the advantage of anonymity, which may ensure more valid responses. For the research in this thesis, student ID numbers were collated wherever possible so that further analysis could be conducted. However, students did not have to provide this information if they preferred to remain anonymous.

However, the biggest pitfall of questionnaire usage as a research method is the poor response rate. There is no scientifically determined criterion for what constitutes an appropriate response rate but Babbie (1992) recommends that 50% is 'adequate', 60% is 'good' and 70% is 'excellent'. In this case, the questionnaire was distributed by hand to obtain maximum response rate. There is also the possibility of bias. It is likely that the respondents will be more motivated than non-respondents. In addition, because the researcher is at some distance, there is little opportunity to develop rapport with the respondent and so there is no opportunity to probe or clarify. Therefore, it is possible that the respondent may not have understood a question or the sort of response required.

### 3.5 CONCLUSION

Questionnaires are used in connection with many modes of observation in educational research. This section has focussed on key areas, which were relevant to the use of this method within the present research study, particularly question wording, types of
questions, the layout and analysis of responses. In this thesis a number of questionnaires have been produced, particularly for data collection in Chapter 7 and Chapter 8, of which this methodology has been used in the process of formulating the questionnaires.

However, questionnaires were not the only method of collecting qualitative data for the research. The subsequent section will now discuss the methodology of interviews in the context of this study.

4. INTERVIEWS

Throughout the research process a number of issues emerged whilst examining the effectiveness of mathematics support. In particular, quantitative data suggested that students’ attitudes and beliefs had an effect on the success of the support. In order to examine such issues more closely, interviews were carried out with a number of students. For example, this may have involved following-up particularly interesting responses from questionnaires. Some of the research questions that were addressed using this research method were as follows:

Why do some students avail themselves of mathematics support whilst other do not?

What is the student perspective on their knowledge/ lack of knowledge in maths and how it has affected their university studies?

What is the student perspective on mathematics support and their use / lack of use of such mechanisms?

A detailed examination of this research method and how this was used in the context of this thesis will now follow.
4.1 OVERVIEW

Interviewing is a popular research method used in qualitative research because interviews are flexible and can provide a rich data source. On a basic level, an interview is an informal conversation or discussion, as described by Moser and Kalton (1971, pg 271) "[the interview is] ...a conversation between interviewer and respondent with the purpose of eliciting certain information from the respondent".

Interviewing is also a popular research method since it can be used as the primary or only approach of collecting data but equally it can be used effectively in combination with other methods. Often, qualitative data from an interview can be used to complement quantitative data from a questionnaire, to provide a conceptual insight into fact and figures. In particular, this was key to the use of interviewing as a research method for the present study. In Chapter 4 it will be seen that quantitative data reveal that a significant proportion of students are not engaging with mathematics support. Interviews were carried out with such students as a means to uncover the reasons for this lack of engagement.

Interview data are generated via the interaction between the interviewer and the respondent from the verbal responses that the respondent gives and also non-verbal gestures, such as body language. Consequently, huge volumes of data will be collected and so the data analysis will be based on a cognitive insight rather than computations performed by a computer, Oishi (2002). Since such a vast amount of data can be generated from one interview, the researcher chose to focus primarily on the verbal responses from participants, as opposed to their body language.

The subsequent sections will discuss important aspects of interviews including their purpose, choosing participants, their structure, interview technique and analysis of data.

4.2 PURPOSE

In terms of education research, Seidman (1991, pg 4) states "If a researcher's goal, however, is to understand the meaning people involved in education make of their experience, then interviewing provides a necessary, if not always completely
Interviewing allowed the researcher an insight into the experiences of others by collecting stories and opinions so that they could be interpreted and described by those experiences. In particular, interviewing was used as a research method in this study since people's knowledge, views and experiences have meaning to the research questions at hand, such as in answering the question "What is the student perspective on their knowledge/ lack of knowledge in maths and how it has affected their university studies?" Indeed, interviewing may be the only reasonable way of gathering this data. Equally, this method was also used as a way of providing depth and dimension to previously gathered data, as in Chapter 5 when the researcher sought elaboration of reasons for disengagement with reactive mathematics support.

### 4.3 Structure

#### 4.3.1 Style

Interviews are commonly divided into three types: structured, semi-structured or unstructured. Each type varies in format and the choice of the interview will depend upon the information required by the researcher. Robson (2002) outlines the main differences of each type of interview:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structured</strong></td>
<td>Has pre-determined questions in a pre-set order. There is no flexibility in the wording or order of questions. Useful for reducing bias.</td>
</tr>
<tr>
<td><strong>Semi-structured</strong></td>
<td>Has pre-determined questions but order can be modified based on the direction of the interview. Questions can be omitted or question wording can be changed.</td>
</tr>
<tr>
<td><strong>Unstructured</strong></td>
<td>Informal discussion regarding a general area of interest. Questions occur spontaneously from the immediate context.</td>
</tr>
</tbody>
</table>
The semi-structured interview was used for all interviews for the research in this thesis to avoid generating copious amounts of worthless data.

4.3.2 Questions

Once the researcher has decided which type of interview to use, he/she must decide on the types of questions to be included. The purpose of the information required will generally decide the types of questions used. Atkinson (1967) outlines two main purposes of questions. Namely, to ascertain facts (using closed questions) or to ascertain opinion or attitude (using open questions). The main differences and advantages of the two types of questions are listed below:

<table>
<thead>
<tr>
<th>Open</th>
<th>When the researcher requires a full investigation of various aspect of the participants' thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The question gives no clues to an appropriate answer and so the respondent is 'open' to answer how he interprets the question. Provides an opportunity to discover information.</td>
</tr>
<tr>
<td></td>
<td>For example: “How do you feel about studying mathematics at university?”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Closed</th>
<th>When the researcher requires the respondent to choose a fixed alternative answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The question directs the respondent’s attention and forces them to chose an answer. Easy to analyse and can be compared with others in the sample.</td>
</tr>
<tr>
<td></td>
<td>For example: “Have you ever visited the Mathematics Learning Support Centre?”</td>
</tr>
</tbody>
</table>

4.3.3 Interview Guide

An interview guide will contain a set of questions in a proposed sequence, accompanied by a set of probes and prompts. Generally conducting interviews for the present research, the researcher required the respondent to speak freely about his/her experiences. However, some order was required to ensure that the research questions
were answered. A commonly used sequence is as follows; *Introduction*, ‘Warm-up’, *Main body*, ‘Cool off’ and *Closure* (for more details and for an example of an interview guide used in this research see Appendix D).

**4.4 Technique**

In order to obtain valuable data for the research in this thesis, the researcher was particularly vigilant of interview technique. One of the most important skills of a successful interviewer is listening. The interviewer must listen attentively so as to be active without intrusion. Indeed, the researcher listened on three levels, as suggested by Seidman (1991). The first level is listening to what the respondent is saying. The second is listening to the respondent’s “inner voice”, as opposed to an outer or public voice. Lastly, the researcher listened whilst conscious of the interview process, paying particular attention to the time, a respondent’s energy levels and what themes have or have not been covered.

The researcher was also careful not to impose his/her own beliefs on the respondent and avoided ‘leading’ questions that could bias the data. The researcher also partially memorised questions in order to create a natural tone to the conversation and avoided long pauses, since these could irritate or embarrass the respondents. However, a slight pause was sometimes needed to act as a probe or to allow time for the respondent to reflect.

Generally, the researcher aimed to build-up a relationship with the respondent so that he/she felt at ease and assured. This helps the respondent’s comprehension and should result in a greater accuracy of response, Atkinson (1967). Since in some cases the interviews involved discussing sensitive subjects, such as failing an exam, it was particularly important that the author employed such techniques to ensure that the participants felt comfortable when discussing their experiences.

**4.5 Analysis**

The purpose of every interview is the collection of information, which needs to be recorded in some way. Taking written notes and audio recording the interview are two common options and were used by the researcher. Although taking written notes may
mean the interview will become a slower process, it will not usually be necessary to
write down every single word uttered by the interviewee, simply some sense of the
meaning of what has been said, Dyer (1995).

For the research in this thesis, all interviews were audio-taped as suggested by Robson
(2001). This is to ensure that all data was preserved and, additionally, a tape recording
provided a permanent record. Before the analysis process can begin, each audio tape
should be transcribed. To reduce bias, a full transcript of each tape should be
produced. In terms of the research presented in this thesis, written notes and an audio
recording were taken during every interview and the transcripts were subsequently
produced. However, due to the large quantity of data and since time was an issue, a
selective approach to transcription was used on occasions. This method involved
using written notes as a guide and subsequently picking out relevant passages that
held importance from the audio data and noting tape counter numbers where there
were particular quotations, Creswell (2002).

When analysing the transcripts, the researcher was careful to have an open attitude so
that interesting and important themes could arise from the text, Seidman (1991). The
researcher often read the transcripts several times over until she was left with a
condensed version that had been categorised and made meaningful to the research
questions. Kvale (1996) provides details of five analysis methods that include 1)
meaning condensation, 2) meaning categorisation, 3) narrative structuring, 4) meaning
interpretation and 5) generating meaning through ad hoc methods. The methods of
meaning condensation and meaning categorisation were used conjunctively for the
analysis of the interview data for the present research. The researcher systematically
worked through the transcripts to abridge the meanings expressed by the interviewees
into briefer statements and to categorise meanings into recurring themes.

Whilst there are a number of approaches that can be used to analyse transcripts, a
recurring feature of such methods is the coding and categorisation of important
quotes. Eventually the researcher should have assembled a set of generalisations that
cover the themes of the research and can be backed-up by relevant quotes. For this
present research the author made use of the computer software package Atlas Ti
(www.atlasti.com), particularly to organise and manage relevant themes in the data.
The computer programme itself does not carry out any of the analysis, but rather the researcher uses this as a tool for systematically organising the data and exploring complex relations within it.

4.6 ADVANTAGES AND LIMITATIONS

Like all research methods, interviewing has its advantages and limitations. The major advantage of using interviewing, and a reason for choosing this method, is that it provides large amounts of data that are rich in context and meaning. The data collected provided a rich description of people’s behaviours, attitudes, perceptions and unfolding complex processes. In addition, since qualitative interviewing primarily consists of open questions, the respondents were likely to provide information or insights that the interviewer may not have anticipated, thus highlighting issues that may not have been previously considered by the researcher.

Interviewing is also a flexible and adaptable method for obtaining research data, Robson (2002). Although the researcher had a predetermined set of questions or themes, the researcher had the freedom to change wording or the order of questions according to the reactions of the respondent, thus allowing for further exploration of interesting themes raised during the interview.

Unlike other qualitative methods, such as questionnaires, the researcher could ensure that the respondent had interpreted the questions the way they were intended. Questionnaire responses have to be taken at face value, whereas interviews allowed the researcher to probe for more details and to clarify responses, Oppenheim (1992).

However, a major disadvantage of interviewing is that they can be extremely time-consuming. The researcher was faced with participant recruitment, interview preparation, transcribing the data, Seidman (1991) suggests 4 to 6 hours to transcribe a 90 minute tape), analysing the data and then, finally, writing up the findings. The quality of the results from an interview will also be dependent upon the skill of the interviewer. Not only does the researcher need to be knowledgeable and experienced in the content area, but also he/she has to have strong interpersonal skills.
4.7 CONCLUSION

Interviewing is one of the most widely used methods in qualitative research, since it can be used as the primary research method or can be combined with others. However, the decision to use interviewing should not be made lightly. As with all research methods, there is logic to the choice of such methods, as described in the context of the present research study.

Inherently related to interviews is Focus Groups, an additional method used for data collection for this research. This method will now be discussed in the subsequent section.

5. FOCUS GROUP RESEARCH

In this thesis, focus groups were used as a research method for similar reasons as for the use of interviews. Primarily they were used to gain a deeper understanding of some of the research issues, particularly from the student perspective. However, in some cases focus groups were used with the primary intention to discover information. For example, focus groups were held with students who had never used mathematics support to understand what barriers prevent students from using it.

A detailed examination of this method and how it was more specifically implemented in the context of the present research will now be discussed.

5.1 OVERVIEW

The focus group involves an organised discussion where carefully selected participants discuss their views and experiences of a topic in a non-threatening social environment. Questions are predetermined by a ‘moderator’ and are usually open-ended so as to spur discussion amongst the participants.

This type of group research is a form of ‘group interviewing’. During a group interview, the researcher will pose questions separately to the participants with the main emphasis being on the interaction between the researcher and each of the participants. In comparison, the emphasis of focus group interviews lies with the
interaction between the participants, as Gibbs (1997) states; "the key characteristic that distinguishes a focus group is the insight and data produced by the interaction between participants". Due to the comfortable, permissive environment, participants will influence each other throughout the discussion just as they are influenced in real life situations.

We will now continue to the next section, which outlines the main purposes of focus groups.

### 5.2 Purpose

Focus groups can be used at the preliminary or exploratory stages of a study, Kreuger & Casey (2000) in order to help generate hypotheses or gather background information. It can also be used during a study to diagnose problems or stimulate new ideas that can be used later, which was the main use of focus groups for the present research. For example, focus groups were used in Chapter 5 to gather data pertaining to the reasons behind students' lack of usage of mathematics support. The findings from this data were subsequently used to develop the research questions for understanding what motivates students to use mathematics support.

The next section shall discuss, in detail, the method of conducting a traditional focus group.

### 5.3 Traditional Focus Group Method

The term ‘focus group’ has been fashioned over the years to describe any form of group discussion that comprises individuals assembled to discuss a particular subject, Krueger (1994). It is common to use the term ‘traditional’ to distinguish this type of focus group from modern alternatives such as online or web focus groups. In addition, focus groups are usually distinct in size and composition of the group.

#### 5.3.1 Size

The number of participants for a focus group is significant, with an ideal size (according to Kreuger & Casey (2000)) of 4-8 people. This range should ensure a continuous stimulated conversation amongst the group while at the same time allow
each participant enough time to express their unique opinions, Vaughn et al (1996). However it is not unknown to conduct focus groups with as little as 4 participants or as many as twelve. For the present study, a number of small focus groups were conducted with approximately four students since the population sample itself was relatively small. Consequently, the number of willing participants was limited. Although using small groups means there is a risk of encouraging dominant speakers or limiting the conversation since there is not enough diversity amongst the group, the focus groups used for this research proved successful. A lengthy stimulating discussion was achieved in all cases despite the small numbers.

5.3.2 COMPOSITION

In addition to determining the correct size of a focus group, the composition of participants must also be taken into consideration. A key characteristic of focus group research is the homogeneity between participants, Morgan (1998). Participants should exhibit a specific characteristic that is connected to the topic in mind. For example, the research in this thesis concerned students who did and did not use mathematics support. This particular characteristic was used to determine the composition of some of the focus groups in this study. However, there must also be some variation amongst the group in order to allow for a diverse range of experiences and opinions. Therefore, students taking different courses and from different years were chosen for the research in this thesis.

5.3.3 MODERATOR

The choice of a moderator can have a significant impact on the focus group results, despite establishing the perfect composition of participants. Similar to interviewing, the researcher had to possess a range of skills in order to facilitate successful interaction amongst the group.

Prior to the focus group interview, the researcher created a “permissive” environment, Kreuger (1994) that allowed the participants to feel comfortable and encourage open and honest discussion. Indeed, the moderator was vigilant to listen and focus on understanding the perceptions of the participants even if a participant held opposing views or had limited knowledge of the subject at hand, Kreuger & Casey (2000).
A key aspect of facilitating focus group sessions, which was considered for this research, was that of guiding and controlling the discussion. It is perhaps the primary responsibility of the moderator to ensure that the participants’ responses meet the purpose of the focus group, Vaughn et al (1996). At times the moderator found the conversation drifting and so she was required to steer the conversation back to the topic. The researcher ensured that discussions were not dominated by excessively verbose participants and attempted to draw out the more quiet or retiring participants.

Finally it was important that the moderator was approachable since a friendly manner is a valuable asset, Kreuger and Casey (2000). If the moderator enjoys the experience rather than envisaging the role as a ‘chore’, then the participants will be more likely to open up and in turn this will promote conversation.

If possible, it is recommended to use a moderating team: a moderator and an assistant moderator. The use of an assistant allows the tasks to be shared between the two moderators, which will increase the accumulation of information and the validity of results, Kreuger (1994). In the preliminary stages of this research, the author of this thesis took on the role as ‘assistant’ moderator. This allowed the author to develop her own interviewing and moderating skills so that she was able to run successfully other focus groups at later stages in the study. In addition, an assistant was also useful during the analysis stage of the data since he/she can often give a different interpretation of the findings, which can prevent bias.

5.3.4 Practical Organisation

The practical organisation of the focus groups was important since this could influence the quality of the data. First, a suitable location should be found, this was often in a private room located on the university campus. This ensured that the session was free from distraction, both visually and audibly, in order to prevent interruptions or interference. The room itself was arranged informally (as suggested by Morgan (1998)) with chairs arranged with participants facing each other, since eye contact is vital between participants, Kreuger (1994).

Focus group discussions were recorded for the present research, primarily to validate results, such as with interviews. In particular, audio recordings were taken so that the
moderator did not need to take extensive written notes and could, therefore, concentrate on directing the discussions successfully. When recordings were being taken, permission of the participants was required due to a number of ethical reasons (for more details see Section 6.2). However, it should be anticipated that recording equipment could go wrong. Morgan (1998, pg 123) suggests using two recorders in order to “...provide a backup of the data.”, but written notes should be taken at all times and as extensively as possible. In order to keep track of what is being said by each of the participants the researcher chose to tabulate the notes. For example the method used in this study was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Participant A</th>
<th>Participant B</th>
<th>Participant C</th>
<th>Participant D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Issue 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Issue 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.4 ANALYSIS

The analysis stage of focus group research has been a great concern of researchers. A vast quantity of data was usually produced from focus group discussions, including transcripts of possibly 20 pages in length. When analysing such vast quantities, Kreuger and Casey (2000, pg 127) repeatedly emphasise the importance of the purpose of the study; “... the purpose keeps us on track”. Usually the purpose of the study will determine the depth of analysis, and so the researchers kept this in mind during the analysis stages of the present research.

Focus group discussions were transcribed immediately after they had been conducted since the transcription process can be lengthy, Vaughn et al (1996). For this present study the researcher transcribed all audio data since this aided in the analysis of the data as first-level analysis was in fact occurring. As advised by Morgan (1998), analysis may require many careful readings of the transcript, in order to pick out all the relevant themes.

The actual analysis strategy can be conducted in a number of ways. Kreuger and Casey (2000) suggest four main strategies that work well; the long table approach,
computer aided approach, rapid approach and the sound approach. The following are most commonly used during the analysis process of this research:

**The Long Table Approach**  Recommended for beginning analysts. The transcript is cut up into individual quotes in order to identify themes and categorize results.

**Computer Aided**  Can be used in a variety of ways, including cutting and pasting the transcript into a word document, coding results, or using specially developed analysis software.

The other approaches to analysis provide speedy results but will usually only capture the main essence of the discussion. These include the *Rapid approach* and the *Sound approach*, details of which can be found in Kreuger and Casey (2000, pg 132). The author of this thesis chose the long table approach when analysing data from preliminary focus group sessions. This ensured a thorough analysis particularly since the author was a novice in this area. During the later stages of the research the author conducted a similar approach with the use of computer software, namely Atlas Ti, more details of which can be found in the subsequent chapters of this thesis.

During analysis the researcher identified key themes within the discussion, as discussed in Section 4.5. In addition, the researcher sought evidence to prove or disprove ideas, as suggested by Kreuger & Casey (2000).

**5.5 Advantages and Limitations**

The method of focus group research provides a unique source of data that can be hard to find using other research methods. The use of open questions to promote discussion allowed the researcher to gather a large and rich amount of data. Moreover, the researcher could draw upon the participants' feelings and beliefs in order to obtain a deeper understanding.
Another advantage is that focus group research provides participants with the opportunity to be involved with the decision making process, Gibbs (1997). For example, during the focus groups conducted in this study, participants were asked for personal recommendations on how to improve mathematics support within their institution, so that action could be taken to assist in their learning of mathematics. Since participants were given some sense that their contribution could make a difference then this encouraged participants to share their ideas.

However, like all research techniques, focus group interviews can have limitations. The moderator had little control over the data produced since she could not control the interaction between the participants.

Focus groups were also more difficult to assemble, compared to interviews, in order to obtain the correct composition of participants. Focus group interviews tend to involve “purposive sampling” which can result in the researcher relying on available and willing participants with little regard to the pre-identified characteristics, Vaughn et al (1996). This is discussed further, with regards to the present research, in Section 6.1.

Finally, although focus group interviews can provide a rich source of data, these data can be difficult to analyse (analysis of this qualitative data is discussed further in Section 6.2).

5.6 CONCLUSION

The use of focus groups for academic research can produce invaluable data if implemented correctly. The interaction between participants is a key feature of focus group research that allows the researcher a deeper insight into the target audiences' attitudes and experiences towards a specific topic, hence, the use of focus groups in this study. Using this method allowed the researcher to explore unanticipated issues that arose during the discussion, which may not have been possible through the use of other research methods, such as questionnaires.

The use of such qualitative methods allowed the researcher to obtain a rich data set. However there are a number of theoretical issues that were considered when
implementing these methods in the current study. These will now be discussed in detail.

6. THEORETICAL ISSUES

In various sections of this chapter it has been indicated that the research methods chosen will depend upon the research questions. Given that the aim of the research was to investigate the effectiveness of mathematics support systems and the issue of student engagement, a mixture of quantitative and qualitative methodology has been used. Whilst quantitative data provide concrete facts and figures, qualitative methods provide a deeper insight into the statistics and can uncover further issues that are not always apparent from quantitative data.

The researcher has elected to use a mixture of qualitative methods, namely, self-completion questionnaires, interviews and focus groups. This choice was mainly determined by the research questions, which sought to uncover students' experiences of various mathematics support systems and attitudes towards mathematics in general. Inevitably, obtaining such data would involve getting students to discuss their individual experiences in an interview or focus group discussion. Quantitative questionnaires were generally used to collect preliminary findings and generate hypotheses. In order to obtain depth to the research findings it was often necessary to conduct interviews with small groups of students and, as suggested earlier, a purposive sampling strategy is appropriate in such studies. Where possible, information rich cases, which reflect the larger population, were chosen to reduce bias.

Details of the methods of data collection and analysis are described in detail in Chapter 5, Chapter 7 and Chapter 8. However this present section addresses, at a theoretical level, issues surrounding and associated with these methods. It also describes the precautions taken to avoid such issues.
6.1 Sampling

Sampling is particularly important to ensure accurate and valid results. It is particularly important to accurately identify the population and sample needed for the research in question. The population is simply all the members of the group that you are interested in. So for example, in the context of this research the population may be all students who could have used mathematics support. A sample is a sub-set of the population that is usually chosen because to access all members of the population is prohibitive in time, money and other resources. However, it is important to ensure that the sample is as representative as possible. For example, if a key aspect of the research is to compare male and female then it is advised that an equal number of responses from each gender should be collected.

It should be noted that questionnaires can often result in a poor response rate, particularly mail questionnaires, Fowler (2002). Therefore, if a sample of 100 responses is required (determined by conducting sample size calculations, see Cochran (1963) for details) but a response rate of 20% is expected, then the researcher will need to send out 500 questionnaires.

In the case of interviewing and focus groups, a small sample of the population will normally be used due to the large amount of data that can be generated from each interview. If the sample is too large then the data will be extremely difficult to analyse. Usually, the researcher will keep interviewing respondents until a saturation point is reached; whereby no new information is being elicited from new respondents. This was a particularly important issue for the present research, since the difficulty in recruiting participants meant it was often difficult to obtain large samples. However, to enhance validity of the data, interviews were generally conducted until a saturation point was reached.

When deciding upon whom to interview, the researcher generally took a ‘purposeful’ sample. Random sampling was usually not possible, since this required a large number of participants. Inevitably, ‘purposeful’ sampling involves an element of self-selection. Purposive sampling selects information rich cases from a small sample that reflects a larger population. Although participant recruitment was difficult for this
present study, students who took part in focus group sessions were only contacted and invited to take part if they met certain requirements, for example, if the student had never used mathematics support and had failed a mathematics module. Although to some degree purposive sampling may occur when using interviews as a research method, it is more likely to happen using focus groups, since participants are not only required to discuss sensitive issues but to discuss these with a group of strangers.

In addition, the researcher was wary when choosing such participants and, where possible, avoided selecting the ‘easy’ options. As Seidman (1991) expresses: “the easier the access [to the participant], the more complicated the interview”. In education research, it is advised that the researcher should avoid interviewing his/her own students, since it is likely that the students will not be entirely open and may respond with what the interviewer wants to hear rather than what the student actually feels. This was a particular issue for the current research since the author of this thesis had assisted in tutorial sessions involving some of the interview participants. However, since the author was familiar to the participants, this encouraged students to take part in the research (in fact this proved to be an obstacle later when recruiting participants who did not know the author). Although it is possible that this may have impeded the honesty of replies from the respondents, it was felt that the students were more willing to talk about their personal feelings than they may have been with a stranger.

6.2 INTERPRETATION OF QUALITATIVE DATA

The difficulty of analysing qualitative data has been touched upon in the previous sections. In particular, due to the subjective nature of such methodologies, researchers must be wary of bias when interpreting their data. It is generally recommended that a ‘literal’ interpretation of interview data should be avoided and that the researcher should not forget about the social situation of the interview. In particular, Kvale (1996) urges that the researcher should not lose sight of the original interaction of the interview situation. The researcher should be wary of a participant’s response, since they are recalling past experiences and are likely to be telling a story rather than giving a direct view of how they experienced a phenomenon. For this research, if a respondent was asked “Did you enjoy mathematics at secondary school?”, then we
must consider that a mature student may find this much more difficult to answer than a much younger student. In this case, the researcher should consider what constitutes an appropriate time scale.

Fortunately, interviews and focus groups allow the researcher to probe responses in an attempt to obtain a clear picture and to increase validity, Vaughn et al (1996). A skilled interviewer should be alert to when a respondent is using a ‘public’ voice rather than his/her own personal feelings. However, this is not the case for questionnaires. The reliability and validity of questionnaire data depends upon the technical proficiency of the researcher, Robson (2002). In particular, if the questions are ambiguous or incomprehensible then there is a possibility of misinterpretation by the respondent. Although interviews and focus group interviews can provide a rich source of data, these data can be difficult to analyse. Interpretation of the results is not always straightforward due to the open-ended nature of responses from participants. Sometimes comments can be taken out of context during the analysis stage or conclusions of the discussion can be reached prematurely, Kreuger (1994).

There are also issues surrounding the interpretation of responses to open questions on a questionnaire. Since there is no social interaction between the researcher and respondent then written comments must be taken at face value. Consequently, it is difficult to conceptualise the comments made by the respondent since the researcher is unaware of the context in which they were made.

In this present study, the concerns outlined in this section were addressed in a number of different ways. Firstly, the researcher was careful to ask respondents to ‘reconstruct’ experiences rather than remember them, as suggested by Seidman (1991). The researcher also attempted to conduct analysis and reporting of the data within a framework that considers the social situation in which the data were gathered, paying particular attention to non-verbal cues that may have provided a message to understand the verbal responses. In particular, the researcher of the present study was careful to ensure participants did not agree with a particular statement because of peer pressure. The researcher used non-verbal cues to determine whether participants felt uneasy, which may have led to false agreement.
6.3 **ETHICAL ISSUES**

There are many ethical considerations when conducting a research study. In particular, the researcher should be aware of obtaining informed consent and should be open about research purposes and confidentiality.

Participants of research will be sharing personal information with the researcher and may be asked to reconstruct part of the life history, which if misused, could leave the participants extremely vulnerable. Participants have a right to be informed of the potential risks and benefits of the research and should be aware of the purpose and conditions of the research study. Written consent is particularly important here since this will protect the respondent from such vulnerability and will also protect the researcher from any misunderstandings about the research or use of the data. When obtaining data for the research presented in this study, the author ensured that a written consent form was produced and signed by all participants. The consent form contained details of the research project, informed the participant of how they would be involved, described how their data would be used and stored and gave details of who to contact if the participant felt they had been placed at risk (see Appendix E for an example of the consent form used).

There are also ethical considerations concerning the use of incentives in recruiting participants for interviews and focus groups. In some cases it may be necessary to use incentives to improve response rates. In particular, incentives are usually required for focus group sessions for two main reasons. First, focus groups can be demanding, and they require individual contribution from each participant. Second, people who are outgoing and enjoy talking with others will be more likely to volunteer than individuals who are shy and find communicating difficult. Therefore, an incentive was usually offered in order to tackle this problem somewhat; otherwise, the findings could be biased. If incentives were used then the researcher ensured that they were not perceived as a bribe to elicit information but rather a ‘good-will’ gesture to show appreciation. Therefore, the researchers chose to offer non-monetary incentives such as refreshments and USB memory sticks. Also, to ensure that the incentive was not perceived as a ‘bribe’ the value of the incentive was never too large, but reasonably adequate so as to compensate the participant for their time and effort. Since recruiting
participants, particularly disengaged students, was a difficult process, incentives were offered to students participating in interviews. However, in cases where a monetary incentive was used, the value of such was kept reasonably small so as to reflect the cost of the participant's time.

Probably one of the most important ethical considerations is confidentiality and anonymity. An issue that was considered by the researcher, was that absolute anonymity was not always possible. Since the respondent is sharing information in the context of his/her personal life, a reader who knows the participant may be able to recognise them. There was also the issue of ensuring confidentiality of individuals when the data is being shared with the public. It is common practice to use pseudonyms in the reporting of the study. However, the researcher must be careful in the choice of pseudonyms, particularly whether they should be 'real' names or a system such as 'Student A', 'Student B' and so on. There is a danger that using 'real' names could alert the reader to the ethnicity of the respondent, which could evoke racial stereotypes by the readership, Seidman (1991).

In this present study, the researcher adopted specific ethical procedures to address such issues. Participants of interviews and focus groups were asked to sign an informed consent form (as discussed above). Students were also given pseudonyms by the researcher, based upon a system rather than 'real' names. This was to ensure that as much information as possible was not disclosed about individuals, particularly their race and gender. Any data that included the respondents' real identities were secured within a locked cabinet or on a password protected computer.

7. Summary

This chapter has laid out a theoretical justification for the research methodology used in the present study. The starting point of this discussion was the adoption of a mixed methods approach and the implications this has for the research findings in this thesis. This was followed by a critical examination of three research methods, namely questionnaires, interviews and focus groups, which were used as the main methods of data collection. Within this discussion, the research methods chosen were justified as suitable methods of data collection for this study and were contextualised for
mathematics education. Finally, this chapter has discussed the theoretical issues and ethical concerns with regards to the research methodology.

The actual methods of data collection and analysis that were used will be discussed in more detail in each of the subsequent chapters, since each chapter relates to different research methods. This will begin with Chapter 4, which describes the chosen research methods of the quantitative paradigm.
CHAPTER 4 – THE MATHEMATICS LEARNING SUPPORT CENTRE

1. INTRODUCTION

A review of the literature shows that many universities offer additional mathematics support provision in response to concerns of ill-preparedness amongst students for the mathematical demands of Higher Education courses. Indeed Perkin and Croft (2004) reported that 66 out of 106 UK Higher Education institutions had some form of mathematics support provision. At present, out of these 66 institutions, there are two leading providers of mathematics support for students. These are Loughborough University, through its Mathematics Learning Support Centre (MLSC), and Coventry University, through its Mathematics Support Centre (MSC).

Both the MLSC and the MSC have established themselves as integral parts of their respective universities. Since their establishment the centres have expanded both in terms of resources and their purpose, with their success being evident by the thousands of visits made by students seeking mathematics support and, more recently, recognition as a Centre for Excellence in Teaching and Learning (CETL) by the Higher Education Funding Council for England (HEFCE). Due to the growing success of the MLSC and the MSC, a continued evaluation of their use and impact is essential. The research presented in this thesis contributes this. Not only does this provide important information with regards to the popularity of the centres but it also provides an insight into how the centres are perceived from the student perspective. In particular, such data can be used to determine if the MLSC and MSC are meeting the requirements of the students who use them and also to understand why they consider such support to be important.

Of particular interest for the present research is the construct of student engagement and how this may relate to the effectiveness of mathematics support. Indeed, it has been identified from the literature that student engagement is a key concern regarding mathematics at university and mathematics support. In particular, there is evidence to suggest that many students fail to engage with mathematics at university and lack
motivation (Hall, 1982 cited in Kahn & Hoyles 1997), particularly those that are mathematically unprepared and who find themselves struggling with the demands of their courses. Moreover, there is growing concern that students who need mathematics support lack motivation and fail to engage with it. Since a Mathematics Support Centre is reactive, in the sense that students must take the initiative to use it, student engagement with the support is vital to its success. Therefore, this chapter will carry out a detailed examination of the usage of mathematics support at Loughborough University’s MLSC to investigate the extent to which the support is being effectively used by students who require it. In this chapter student engagement will be examined by considering the construct as a behavioural component to depict the extent to which students participate in educational practices. Therefore, engagement will be measured, in part, by considering concrete data (such as attendance).

This chapter will use quantitative data to investigate the effectiveness of the MLSC. Usage statistics over a three-year period (from 2004-5 to 2006-7) will be analysed and compared to evaluate the success and effectiveness of the support. In particular, analysis will be undertaken in an attempt to understand which students use the centre, in terms of Science, Technology, Engineering and Mathematics (STEM) and non-STEM. Moreover, mathematics module marks of first year students taking STEM courses are analysed and compared against centre usage. Within the discussion of these findings, the issue of student engagement will be examined. A deeper investigation of the relationship between student engagement, mathematics support and mathematics performance will be carried out in the final section of this chapter. In particular, linear and multiple linear regression models will be considered. Such models are constructed to establish if a student’s performance in a mathematics module could be predicted and, particularly, whether there is a relationship between student engagement with the MLSC and mathematics performance.

However, prior to this analysis of the usage data, background information with regards to the MLSC will first be given.
2. BACKGROUND

2.1 LOUGHBOROUGH UNIVERSITY

Loughborough University provides mathematics support via its Mathematics Learning Support Centre (MLSC). The MLSC was established in 1996 within the Department of Mathematical Sciences, and it was initially intended to cater for engineering undergraduates with mathematics learning needs. Due to its popularity, the Centre was established as a permanent feature in 1998 and expanded when the Mathematics Education Centre was formed in 2002. It now provides a wide range of supporting mechanisms. These include paper-based and computer-based support, drop-in surgery and a Centre Website. A variety of pre-sessional materials are also available to students. The MLSC has proved immensely popular amongst university students from varying departments, which is evident through the thousands of visits the centre receives each year.

3. ANALYSIS OF USAGE DATA

In order to carry out a successful evaluation of mathematics support, data is needed from a range of sources to include both quantitative and qualitative data. Indeed, Challis et al (2004) suggests that data should be gathered in six main areas, namely Baseline information, Output measures, Process measures, Student responses, Staff and expert opinion and Other data. In the first instance we will consider the first three areas, all of which comprise quantitative data. In particular, Baseline information will consist of diagnostic test results (it is recommended by Challis et al that entry qualifications and grades should be considered, however, it was not possible to collect such data in the scope of the present study), Output measures will consist of end of module performance data, and Process measures will consist of support usage data and also attendance data (in Section 4).

Since the centre has no influence over the pre-requisites or assessment for degree courses then data such as exam marks and progression rates cannot be used alone to assess the efficacy of the MLSC, since it is very difficult to quantify the extent to which the MLSC has enabled a student to pass when they would otherwise have failed. However, other sources of data, as mentioned above, can be used in
conjunction with exam marks and progression rates to measure the extent to which the centre is achieving its purpose. Usage statistics are of particular importance since such information can be analysed easily and immediately in order to determine who is using the centre and how frequently it is used. The MLSC uses a swipe-card system to record usage, in which students swipe their university identity cards in a reader and records of usage and detailed statistics can be produced automatically. Not only does this provide data pertaining to the number of visits to the centre but also details of the students themselves, including their department and year of study. In this section, the usage data will initially be analysed by comparing usage amongst STEM and non-STEM students before a more detailed analysis of the data pertaining to first year STEM students will be examined.

3.1 GENERAL USAGE OF THE MLSC

In examining the effectiveness of the MLSC, not only is it important to record how many students use the centre within a particular year, but also to examine how the usage of the centre changes over time, particularly year to year. Figure 4.1, compares the usage data of the MLSC over a three-year period, from 2004 to 2007 (a detailed breakdown of usage by year can be found in Table 4.1).

Figure 4.1: Comparison of the number of students and visits to the MLSC in 2006-07, 2005-06 and 2004-05.

Figure 4.1 shows that the number of visits to the centre has fluctuated over the three years. In 2005-6 there was a drop of 936 visits (or 19%) compared to the previous
year. However, since the opening of a second location of the MLSC in 2006-7 and the extension of resources and facilities within the centre, the number of visits has increased (although there is no improvement compared to 2004-5). We may expect a larger increase in the number of visits since the students now have the option of visiting two centres. However, it should be noted that in previous years there had been 29 hours of mathematics support available each week (and six hours of statistics) within the original centre, whereas in 2006-7 there was 30 hours of mathematics support (and nine hours of statistics) in both locations combined. Since this has not increased by a substantial amount, it is perhaps not surprising that the increase in the number of visits is not larger. Moreover, the second location of the MLSC was not fully resourced until the second semester of 2006-7. This is translated in the usage statistics, since the second semester saw a larger increase in the number of visits compared to the first semester in 2006-7.

In terms of the number of students using the MLSC, Figure 4.1 shows that there has been a steady increase over the past three years. Indeed, in 2006-7 there was an increase of 202 (16%) students who used the support compared to two years previously in 2004-5. This suggests an increased awareness of the centre, or possibly an increase in the perceived usefulness of the centre, since more students are coming to visit it. However, Figure 4.1 also highlights the average number of visits made by students in each year, which has fluctuated over time with an overall decrease from 2004-5 to 2006-7. On average students made 4.6 visits in 2004-5 compared to 3.6 in 2005-6 and 3.7 in 2006-7. The statistics show a notable decrease of nearly one whole visit since 2004-5, meaning that students are not using the centre as often as in previous years. It is possible that many students fail to make a repeat visit after their initial visit. Indeed, a closer examination of the usage statistics reveals that 45% of the users in 2006/7 made one visit and never returned compared to 41% in 2004/5. Thus, close to half of the users of the MLSC only accessed the support once. It is anticipated that one visit will not be of sufficient benefit to the student since it is likely that students will need regular support to help prepare them for the mathematics on their course. Indeed, the MLSC requires students to make return visit in order to be deemed as successful. However, it appears that this is not the case since a large proportion of the users of the MLSC are failing to fully engage with it since they are only attending once.
Over the past three years it is evident that there has been some change in the number of visits to the centre and perhaps the nature of those visits. Whilst there appears to be an increased awareness of the MLSC and its support facilities (compared to 2004-5), many students fail to use the support regularly. This could be explained by three possible reasons:

1) The student was sufficiently helped in one visit to the MLSC and no longer required support. Therefore, no additional visits were needed.

2) The student was sufficiently helped during their visit to the MLSC but unknown factors have prevented the student from returning for further support.

3) The student was not sufficiently helped and so the student did not return.

However, since exam results for service mathematics modules have not significantly improved over the three years and, moreover, there remain relatively high failure rates amongst some first year undergraduates, it appears that students who require mathematics support are either not benefiting from it or are failing to engage with it. However, the usage statistics alone cannot confirm this. In order to understand this lack of engagement, qualitative data associated with the users and non-users of the centre is needed. Such data was collected and analysed, and will be discussed in Chapter 5. Further analysis will now be conducted by comparing usage data between STEM and non-STEM students.

3.2 ANALYSIS BY STEM AND NON-STEM STUDENTS

Traditionally the MLSC has provided mathematics support for students within STEM departments, largely due to the considerable amount of mathematics that is covered within their degree programmes. Indeed, when the centre opened in 1996 the MLSC initially provided mathematics support only for students taking Engineering degree courses. Hence the support facilities and resources were aimed at such students. Unsurprisingly students from the School of Mathematics historically account for the largest proportion of visits (44% in 2006-7) closely followed by students taking Engineering courses (41% in 2006-7). A breakdown of the usage data with regards to STEM and non–STEM students can be seen in Table 4.1. Clearly the data show that
students from STEM departments dominate the number of visits to the MLSC. However, since the widespread recognition that many students from all departments enter university inadequately prepared for the mathematics on their courses, in recent years the MLSC has extended its support to cater for all students on the campus. Despite these changes and due to the nature of the support facility, the centre is generally perceived as a resource for students who study large amounts of mathematics (as indicated via qualitative data presented in Chapter 5), and consequently there is a perceived difficulty in encouraging students from non-STEM departments to use the support facilities. This is of particular concern since it is possible that students who are in need of the support, and could benefit from it, are not accessing it.

On analysing the MLSC usage data from 2004-5 (see Table 4.1) it can be seen that significantly fewer students from non-STEM departments accessed the support compared to students from STEM departments. However, over the three-year period there has been a significant increase in the proportion of students from non-STEM departments using the centre. In particular, non-STEM students account for 17% of the visits in 2006-7 compared to 9% in 2004-5.

The average number of visits made by non-STEM students has fluctuated over the three-year period. There has been a small decrease in the average number of visits made by non-STEM students from an average of 3.0 visits in 2004-5 to 2.6 visits in 2006-7. In terms of STEM students, their average number of visits has notably decreased over time. Indeed, in 2006-7 STEM students made nearly one less visit (0.8 visits) on average in 2006-7 compared to the average number of visits in 2004-5. Clearly, an indication that students are making repeated visits over an extended period of time suggests that the centre is providing helpful support to the students. However, since STEM students are making fewer visits on average, it appears that there is some unknown factor affecting their usage.

It should also be noted that these changes have occurred despite there being an overall increase in the proportion of students registered for STEM courses in 2006-7, since 6970 students were registered in 2004-5 compared to 7262 students in 2006-7.
On further analysis of the usage data, there has been a small increase in the proportion of STEM students making just one visit to the MLSC, since 40% of such students made only one visit in 2004-5 compared to 42% in 2006-7. Conversely, there has been a small decrease in the proportion of non-STEM students making just one visit, since 55% of such students made just one visit in 2004-5 compared to 53% in 2006-7. Again, this reiterates that students, in particular STEM students, are not regularly engaging with the support.

It may be argued that since the extension of the MLSC’s facilities to accommodate non-STEM students, we may expect an increase in the usage by these students as they become increasingly aware of the centre and its resources. In addition, we may also expect a ‘peak’ with regards to the usage by STEM students. However, since there appears to be fewer regular STEM users and, in addition, an increase in the proportion of STEM students making only one visit, it appears that the support is not being used to its full effect. The usage data cannot provide reasons as to why this is the case. It is possible that STEM students are no longer satisfied with the service provided by the MLSC. However, another possibility is that students lack the motivation to engage with the support. Further analysis is needed to understand the changes indicated by the statistics, in particular qualitative data would provide a deeper insight. Such data was collected and analysed, the details of which will be discussed in Chapter 5.
<table>
<thead>
<tr>
<th>STEM Department</th>
<th>2004-5</th>
<th></th>
<th></th>
<th>2005-6</th>
<th></th>
<th></th>
<th>2006-07</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students No. %</td>
<td>Visits No. %</td>
<td>Avg Visits</td>
<td>Students No. %</td>
<td>Visits No. %</td>
<td>Avg Visits</td>
<td>Students No. %</td>
<td>Visits No. %</td>
<td>Avg Visits</td>
</tr>
<tr>
<td>Aeronautical &amp; Automotive Engineering</td>
<td>51 4.87</td>
<td>138 2.84</td>
<td>2.7</td>
<td>54 4.99</td>
<td>153 3.90</td>
<td>2.8</td>
<td>65 5.20</td>
<td>140 3.03</td>
<td>2.2</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>32 3.06</td>
<td>147 3.02</td>
<td>4.6</td>
<td>33 3.05</td>
<td>116 2.95</td>
<td>3.5</td>
<td>41 3.28</td>
<td>251 5.44</td>
<td>6.1</td>
</tr>
<tr>
<td>Chemistry</td>
<td>8 0.76</td>
<td>10 0.21</td>
<td>1.3</td>
<td>12 1.11</td>
<td>15 0.38</td>
<td>1.3</td>
<td>10 0.80</td>
<td>32 0.69</td>
<td>3.2</td>
</tr>
<tr>
<td>Civil &amp; Building Engineering</td>
<td>120 11.46</td>
<td>457 9.40</td>
<td>3.8</td>
<td>120 11.09</td>
<td>380 9.68</td>
<td>3.2</td>
<td>138 11.05</td>
<td>340 7.36</td>
<td>2.5</td>
</tr>
<tr>
<td>Electronic &amp; Electrical Engineering</td>
<td>134 12.8</td>
<td>524 10.78</td>
<td>3.9</td>
<td>95 8.78</td>
<td>328 8.35</td>
<td>3.5</td>
<td>88 7.05</td>
<td>240 5.20</td>
<td>2.7</td>
</tr>
<tr>
<td>Institute of Polymer Technology &amp; Materials Engineering</td>
<td>35 3.34</td>
<td>97 2.00</td>
<td>2.7</td>
<td>35 3.23</td>
<td>137 3.49</td>
<td>3.9</td>
<td>30 2.40</td>
<td>73 1.58</td>
<td>2.4</td>
</tr>
<tr>
<td>Physics</td>
<td>51 4.87</td>
<td>158 3.25</td>
<td>3.1</td>
<td>82 7.58</td>
<td>355 9.04</td>
<td>4.3</td>
<td>92 7.37</td>
<td>356 7.71</td>
<td>3.9</td>
</tr>
<tr>
<td>School of Mathematics</td>
<td>293 27.99</td>
<td>2242 46.12</td>
<td>7.7</td>
<td>301 27.82</td>
<td>1604 40.85</td>
<td>5.3</td>
<td>313 25.06</td>
<td>2009 43.51</td>
<td>6.4</td>
</tr>
<tr>
<td>Wolfson School of Mechanical &amp; Manufacturing Engineering</td>
<td>157 15.00</td>
<td>626 12.88</td>
<td>4.0</td>
<td>169 15.62</td>
<td>466 11.87</td>
<td>2.8</td>
<td>164 13.13</td>
<td>383 8.30</td>
<td>2.3</td>
</tr>
<tr>
<td>Design &amp; Technology</td>
<td>20 1.91</td>
<td>30 0.62</td>
<td>1.5</td>
<td>20 1.85</td>
<td>33 0.84</td>
<td>1.7</td>
<td>3 0.24</td>
<td>3 0.06</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>901 84.2%</td>
<td>4429 90.5%</td>
<td>4.9</td>
<td>921 83.3%</td>
<td>3587 90.5%</td>
<td>3.9</td>
<td>944 75.3%</td>
<td>3827 82.8%</td>
<td>4.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-STEM Department</th>
<th>2004-5</th>
<th></th>
<th></th>
<th>2005-6</th>
<th></th>
<th></th>
<th>2006-07</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students No. %</td>
<td>Visits No. %</td>
<td>Avg Visits</td>
<td>Students No. %</td>
<td>Visits No. %</td>
<td>Avg Visits</td>
<td>Students No. %</td>
<td>Visits No. %</td>
<td>Avg Visits</td>
</tr>
<tr>
<td></td>
<td>25 2.39</td>
<td>41 0.84</td>
<td>1.6</td>
<td>22 2.03</td>
<td>26 0.66</td>
<td>1.2</td>
<td>40 3.20</td>
<td>102 2.21</td>
<td>2.6</td>
</tr>
<tr>
<td>Business School</td>
<td>9 0.86</td>
<td>13 0.27</td>
<td>1.4</td>
<td>7 0.65</td>
<td>7 0.18</td>
<td>1.0</td>
<td>23 1.84</td>
<td>54 1.17</td>
<td>2.3</td>
</tr>
<tr>
<td>Computer Science</td>
<td>19 1.81</td>
<td>42 0.86</td>
<td>2.2</td>
<td>51 4.71</td>
<td>98 2.50</td>
<td>1.9</td>
<td>78 6.24</td>
<td>260 5.63</td>
<td>3.3</td>
</tr>
<tr>
<td>Economics</td>
<td>0 0.00</td>
<td>0 0.00</td>
<td>0.0</td>
<td>0 0.00</td>
<td>0 0.00</td>
<td>0.0</td>
<td>1 0.08</td>
<td>1 0.02</td>
<td>1.0</td>
</tr>
<tr>
<td>European and International Studies</td>
<td>2 0.19</td>
<td>2 0.04</td>
<td>1.0</td>
<td>1 0.09</td>
<td>15 0.38</td>
<td>1.5</td>
<td>1 0.08</td>
<td>1 0.02</td>
<td>1.0</td>
</tr>
<tr>
<td>Geography</td>
<td>9 0.86</td>
<td>11 0.23</td>
<td>1.2</td>
<td>22 2.03</td>
<td>39 0.99</td>
<td>1.8</td>
<td>44 3.52</td>
<td>77 1.67</td>
<td>1.8</td>
</tr>
<tr>
<td>Human Sciences</td>
<td>9 0.86</td>
<td>16 0.33</td>
<td>1.8</td>
<td>19 1.76</td>
<td>35 0.89</td>
<td>1.8</td>
<td>49 3.92</td>
<td>79 1.71</td>
<td>1.6</td>
</tr>
<tr>
<td>Information Science</td>
<td>6 0.57</td>
<td>8 0.16</td>
<td>1.3</td>
<td>6 0.55</td>
<td>11 0.28</td>
<td>1.8</td>
<td>15 1.20</td>
<td>23 0.50</td>
<td>1.5</td>
</tr>
<tr>
<td>School of Art &amp; Design</td>
<td>0 0.00</td>
<td>0 0.00</td>
<td>0.0</td>
<td>2 0.18</td>
<td>2 0.05</td>
<td>1.0</td>
<td>1 0.08</td>
<td>1 0.02</td>
<td>1.0</td>
</tr>
<tr>
<td>School of Sport &amp; Exercise Sciences</td>
<td>62 5.92</td>
<td>294 6.05</td>
<td>4.7</td>
<td>29 2.68</td>
<td>104 2.65</td>
<td>3.6</td>
<td>35 2.80</td>
<td>160 3.47</td>
<td>4.6</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>4 0.38</td>
<td>4 0.08</td>
<td>1.0</td>
<td>1 0.09</td>
<td>1 0.03</td>
<td>1.0</td>
<td>14 1.12</td>
<td>19 0.41</td>
<td>1.4</td>
</tr>
<tr>
<td>Teacher Education Unit</td>
<td>0 0.00</td>
<td>0 0.00</td>
<td>0.0</td>
<td>0 0.00</td>
<td>0 0.00</td>
<td>0.0</td>
<td>4 0.32</td>
<td>13 0.28</td>
<td>3.3</td>
</tr>
<tr>
<td>Total</td>
<td>145 15.8%</td>
<td>431 9.5%</td>
<td>3.0</td>
<td>160 16.6%</td>
<td>338 9.5%</td>
<td>2.1</td>
<td>305 24.6%</td>
<td>790 17.2%</td>
<td>2.6</td>
</tr>
</tbody>
</table>

4.1: Number of students and visits to the MLSC grouped by STEM and non-STEM departments
3.2.1 **Statistical significance**

It should be noted that the above data was tested for statistical significance using the non-parametric chi-square ($\chi^2$) test. This test was used to evaluate the significance of the number of visits made to the MLSC compared to the number of students who made those visits (grouped by STEM and non-STEM). The null hypothesis of this test is that there is no difference between the year and the number of visits made to the centre by STEM students compared to non-STEM students. The test produced a $\chi^2$-statistic of 205.765 with an associated $p$-value < 0.001. A $\chi^2$ result of below 0.05 indicates statistical significance and, therefore, it is almost certain that there is a relationship between the number of visits to the centre and the year these visits were made. Thus it is not just by chance or random fluctuation that account for the year on year change. Table 4.2 compares the number of visits and the percentage of those visits made by STEM and non-STEM students. It can be seen that there was a drop in the number of visits made by STEM and non-STEM students in 2005-6 and a rise (in terms of both cohorts) in 2006-7. However, there was a greater number of visits made by non-STEM students in 2006-7 than in 2004-5, whereas fewer visits were made by STEM students in 2006-7 than to 2004-5. A more detailed output of the SPSS results can be found in Appendix F.

<table>
<thead>
<tr>
<th></th>
<th>2004-5</th>
<th>2005-6</th>
<th>2006-7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>STEM</td>
<td>4429</td>
<td>91.1%</td>
<td>3587</td>
</tr>
<tr>
<td>Non-STEM</td>
<td>431</td>
<td>8.9%</td>
<td>338</td>
</tr>
</tbody>
</table>

Table 4.2: Comparison of the number of visits and the proportion of visits made by STEM/Non-STEM students.

It appears that the change in the proportion of visits made by STEM and non-STEM students has occurred due to the lack of visits made by STEM students (despite there being an increase in the number of students registered on STEM courses in 2006-07) and, moreover, that this difference is statistically significant. It is possible that the 2006-07 cohort of students did not require the same level of mathematics support as was required by the 2004-05 cohort. However, it is also possible that the students do require support but they are failing to engage with it.
It is apparent, therefore, that the usage of the centre has changed over time. It is likely that this is due to the structural change of the MLSC. In particular, the addition of a new location of the centre could account for the increase in non-STEM users. Nonetheless, whilst STEM students remain the larger users of the support, there has been some change in the dynamic of those students within the STEM cohort. Since this has occurred over a three-year period it is possible that these changes relate to the new intake of first year students. In order to investigate whether this is indeed the case, further analysis with regards to first year STEM students will now be conducted.

3.3 MLSC USAGE AMONGST FIRST YEAR STEM STUDENTS

As discussed in the previous section, there is a decrease in the number of visits made to the MLSC by students from STEM departments. Since the decrease in visits has declined since 2004-5, it is possible that the change in these visits relates to first year students. The support provided via the MLSC is specifically aimed at first year students, since it is anticipated that the amount of support needed will decline as students progress through their course (although not necessarily in the case of mathematics students). It is, therefore, particularly important that first year students are aware of the support available to them and that the facilities and resources are used and, moreover, are successful in supporting students with weaknesses in mathematics.

To investigate whether the changes in the usage data relate to first year student usage, usage statistics will be compared in relation to first year students only, as illustrated in Table 4.3. Over the three year period, the proportion of first year students using the MLSC has remained relatively the same. In 2004-5, 2005-6 and 2006-7 approximately 15% of the total population of first year students had visited the MLSC at least once. However, the number of visits made by first year students has decreased over time. Therefore, in 2006-7 first year students were making, on average, fewer visits compared to two years previously. As can be seen in Table 4.3, in 2004-5 first year students made an average of 4.7 visits compared to 3.5 visits in 2006-7. Recall, that with regards to the whole population of MLSC users, on average students made 4.6 visits in 2004-5 compared to 3.7 visits in 2006-7.
<table>
<thead>
<tr>
<th>Number of visits by first years</th>
<th>Number of first year users</th>
<th>Total Number of first year students</th>
<th>Average number of visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004/5</td>
<td>2270</td>
<td>3295</td>
<td>4.7</td>
</tr>
<tr>
<td>2005/6</td>
<td>1842</td>
<td>3434</td>
<td>3.7</td>
</tr>
<tr>
<td>2006/7</td>
<td>1796</td>
<td>3374</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 4.3: Breakdown of first year MLSC visits by STEM students.

Similarly, the general findings from above are reiterated upon further analysis of first year usage. Namely, that there has been a decrease in visits made by STEM students. In particular, STEM students accounted for 88% of first year visits in 2004-5 compared to 76% in 2006-7, despite there been an overall increase in the number of first year students registered for STEM courses (1517 students registered in 2004-5 compared to 1641 students in 2006-7).

Since, there has been a change in the nature of the visits made by first year STEM students (despite the support being traditionally aimed at this cohort) further analysis will now be conducted relating to specific STEM modules. It is anticipated that the decrease in the average number of visits made by STEM students has occurred either because students did not require the same level support as was required in 2004/5 or that such students were failing to engage with the support. Therefore, usage statistics relating to first year students taken from a number of STEM mathematics modules will now be analysed. The data collected relates to eleven separate first year mathematics modules taken by students from various STEM departments. A breakdown of these modules and the departments that they relate to can be seen in Table 4.4. Note that some STEM courses, such as Chemistry, have not been considered since mathematics is taught within course modules rather than as an individual ‘service’ mathematics module.
<table>
<thead>
<tr>
<th>Module</th>
<th>Semester</th>
<th>Department</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Civil and Building Engineering</td>
<td>103</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>Civil and Building Engineering</td>
<td>87</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>Aeronautical and Automotive Engineering</td>
<td>149</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>Aeronautical and Automotive Engineering</td>
<td>148</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>Physics</td>
<td>50</td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>Physics</td>
<td>63</td>
</tr>
<tr>
<td>G</td>
<td>1 &amp; 2</td>
<td>Electronic and Electrical Engineering</td>
<td>105</td>
</tr>
<tr>
<td>H</td>
<td>1 &amp; 2</td>
<td>Manufacturing Engineering</td>
<td>35</td>
</tr>
<tr>
<td>I</td>
<td>1 &amp; 2</td>
<td>Sports Technology</td>
<td>28</td>
</tr>
<tr>
<td>J</td>
<td>1 &amp; 2</td>
<td>Mechanical Engineering</td>
<td>104</td>
</tr>
<tr>
<td>K</td>
<td>1 &amp; 2</td>
<td>Mathematics</td>
<td>197</td>
</tr>
</tbody>
</table>

Table 4.4: Breakdown of first year mathematics modules by department.

In an attempt to understand which of these students use the MLSC, the number of visits made by students from each mathematics module will now be compared against their module marks from that respective module. Figure 4.2 groups the number of visits into four main categories, namely '0 visits', '1 visit', '2-9 visits' and '10+ visits'. These categories relate to students who have never used the centre, students who have visited once but never returned, students who have occasionally used the centre and students who regularly used the centre, respectively. This extends from earlier work published by Pell & Croft (2008), which analysed similar data taken from the 2004/5 cohort of Engineering students at Loughborough University. In their paper, Pell & Croft used the categories '0-1 visits', '2-9 visits' and '10+ visits' to distinguish frequency of use. However, it should be noted that '1' visit has been specified as an individual category for this present research study since this is of particular interest, given that such students may not have returned to the centre because they were not sufficiently helped. In terms of 'regular users', it was believed that a student who had visited the centre 10 or more times over the 30 week period could be justly classified as regularly engaging with the support since they had visited the MLSC, on average, at least once very three weeks. The categories '1 visit', '2-9 visits' and '10+ visits' also closely relates to minus one standard deviation away from the mean number of visits, the mean itself and plus one standard deviation away from the mean respectively.
It should also be noted that since the modules A, B, C, D, E and F ran during one semester only (i.e. for 15 weeks), these modules have been grouped as A&B, C&D and E&F to simplify the classification of use amongst students taking these modules (since a student on module A, for example, who had visited the centre 5 times would not ordinarily be classified as a regular user despite having made, on average, one visit every three weeks). Therefore, only students who had taken both Semester 1 and Semester 2 modules were considered. This translates to 84 students taking A&B, to 145 students taking C&D and to 46 students taking E&F.

Figure 4.2: Frequency of visits to the MLSC by module.

Figure 4.2 reiterates the earlier analysis, namely that students are not accessing the support on a regular basis. Indeed, the data shows that very few students in 2006-07 have been categorised as ‘regular’ users since only 20 students made 10 or more visits to the centre, of which 11 were taking a Mathematics degree. In terms of occasional users (2-9 visits), students from the Civil and Building Engineering, Physics, Mathematics and Mechanical Engineering departments (modules A&B, E&F, J and K) tended to use the centre more frequently than students from other departments. Between 20% and 27% of students from these departments had occasionally accessed mathematics support offered by the MLSC.

However, in all cases, the majority of students had never used the support centre. In particular, very few students from Aeronautical and Automotive Engineering and Sports Technology had accessed the support (89% and 91% respectively) and, perhaps
worryingly, no students from Electrical and Electronic Engineering had accessed the support in 2006-07.

Recall that earlier analysis had indicated a drop in the number of visits to the centre but an increase in the number of students in 2006-07. It was anticipated that this could mean that many students had visited the centre once but never returned. Analysis of the data relating to STEM students making just one visit shows that, in fact, very few students had visited the centre just once. In total, 68 out of 646 students (11%) made one visit only. The majority of those students relate to the Physics, Manufacturing Engineering and Civil and Building Engineering departments.

It is possible that the students who were regular/occasional users of the centre were students in need of mathematics support, and those who had never used the centre may not have needed the support. To ascertain if this is indeed the case, we will now compare usage statistics with regards to the students’ module grades.

Table 4.5 (as adapted from Pell & Croft, (2008)) categorises module marks in relation to a ‘grade’ from A* to F. Grade A* and A are equivalent to a First class degree mark, B is equivalent to a Upper Second class mark, C is equivalent to a Lower Second class mark, D is equivalent to a Third class mark and both E and F are equivalent to a Fail. For modules A&B, C&D and E&F, the average mark of the two modules has been taken.

The most striking feature of Table 4.5 is that 86% of students who had failed a mathematics module had never visited the MLSC. These students were clearly in need of mathematics support but they had failed to avail themselves of such services. Unfortunately this means that the MLSC is not being used to its full potential, since students who really do need the support are not engaging with it. Since the usage statistics do not indicate why failing students are not engaging with the support it appears that further investigation is needed in an attempt to understand what reasons are preventing students from accessing the support facilities. This will be done using a qualitative methodology in Chapter 5.
<table>
<thead>
<tr>
<th>Module</th>
<th>Visits</th>
<th>Grade</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A* &gt; 79%</td>
<td>A 70-79%</td>
</tr>
<tr>
<td>A&amp;B</td>
<td>0</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>0</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E&amp;F</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>0</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>J</td>
<td>0</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>K</td>
<td>0</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>All modules</td>
<td>0</td>
<td>45</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>2-9</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>128</td>
<td>156</td>
</tr>
</tbody>
</table>

Table 4.5: Frequency of visits to the MLSC by module and grade.
It should be noted that these data was also evaluated using a nonparametric statistical test of significance. Similar to previously, the $\chi^2$ test was used to evaluate the significance of the number of visits compared to the module grade achieved. Since the $\chi^2$ test is nonparametric, it is insensitive to the size of visits; it considers 'one' visit in the same manner as a '10' or '100' visits. Since, the number of visits made by students from particular grade bands was relatively small (for example students who had failed or achieved an 'E' or 'F' grade), the $\chi^2$ test could not be conducted by comparing across such broad categories. Therefore, the categories were condensed and these data was evaluated using the $\chi^2$ test. Table 4.6 shows the data relating to the condensed categories. The grades have been categorised as either a 'Fail', 'Pass' (40-69%) or 'Excellent Pass' (≥ 70%). Likewise, the visits have been categorised as '0 visits', '1 visit' or ' >1 visit' (due to the small numbers it is impossible to split the categories to reflect occasional and frequent users). These categories ensure that the data is distributed as evenly as possible to perform an accurate test.

<table>
<thead>
<tr>
<th></th>
<th>Fail (≤ 40%)</th>
<th>Pass (40-69%)</th>
<th>Excellent Pass (≥ 70%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 visits</td>
<td>67 86%</td>
<td>338 71%</td>
<td>122 63%</td>
</tr>
<tr>
<td>1 visit</td>
<td>6 8%</td>
<td>52 11%</td>
<td>23 12%</td>
</tr>
<tr>
<td>&gt; 1 visit</td>
<td>5 6%</td>
<td>83 18%</td>
<td>25 6%</td>
</tr>
<tr>
<td>Total</td>
<td>78 100%</td>
<td>473 100%</td>
<td>193 100%</td>
</tr>
</tbody>
</table>

Table 4.6: Frequency of visits to the MLSC by grade.

The null hypothesis for the $\chi^2$ test is that there is no association between the module grade and the number of visits made to the centre. The test produced a $\chi^2$-statistic of 15.768 with an associated $p$-value of 0.003. A $\chi^2$ result of below 0.05 indicates statistical significance and, therefore, it is almost certain that there is a relationship between student engagement (in terms of the number of visits to the MLSC) and module grade achieved. A detailed output of the SPSS results can be found in Appendix G.

From Table 4.5, it can also be seen that many other students had not used the MLSC, including students who had only just passed a mathematics module (grade 'D' students). It is possible that these students could have also improved upon their grades.
if they had accessed the mathematics support, or in terms of the students who performed well, they had achieved a good grade without mathematics support. Indeed, further investigation indicates that the higher the module grade the more likely that the student had accessed the MLSC more than once. In particular, 25% of students who had achieved an ‘Excellent Pass’ \((\geq 70\%)\) had used the support more than once, of which 5% were classified as regular users. This could indicate that mathematically able students had used the support to achieve a higher grade. This coincides with similar findings from Pell and Croft (2008) since they concluded that better students seeking excellence use the MLSC more than students looking to avoid failure. In comparison, 18% of students who had achieved a ‘Pass’ \((40-69\%)\) had used the support more than once, of which 2% were classified as regular users and 6% of students who had achieved a ‘Fail’ \((\leq 40\%)\) had used the support more than once, of which 1% were classified as regular users.

We will now consider students who had used the centre either once, occasionally (2-9 visits) or regularly (10 or more visits). Figure 4.3 compares students’ grades (from all 11 modules) with the number of visits they had made to the centre.

From Figure 4.3 we can see that only one student who failed a mathematics module was classified as a ‘regular’ user. In this case the student was not able to pass the mathematics module despite the support. However, without further investigation it is impossible to ascertain why the student failed. Since this student is an exceptional case, the remaining data suggests that generally students who had failed a mathematics module had rarely used the centre. This reiterates the above findings; that students who are in need of the support are not engaging with it. On further analysis of the remaining 4 students who had failed a mathematics module and rarely or occasionally used the centre, the data indicates that generally such students only accessed the support either during the exam period or near a coursework deadline. For students who had potentially used the support for help with coursework, it is possible that they received adequate help at the time but for unknown reasons did not return for further help in their course. Equally likely is that the student was not helped sufficiently, because their visit was for help with coursework (in which case, support staff can give limited help). However, again further investigation is needed to confirm this. It appears that students who only accessed the MLSC during the revision period
and who failed their mathematics exam did not receive a sufficient amount of help required to pass the module. It is likely that this is because such students were in need of continued support throughout the year, and that one or two visits at the end of the semester was not adequate preparation for their exam.

![Figure 4.3: Comparing a student's mathematics module grade against the number of visits made to the MLSC.](image)

It can also be seen from Figure 4.3 that generally, in terms of regular users of the centre, the more visits a student made to MLSC the better their module grade. Indeed, a notable number of students achieving A* and A grades engaged with the support (see Table 4.5). This is perhaps due to the pursuit of excellence amongst such students, as suggested by Pell and Croft (2008). The data indicate that if a student engages regularly with mathematics support then it is likely that they will perform well. However, additional analysis is required to investigate this issue further. Therefore, the next section will investigate the issue of student engagement and its relationship to a student’s mathematics performance, by constructing regression models. This will be done by comparing student attendance rates and MLSC usage (as means of measuring student engagement in terms of the extent to which a student engages with educational practices) with module marks. Diagnostic test marks will also be compared to module marks.
4. REGRESSION MODELS

Comparison of usage data with a student’s mathematics module grade has shown that the majority (67 out of 78, 86%) of STEM students who had failed a mathematics module did not engage with mathematics support. Indeed, of the 11 students who did access the support, the majority (76%) used the MLSC only once or twice and it is likely that this will not be of sufficient benefit to the student. In addition, in terms of regular users, it was found that generally the more visits a student made to the centre the more likely it was that they would achieve a high grade, suggesting that a student who engages with mathematics support will perform well in the mathematical component of their degree.

It is important to understand what action can be taken to help engage students who are failing and to identify such students. Therefore, this section will specifically analyse students’ diagnostic test marks (as a predictor of whether they are at risk of failing) and attendance data as a measurement of student engagement (in terms of a behaviour as explained in Chapter 1). In addition, recall, that Challis et al (2004) suggest that diagnostic test marks should be used as Baseline Information and attendance data should be used as Process Measures when evaluating the effectiveness of mathematics support.

In order to create and use regression models we must first check for correlation between variables to ascertain whether there is a strong enough relationship.

4.1 SIMPLE LINEAR MODELS

In the first instance we will construct simple linear regression models to investigate a linear relationship between a response variable and a possible predictor variable by using the well-known method of least squares. For the present study the response variable of interest is that of ‘Mathematics Module Mark’. Three predictor variables will be considered, namely ‘Diagnostic Test Mark’, ‘Attendance’ (lecture and tutorial) and ‘MLSC usage’. Each of these three variables will be considered in turn to predict a student’s mathematics module grade.
A scatter plot of students' mathematics module grade against their diagnostic test mark (taken on commencement of the degree courses) was created, as can be seen in Figure 4.4. It should be noted that data regarding the Semester 2 modules (which directly followed a Semester 1 module) have not been taken into account, since this would relate to a student's second mathematics assessment mark, rather than their initial assessment following the diagnostic test. In addition, students taking a Mathematics or Physics course will complete a different diagnostic test to students taking an Engineering course (although both tests assess students' competency of similar mathematical topics). The figure shows the correlation between the two variables and the least squares line of best fit is also visible. It can be seen that there is a small positive correlation (correlation coefficient of 0.413) between a student's mathematics diagnostic test mark, $x$, and their mathematics module grade, $y$. This model has the equation:

$$y = 0.4168x + 28.682$$

This model predicts that a student who scored 40% in the mathematics diagnostic test will perform some 12.5% (i.e. one grade boundary) less than someone who scored 70% in the mathematics diagnostic test.
This model produces an $R^2$ value of 0.17, which indicates that 17% of the variation in a student’s mathematics module mark can be explained by their mathematics diagnostic test result. As a predictive variable, ‘Diagnostic Test Mark’ has low predictive power, suggesting that such a model is limited in predicting a student’s module mark. However, the variable is significant at the 0.05 level, indicating that a student’s diagnostic test score is significant with regards to the student’s module mark. Since the variable has a significance < 0.001, it is almost certain that a student’s diagnostic test score is statistically significant.

For comparison, a scatter plot of students’ second mathematics module, i.e. in Semester 2 only, grade against their diagnostic test mark was created, as can be seen in Figure 4.5. This model has the equation:

$$y = 0.2722x + 36.681$$

This model has an $R^2$ value of 0.03, which indicates that only 3% of the variation in a students second mathematics module mark can be explained by their mathematics diagnostic test result. This suggests that there is no relationship between a student’s diagnostic test result and their second mathematics module grade. Hence, in terms of creating a multiple regression model, the second mathematics modules will not be considered.

Figure 4.5: Comparison of diagnostic mark against second mathematics module mark.
Similarly, a scatter plot was created of students’ attendance rate against the module mark. This can be seen in Figure 4.6. The figure shows the correlation between the two variables and the least squares line of best fit is also visible. It can be seen that there is a small positive correlation (correlation coefficient of 0.296) between a student’s attendance rate, \( x \), and their mathematics module grade, \( y \). This model has the equation:

\[
y = 0.162x + 47.815
\]

Interestingly, this model predicts that a student who attended their sessions 90% of the time will only achieve one grade boundary (i.e. 11.3%) more than somebody who only attended 20% of the time.

![Figure 4.6: Comparison of module attendance (tutorial only OR combined lecture/tutorial) against mathematics module mark.](image)

The model produces an \( R^2 \) value of 0.0879, which indicates that only 8.8% of the variation in a students’ mathematics module mark can be explained by their attendance rate for that module. In terms of predictive power, this indicates that the variable is very weak. However, it should be noted that attendance data for the eleven modules differs. In some cases, attendance was recorded for both lecture and tutorial sessions, whilst for other modules attendance for tutorial sessions only was taken. In addition, no attendance was recorded for the Physics and Mathematics modules. When analysing tutorial attendance only against module mark, we could consider that it may
be possible for a student to succeed in mathematics whilst attending very few tutorial sessions. However, they may have attended most of their lecture sessions.

Indeed, in four of the modules (modules A, B, C and D) attendance data for only tutorials were recorded. Therefore, a scatter plot for the remaining modules (which considers combined lecture and tutorial attendance since it is not possible to distinguish between the two) was produced, as can be seen in Figure 4.7. The figure shows a much stronger positive correlation compared to that in Figure 4.6 (correlation coefficient of 0.447 compared to 0.296). This model has the equation:

\[ y = 0.3368x + 32.091 \]

This model predicts that a student who attended their sessions 90% of the time will achieve one grade boundary (i.e. 10.1%) more than somebody who only attended 60% of the time.

The new attendance model produces an \( R^2 \) value of 0.1997, which indicates that approximately 20% of the variation in a students’ mathematics module mark can be explained by their attendance rate (lecture and tutorial) for that module. It is clear that this is a better model compared to the previous model for attendance.

![Figure 4.7: Comparison of module attendance (disregarding tutorial only attendance) against mathematics module mark.](image-url)
It should be noted, that as a predictive variable, ‘Attendance’ also has low predictive power, suggesting that such a model is limited in predicting a student’s module mark. However, the variable is significant at the 0.05 level, indicating that a student’s diagnostic test score is significant with regards to the student’s module mark. Since the variable has a significance < 0.001, it is almost certain that a student’s attendance is statistically significant.

Finally, Figure 4.8 shows the scatter plot of students’ MLSC usage against their mathematics module mark.

Figure 4.8: Comparison of number of visits made to the MLSC against mathematics module mark.

Figure 4.8 shows the correlation between the two variables and the least squares line of best fit is also visible. It can be seen that there is a small positive correlation (correlation coefficient of 0.122) between a student’s MLSC usage, $x$, and their mathematics module grade, $y$. This model has the equation:

$$y = 0.9216x + 56.367$$

This model predicts that a student who never visits the support centre will achieve one grade boundary (i.e. 9.2%) less than somebody who visits the support centre 10 times (i.e. a ‘regular’ user). Using the data for example, the most regular user in Figure 4.8 visited the MLSC 39 times. The model predicts that this student will achieve 92% in
their mathematics module. In comparison, a student who attended 6 times will achieve a predicted grade of 62% and a student who attended once will achieve a predicted grade of 57%.

However, the model produces an $R^2$ value of 0.0149, which indicates that only 1.5% of the variation in a students' mathematics module mark can be explained by the number of visits they make to the centre. This indicates no relationship between the variables and that such a result suggests that the model is poor and cannot be used to predict a student's grade. However, it should be noted that there is a relatively large number of students who had never used the support centre and it is possible that many of these students did not require mathematics support. Indeed, 26% of the cohort had achieved greater than 70% in their mathematics module and thus it is probable that these students would have passed with or without the availability of mathematics support. Considering students who had visited the MLSC at least once slightly changes the model. However, this relates to a small difference of one or two module marks.

$$y = 0.7855x + 57.516$$

This has an $R^2$ value of 0.0363, which indicates that only 3% of the variation in a student's mathematics module mark can be explained by the number of visits they make to the centre. Although there is a small improvement, the small $R^2$ value indicates that the new model is almost as poor.

However, although the variable is poor in terms of predictive power, it is statistically significant. Since the variable has a significance $< 0.001$, it is almost certain that a student's usage of the MLSC is statistically significant with regards to their module mark. In addition, when attempting to predict mathematics module performance amongst students who are at risk of failing, it is possible that the variable "MLSC usage" will be important. In particular, the variable shows some indication of the extent to which the student is engaged (in terms of educational practices). Moreover, within a multiple regression model it is believed that this variable is necessary in understanding the relationship between a student's performance in mathematics, their engagement with the subject and their engagement with the support available.
From these simple regression models it has emerged that a single variable can be used to explain up to 20% of the variation in how a student performs in a first year mathematics module. Although the three variables considered here have been shown to have limited predictive power within the linear models, all three variables were shown to be statistically significant, indicating that it is almost certain that such factors are significant with regards to a student module mark. However, it should be noted that there are obviously many other factors that could affect a student’s final module grade. Whilst some of these may be quite basic, for example age and gender, others may be more complex and harder to measure, for example motivation or amount of time spent on extra curricular activities. Since it is so difficult to accumulate such data with regards to the latter variables, these will not be considered when constructing a multiple linear regression model. Moreover, with regards to gender and age, these variables were excluded since the sample of students was largely homogeneous, namely male aged between 18-25. Section 4.2 will now produce the results of forming a multiple regression model in an attempt to create a stronger predictive model.

4.2 MULTIPLE LINEAR REGRESSION MODEL

Multiple linear regression models are very similar to simple regression models in the sense that both are used to model a relationship between a dependent variable and an independent variable/variables. However, most real world phenomena are multifactorial in nature, meaning there is more than one factor that impacts on, or causes changes in the dependent variable. In order to predict the dependent variable as accurately as possible, it is usually necessary to include multiple independent variables in the model. Multiple linear regression allows us to test how well we can predict a dependent variable on the basis of multiple independent variables.

For the present study the multiple regression model aims to predict the dependent variable “mathematics module mark” based on the value of three independent variables namely, “diagnostic test mark”, “attendance rate” and “MLSC usage”. Since all three variables were shown to have significance < 0.001, it is almost certain that there is some significant relationship between the variables and a student’s module mark.
It should be noted that data regarding all three variables could not be collated for all 793 students. For example, 146 students had not taken the diagnostic test. In addition, attendance data was not available for the two Physics modules or the Mathematics module. Therefore, the multiple regression model can only be used to predict mathematics performance of Engineering students based on a sample of 455 students.

The data was analysed using the statistical package SPSS. The respective output can be seen in Table 4.7. Considering the module mark, y, with respect to the 3 variables as stated above, the following linear regression model was produced:

\[ y = 0.397x_1 + 0.182x_2 + 0.612x_3 + 17.689 \]

The variables \( x_1, x_2, x_3 \) and their coefficients are those indicated in Table 4.7. The squared multiple correlation (R square) can be directly interpreted in terms of percentage of accountable variation. The model produces an \( R^2 \) value of 0.267, which indicates that 27% of the variance in a student’s mathematics module mark can be accounted for by their diagnostic test mark, attendance and MLSC usage.

In Table 4.7 there are some other standard statistical measures, namely the standard error and the t value. Both of these are associated with perhaps the most important measure, the level of statistical significance. All three variables are regarded as significant at the 0.05 level, which means that we can be 95% certain that the respective variables are statistically significant. Indeed, since both variables \( x_1 \) and \( x_2 \) have a significance < 0.001, we can be almost certain that they are statistically significant.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Significance</th>
<th>Possible Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>17.689</td>
<td>3.200</td>
<td>5.529</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>( x_1 )</td>
<td>0.397</td>
<td>0.039</td>
<td>10.148</td>
<td>0.000</td>
<td>0-100</td>
</tr>
<tr>
<td>Diagnostic Test mark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( x_2 )</td>
<td>0.182</td>
<td>0.024</td>
<td>7.527</td>
<td>0.000</td>
<td>0-100</td>
</tr>
<tr>
<td>Attendance rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( x_3 )</td>
<td>0.612</td>
<td>0.278</td>
<td>2.224</td>
<td>0.027</td>
<td>0-39</td>
</tr>
<tr>
<td>No. of visits to MLSC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.7: Multiple regression model of engineering students' performance in a first year mathematics module.
When considering this model it is important to note the differences between the possible values for each variable and what effect the corresponding coefficient may have on the model. From Table 4.7, it can be seen that each of the three variables can take a range of discrete values. Note that each variable has a different coefficient in the model which will account for the differences in variability. Thus, variable $x_1$ multiplied by its coefficient can have an effect of up to 39.7 ($100 \times 0.397$), variable $x_2$ multiplied by its coefficient can have an effect of up to 18.2 ($100 \times 0.182$) and variable $x_3$ multiplied by its coefficient can have an effect of up to 23.9 ($39 \times 0.612$).

With regards to variable $x_3$, the coefficient value of 0.612 shows that visiting the MLSC is positively related to a student's performance in the mathematics module. However, a small number of visits will have relatively little difference on their overall grade (for example 5 visits could relate to a difference of 3 marks). On the other hand if the student is a 'regular' user of the centre then this could be associated with a notable difference in their final module mark. For example, according to the model, a student who visits the centre 17 times can achieve one whole grade boundary (i.e. 10%) more than a student who never uses the support. This indicates the importance of regular student engagement with mathematics support. This is perhaps more so for students who are at risk of failing since it is possible that they will need to work harder to pass a mathematics module compared a student who is able in mathematics.

Similarly, the variable $x_2$ (Attendance rate) has a positive coefficient value of 0.182. This means that if a student regularly attends their lecture/tutorial sessions then this will be positively related to the student's performance in the mathematics module. According to the model, a student who attended timetabled sessions 100% of the time achieved nearly one whole grade boundary (9%) more than a student who attended 50% of the time. This reiterates the importance of student engagement (considering this as a behavioural component to measure the extent to which a student participates in educational practices) and its relation to a student's performance. If a student is engaged with their course then it is likely that they will achieve higher marks. Thus if a student attends the majority of their timetabled sessions then this indicates that they are well-engaged and, as such, this will relate to a positive performance in mathematics.
There are very many factors that could affect a student's performance, which have not been built into the models (as discussed previously). However, to gather such data would be a difficult and time-consuming task and would not be appropriate for the scope of this thesis. Nonetheless, a multiple regression model of these three variables can be used to explain 27% of the variation. Although this means that the model is limited in predicting a student's performance in mathematics, perhaps more importantly, all variables are deemed as being statistically significant. This indicates that student engagement with mathematics and mathematics support is significant with regards to a student's module grade. However, this analysis has also shown the complexity of student engagement and its relation to a student's performance.

5. SUMMARY AND DISCUSSION

In this chapter quantitative data regarding the usage of the Mathematics Learning Support Centre (MLSC) at Loughborough University has been analysed to partly evaluate the success and effectiveness of the support mechanism and to examine the issue of student engagement and how this relates to a student's performance in mathematics. In particular, data relating to three areas (Baseline Information, Output Measures and Process Measures) have been analysed at this stage of the study.

The usage statistics show that the MLSC is an important support mechanism since the centre receives a steady flow of visits throughout the year. Indeed, 4617 visits were recorded in the academic year 2006-7. However, the average number of visits made by students has decreased over time, indicating that students are failing to make repeated visits to the centre over an extended period of time. Indeed, nearly half (45%) of all users of the MLSC in 2006-7 had only visited the centre once. This indicates that the support is not being used effectively since it is likely that regular support is needed to be of sufficient benefit to a student.

Whilst STEM students account for the majority (83%) of visits made to the MLSC, there has been a steady decrease in the number of visits made by STEM students. 4429 visits were made by STEM students in 2004-5 compared to 3827 in 2006-7. There has also been a decrease in the average number of visits made by STEM students. On average, STEM students made nearly one whole visit (0.8) less in 2006-7
compared to 2004-5. It is possible that these students do not require the same level of mathematics help as was needed in previous years or that students are sufficiently helped in just one or two visits and do not require any further help. However, performance data does not support this.

Indeed, 86% of first year STEM students who had failed a mathematics module had never used the MLSC. Clearly such students were in need of mathematics support but for unknown reasons these students failed to engage with it. In addition, students who regularly engaged with mathematics support via the MLSC were generally high achieving students, with only one regular user having failed a mathematics module. Clearly the MLSC is being used by high achieving students looking for success rather than students looking to avoid failure. However, it is likely that the students who are regularly engaging with the support are students who are generally motivated and engaged and would seek support regardless of the MLSC.

Due to the nature of the support via the MLSC, student engagement is crucial to its success. Hence, if students fail to engage with the support then they cannot benefit from it. The issue of student engagement with mathematics support and its effect upon a student’s performance was investigated further by constructing simple linear regression models and a multiple linear regression model. Three variables were considered, namely ‘Diagnostic Test Mark’ ‘Attendance Rate’ and ‘MLSC usage’, where the latter two variables were used as measurements of student engagement (in terms of a behavioural component to depict the extent to which students participate in educational practices). It emerged that individual simple linear regression models could be used to explain 27% of the variation of a student’s mathematics module mark. When considering combined lecture/tutorial attendance it emerged that the variable ‘Attendance Rate’ was the strongest predictor and could be used to explain 20% of the variation in a student mark. The model involving this variable indicates that a student who is engaged with their mathematics module (in terms of attendance) will perform significantly better than a student who is not engaged. However, the model involving the variable ‘MLSC usage’ produced a small $R^2$ value (0.03) suggesting that such a model is poor.
To determine the importance of the three variables and their relationship in a multifactorial model, a multiple linear regression model was constructed. This produced an R² value of 0.27 indicating that 27% of the variation of a student’s mathematics module mark can be explained using this model. This means that the model is limited in predicting a student’s module mark; however, since all three variables emerged as being statistically significant this indicates the importance of the relationship between a student’s module mark and their engagement. The multiple regression model shows that there is a significant relationship between student engagement (in terms of engaging with educational practices, measured by attendance and MLSC usage) and a student’s mathematics module mark. Therefore, it is likely that if a student is generally engaged with their academic work at university, i.e. attending the majority of their timetabled sessions and using mathematics support on a regular basis, then they will perform significantly better in a mathematics module than somebody who is not engaged.

However, the data indicates that students who are not engaging with their studies or with mathematics support are students who are failing the mathematical component of their degree. The statistics alone do not indicate the reasons why such students are not accessing the support, and moreover, what motivates students who are engaged and who regularly use mathematics support. Consequently, the next chapter will give details of a qualitative research approach. The connection between student engagement, student motivation and mathematics support will be examined further by analysing students’ attitudes, beliefs and feelings regarding mathematics and mathematics support at university. In particular, Chapter 5 will analyse interview data to examine the reasons why students failed to engage with the reactive support mechanism.
CHAPTER 5 – UNDERSTANDING WHY STUDENTS FAIL TO ENGAGE WITH MATHEMATICS SUPPORT

1. INTRODUCTION

In Chapter 4 it was discovered that some students are failing to engage with the mathematics support provided by Loughborough University’s Mathematics Learning Support Centre (MLSC). In particular, first year students who have failed a mathematics module are less likely to obtain regular mathematics support in comparison with other first year students. The present chapter investigates the reasons why students fail to engage with mathematics support, particularly students who have failed a mathematics module during their first year at university. This has been achieved by using a qualitative methodology. Data were collected and analysed from questionnaires and interviews with non-users of the MLSC and regular users of the MLSC.

The first section of this chapter will investigate the views of non-users of the MLSC. This has entailed the running of a number of focus groups and interviews with various students across the University campus. This section will give details of the study itself, including the methodology used, the participants and the analysis process. Data from the focus group and interviews will then be analysed and the results of these will be discussed in detail accompanied by illustrative quotes. In particular, the section will describe the perceived barriers that have prevented students from engaging with this method of support.

The following section will investigate the views of regular users of the MLSC to give an insight into how non-users may be encouraged to engage with the mathematics support. It will give details of the methodology used, namely semi-structured interviews, as well as details of the participants. An examination of the data will be carried out in two stages. The first stage will discuss the barriers (as described by the non-users) that prevent students from engaging with the support from the perspective of students who have regularly used the MLSC. In particular, it will examine whether
such barriers had originally been an issue with the regular users and, if so, how they had overcome them. The second stage will investigate how regular users engage with the support and will examine the way in which the students used the MLSC to support their learning of mathematics. It will also consider the extent to which the students themselves felt they were motivated and engaged with mathematics and their university courses and how this may have influenced their engagement with mathematics support.

The final section, will discuss possible action that may be taken to improve student engagement with mathematics support and the issue of how student motivation may affect such action. In particular, findings from the research regarding both the users and non-users of the support will be discussed to understand why some students fail to engage with MLSC.

2. NON-USERS OF MATHEMATICS SUPPORT

This section will present results from focus groups and interviews conducted with students who have failed to engage with mathematics support. It will first provide details of the study, including details of the methodology used and a description of the participants. It will then discuss a number of barriers, as described by the students, that may contribute to a lack of engagement with mathematics support.

2.1 METHODOLOGY – PHASE 1

In Chapter 4, analysis of MLSC usage data from 2005/6 revealed that over 90% of Engineering and Physics students who had failed a first year mathematics module, had either never or very rarely used the MLSC. Therefore, all students who had completed their first year Engineering course (Electronic and Electrical Engineering, Civil Engineering, Aeronautical and Automotive Engineering and Mechanical Engineering) or Physics course and who had failed a mathematics module and who had rarely or never used the MLSC were initially targeted for participation in a focus group session. This accounted for a total of 87 Engineering and Physics students. However, since 28 students had withdrawn from their course at the end of the first year, a total of 59 students were contacted in the first semester of 2006/7. These students were contacted
on two separate occasions, via e-mail, to take part in a focus group session in November 2006. An incentive of £10 was offered for attending the session. Three students volunteered; two Engineering students and one Physics student.

A second focus group was arranged for February 2007 by targeting current first year students (academic year 2006/7) who had failed a first semester mathematics module and who had rarely or never used the centre. These students were registered for a course in Civil Engineering, Aeronautical and Automotive Engineering, Physics or a Science and Engineering Foundation year. By including Foundation students, 120 failed students were targeted and the same method as above was used to recruit students. Likewise, an incentive of £10 was offered to all students as compensation for their time. Two students attended the session, both of whom had taken the Science and Engineering Foundation year. Since it is recommended that a focus group should comprise of more than two participants in order to ensure a continuous and stimulated discussion, Vaughn et al (1996), the students were interviewed in a group setting. Finally, two first year Physics students agreed to be interviewed individually. The details of the participants of the study are summarised in Table 5.1.

It was originally anticipated that two focus group sessions would be conducted each with groups of four to five students. However, due to a lack of response, one focus group was conducted, one group interview and two individual interviews were conducted. This apparent lack of willingness to share the student perspective may indicate that the students who had failed the mathematics module, in particular students with a 'hard' fail (<30%), were not comfortable in discussing their thoughts about mathematics or their ability in this subject. Their unease also may have been exacerbated by the thought of discussing their feelings within a focus group setting, despite all students being of similar ability.

In the focus group session a number of questions were put to the participants, which they discussed in a group setting (see Appendix H for details). Students were able to react to statements made by other students to ensure a stimulated discussion, Vaughn et al (1996). The session lasted for approximately one hour.
<table>
<thead>
<tr>
<th>Student</th>
<th>Year</th>
<th>Course</th>
<th>Maths module mark %*</th>
<th>Number of visits to the MLSC</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>Physics</td>
<td>33%</td>
<td>3</td>
<td>Focus Group</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>Electrical and Electronic Engineering</td>
<td>34%</td>
<td>2</td>
<td>Focus Group</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>Electrical and Electronic Engineering</td>
<td>33%</td>
<td>0</td>
<td>Focus Group</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>Science and Engineering Foundation</td>
<td>20%</td>
<td>0</td>
<td>Group Interview</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>Science and Engineering Foundation</td>
<td>32%</td>
<td>1</td>
<td>Group Interview</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>Physics</td>
<td>33%</td>
<td>0</td>
<td>Interview</td>
</tr>
<tr>
<td>G</td>
<td>1</td>
<td>Physics</td>
<td>35%</td>
<td>0</td>
<td>Interview</td>
</tr>
</tbody>
</table>

* Marks below 40% are deemed as a fail and marks below 30% are deemed as a 'hard' fail.

Table 5.1: Non-user student profiles

The interview sessions were semi-structured using the same questions used in the focus group session. This method allowed for a more detailed probing of the students' responses. The group interview lasted for 40 minutes. Although it is possible that the responses made by the two students could have prompted answers from each other, there was no discussion between the two participants. The interviewer posed several questions that were answered separately by each participant. The individual interviews lasted for approximately 20 minutes each and were conducted in a similar manner to the group interview. However, the two students' responses were not prompted by other participants. All sessions were led by the researcher and the discussions were recorded using a digital voice recorder.

The recordings of these sessions were transcribed by the researcher. The transcripts were read in detail to identify common themes and these were then categorised using Atlas Ti software (www.atlasti.com). This method involves highlighting key quotes from the text and assigning a 'code' that encapsulates the meaning of the quote (see Appendix I for further details). The codes are then structured into hierarchal networks within the themes to create a picture of the individual quotes.
2.2 Methodology – Phase 2

Since the method of recruiting participants for additional focus group sessions and/or interviews had limited success, it was decided that a different method would be implemented in order to obtain more data. This involved the researcher approaching various students around the university campus and conducting “on the spot” interviews. The questions asked by the researcher were similar to those that were used for the focus groups and interviews (see Appendix J for details). The responses were recorded in writing by the researcher, since this allowed the students to give short precise answers that could be quickly recorded. This also allowed the researcher to probe any interesting comments made by the student.

However, this recruiting method meant that the participants would not necessarily be first year students nor would they have failed a mathematics module. Since the students could have widely varying backgrounds, the researcher also asked for specific details about the student, such as their course, year of study and their ID number (see Appendix J for details of the questionnaire) so that students could be easily categorised.

Students were recruited on three separate occasions. In the first instance, the researcher approached 30 students in the campus library during Week 12 of Semester 2 (2006/7), at which time students were revising for their end of year exams. Since it was anticipated that a specific sample of students would be using the library during this particular revision week (i.e. those who had a forthcoming exam), the researcher visited the library on a second occasion during Week 13 of Semester 2 and approached 33 different students. On the final occasion, during Week 15 of Semester 2, the researcher went to the Student’s Union and the student canteen to approach an additional sample of 22 students. Since the total sample of 85 students were approached on the three occasions, it is anticipated that their responses represent the views of students who were engaged with the mathematics on their course and also the views of students who may not have been engaged with the mathematics on their course. In addition, analysis of these responses revealed that the data had reached a saturation point, whereby the responses were becoming repetitive and contained no new ideas.
It should be noted that since the students were offering to participate in the research during the revision period, a small incentive of a chocolate bar was offered to each student as compensation for their time.

As discussed previously, due to the nature of the method of data collection, the students came from widely varying backgrounds, and not all students met the original requirements (students who had failed a first semester mathematics module \textit{and} who had rarely or never used the centre). However, since students had provided their Student ID numbers, this information was used to establish how often students had used the MLSC and whether or not they had failed a mathematics module. Therefore, of the 85 students who were questioned, 10 met the original requirements (and so were part of the 207 targeted students). Of the remaining 75 students, 60 had never or rarely used the centre but had passed their mathematics module, two had used the centre but failed their mathematics module and 13 had used the centre and passed their mathematics module. Since this section is concerned with examining reasons for a lack of engagement with mathematics support, the responses given by the 10 students who had failed and never used the MLSC and the 60 students who had passed but never used the MLSC are analysed.

Figure 5.1 shows the breakdown of the students in relation to their current year of study. The majority (55\%) of students were in their second year, 21\% were first year students, 14\% were third year students, 4\% were fourth year students and 6\% were postgraduate students. Although the study originally intended to target current second year students, all students were asked to reflect upon their experience of using the centre, or otherwise, during their first year. In addition, the 15 students who had used the MLSC were invited to give additional comments with regards to mathematics support throughout their time at university.
The first phase of this research had focussed on the opinions of students from Engineering and Physics courses since originally it was only possible to obtain mathematics module results for these students. However, since the MLSC supports all students across the university it was felt that the study should be extended to include students from all departments to gain a broader insight into the differing student perspectives. Consequently, the participants in this phase of the study represent all three faculties across the university. Figure 5.2 gives a break down of the students in relation to each faculty and department.

Figure 5.1: Distribution of students in relation to their year of study.

Figure 5.2: Distribution of students in relation to the faculties/departments across the university.
It can be seen that the Faculty of Engineering represent the largest group of students (48%), closely followed by the Faculty of Social Sciences and Humanities (41%). Only 11% of students were from the Faculty of Science. Recall that in the first phase of this research, the opinions of students from just three courses, Electrical and Electronic Engineering, Physics and Science and Engineering Foundation studies, were investigated. However, since a wider spread of courses were represented in the second stage of this study it is anticipated that this will give a fairer representation of the students’ views.

The second phase of this research proved successful in targeting additional students from the Engineering Faculty, who did not respond to the first phase of this research. Furthermore, a sample of students from non-science degrees also participated in the second phase of this research. It was felt that this was particularly important, since students from the Faculty of Social Sciences and Humanities do not use the MLSC as frequently as students from the Faculty of Engineering and the Faculty of Sciences. Therefore, it is essential to understand why these students in particular fail to access the support.

2.3 A NOTE ABOUT SAMPLING

It is recognised that to ensure that the views of the non-users and regular users of the MLSC were fairly represented, a substantial sample of students would be needed for data collection. However, determining an ‘adequate’ sample size for qualitative data is not so straightforward as merely using statistical calculations. Indeed, to be 100% certain that the views of the population are expressed, ultimately the researcher would need to consider the whole population. The use of confidence intervals can, however, reduce the sample size. For example, let us take the case of the population of non-users. In 2005/6 and 2006/7 there were 196 non-users of the MLSC (who had also failed a mathematics module). Using the formula for sample size of a finite population (Cochran (1963) pp 74-75) a sample of 193 students would be required in order to be 95% confident that the views of the entire population were fairly represented (see Appendix K for further details). However, in practice this would be extremely time consuming in terms of collecting and analysing the data. Therefore, it is common practice within qualitative research to use judgement based on prior experience to
determine the sample size and evaluate the quality of the information collected (Sandelowski, 1995). Indeed, in terms of phenomenology (into which paradigm this research can be loosely translated since we are interpreting respondents' statements to describe a 'phenomenon') Van Kaam (1959) cited in Sanelowski (1995) states that a study should require "...10 to 50 descriptions of a target experience in order to discern its necessary and sufficient constituent". Therefore, when obtaining a sample of users and non-users for data collection, the researcher has sought as many participants as possible. This has involved recruiting students on several occasions and by different methods, as described above and in Section 3.1. Moreover, to enhance validity of the results the researcher has ensured that the sample of students represent the population in terms of their demographic (i.e. gender, year of study, course) and that data has reached a saturation point, whereby no new information was being elicited from the participants.

2.4 RESULTS

Analysis of the interview and focus group data reveals that a number of factors may have contributed to the lack of uptake of mathematics support by failing students. These reasons are summarised in Table 5.2 below. Note that in terms of the responses from the focus group and interviews, the students gave more than one reason to explain why they had not used the available mathematics support. Since these sessions lasted considerably longer than the 'on the spot' interviews, the students had more time to discuss and think about such reasons, hence this may account for attributing multiple reasons.

It can be seen that some of the barriers preventing students from using the centre are relatively 'simple', for example a lack of awareness of the location of the MLSC. However, there also appear to be more complicated issues that act as a barrier. A more detailed discussion of these reasons will now follow. This is accompanied by illustrative quotes made by only the seven students from the first phase of the research, since audio transcriptions were not taken during the 'on the spot' interviews.
<table>
<thead>
<tr>
<th>Reason</th>
<th>Focus Group / Interviews</th>
<th>Total number of responses (77)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of awareness of the location of the MLSC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of awareness of the facilities available in the MLSC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of awareness of the need of mathematics support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too many problems that need addressing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear of embarrassment / intimidation / demoralisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics support perceived as not appropriate for non-STEM students</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2: Reasons given for non-use of the MLSC

2.4.1 LACK OF AWARENESS OF THE MLSC’S LOCATION AND FACILITIES

In the first week of term, lecturers teaching first year mathematics modules are encouraged to promote the extensive support available via the MLSC. In the past this has proven to be the most successful mode of advertising since results from MLSC feedback questionnaires from 2005/6 indicates that 66% of students had heard about the MLSC from their lecturer. Leaflets and posters are also distributed amongst the various departments at the university and the MLSC website advertises support provision.

Nevertheless, as can be seen from Table 5.2, 27 out of 77 students interviewed felt that their lack of awareness of the location of the centre was a significant barrier that had prevented them from using the support.

Although advertising helps to promote an awareness of the MLSC, it is the lack of knowledge of the location of this support that is preventing some students from accessing its services. From the focus group and interviews, out of the seven students who had never used the centre (and failed), four were unaware of its location:
Student D: “I wasn’t aware of where it was...I did ask a few people in my year and they were like ‘Oh, I’m not really sure’. Like because I don’t really think a lot of people come.”

Student F: “I’ve not really known where it was...I knew it was in the Schofield building somewhere but wasn’t sure.”

In particular, Student D had tried to seek out the MLSC by asking her peers, however, they too were unaware of its location. This suggests that a lack of awareness of the MLSC’s location is a common problem. Encouragingly, all students were aware of the existence of the MLSC but not of its location.

Students who were aware of the MLSC revealed that the details of the centre and its support were easily forgotten. This is primarily due to the time period when the MLSC is first advertised to students, as illustrated by these quotes:

Student C: “At the start of the year there’s so much stuff going on, you don’t think of it as somewhere as ‘aahhh’.”

Student E: “Because it’s the first semester you wasn’t really aware of the help as well and where things are and stuff.”

Student B: “I completely forgot about it after the first time I’d heard about it.”

Since the MLSC is located within the Department of Mathematical Sciences and also at a second location within the Social Sciences departments, students from other departments across the university may not be familiar with its location. Therefore, advertising such information is crucial in promoting the support and encouraging students to use it.

In addition, a notable proportion of those students questioned expressed that they had not used the centre because they lacked an awareness of what support facilities were available (21 in total). This was predominantly commented upon by participants of the “on the spot” interviews (17 out of 21). The responses given suggest that although students are conscious of a place where they can obtain support with mathematics or statistics, many are not aware of the services available or whether they are relevant to their individual needs. For example, there was a misconception that students must first make an appointment for one-to-one help before coming to the MLSC. Students were also unaware of the additional resources available in the MLSC, such as the paper-
based resources, online-resources and student working areas. It appears that, for some students, a fear of the unknown has prevented them from accessing the support.

2.4.2 Lack of Awareness of the Need of Mathematics Support

Although some barriers preventing student engagement with the MLSC are relatively simple, others are more complex. It appears that many students are failing to either monitor or direct their own learning and, consequently, students are unaware that support is needed. This was commented upon by 8 out of the 17 students who had failed, which suggests that students are not aware that they may be 'at risk' of failing the mathematical component of their degree. This was also commented upon by 10 out of the 60 students who had passed the mathematical component of their degree. Although these students were successful, in terms of their mathematics module, they commented that they had only started 'learning' the mathematical material during the revision period. Consequently, the students felt that they could have achieved a much higher grade if they had applied more effort throughout the year.

From the focus group and interview data it appears that students are not aware of their problems because of two main factors. The first is a lack of motivation by the students. In particular, some students are failing to attend their lecture/tutorial sessions and, furthermore, they do not complete the set work in their own time.

Student A: "I would say I didn’t really come here [the MLSC] because I didn’t really do the problem sheets, so I didn’t know I had problems."

Student B: "I didn’t use it [the MLSC] because I didn’t think I needed it...If you don’t revise all that often then you have nothing to ask, you don’t really know if you need it or not."

A second factor is that students are failing to manage their time effectively in order to cope with the demands and workload of their courses. For some students, mathematics is perceived as a lower priority than the other modules on their courses.

Student D: "When you start getting coursework in the other modules it’s easier to push the maths away. The time just goes so quick as well, and then you move onto the next topic and it’s even harder."
However, some students did attend lecture and tutorial sessions but they were unaware of their problems until they had received their examination results (recall that all students interviewed had failed a mathematics module). For example:

Student E: “I felt like I was getting sufficient help in the tutorials...that’s why I didn’t use the support centre to be honest. I didn’t know better at the time.”

When asked if he had used the centre:

Student G: “No not really because there’s been nothing that’s been too over my head where I’m thinking ‘oh I really need help on this.’”

It appears that many students are failing to adapt to university and consequently they are failing to recognise their need for mathematics support. Without help some students struggle to keep up with the mathematical demands of their course and a lack of engagement may result from this. By the time students are aware of a problem, usually when students begin to revise for their exam or after they have received their exam results, many believe it is too late to obtain support.

2.4.3 Too many problems that need addressing

Since some students are failing to monitor and direct their own learning, they consequently become overwhelmed by the amount of module material. From the data, two students in particular felt that they had failed to grasp basic mathematical concepts and as a result the number of problems and their general lack of mathematical understanding increased. Consequently, they felt that they had too many problems to address, which could not be solved in one visit to the MLSC.

Student D: “I think it was more just I’d come and have so many questions because it was more than one thing I had a problem with. So I didn’t really fancy camping out here [the MLSC].”

The above comments suggest that the students perceive the MLSC as a ‘quick fix’ to help with problems. This student felt overwhelmed by the amount of help he needed and did not perceive the MLSC as a place where this level of support could be obtained.
2.4.4 EMBARRASSMENT, INTIMIDATION AND DEMORALISATION

An additional barrier that prevented 20 of the students from using the MLSC was feelings of embarrassment or intimidation. In particular, this was a significant barrier in preventing the failing students from accessing the support, since 10 out of the 17 failed students attributed this factor to their lack of attendance. A feeling resonating throughout the participants of this study was their uneasiness about engaging with the support via the MLSC. Two students associated this with feelings of embarrassment:

Student D: “I think probably just the embarrassment, because I feel like I’m that bad at maths.”

Student E: “It’s just in your mind you don’t want to ask, you still feel quite embarrassed.”

These comments suggest that some students feel that their mathematics knowledge is inadequate and, consequently, they feel ashamed to ask for help. Other students felt intimidated to ask the support staff for help.

Student A: “I sometimes feel intimidated by some of the lecturers so I wouldn’t ask them for help.”

Student C: “I still sort of feel intimidated to come down here [the MLSC] on my own.”

Student D: “I think coming here to like a support centre at a university, it’s a bit daunting.”

The comments above suggest that these students are scared to access the support, possibly due to the way in which they perceive the support staff. Finally, there was also a consensus that if students did come and ask for help then they would feel demoralised by the staff.

Student A: “The lecturers are just so far and away cleverer than us that I feel a bit small asking them something that is so incredibly easy for them.”

Student B: “I did come in and ask for help and she was going through it [a problem] with me and asking me questions ‘What do you do after this?’ But I didn’t know so I just felt like proper dumb.”

These comments suggest that students feel uncomfortable in asking for help from the lecturers on duty in the MLSC. It appears that students perceive the lecturers to be
considerably more intelligent than themselves, and as a result they feel that their problems are minor or unworthy or that they will end up feeling ‘stupid’. From the discussions with the students, it appears that support staff are regarded as ‘strangers’ since the lecturers in the MLSC are recruited form the School of Mathematics, as opposed to Engineering or other Science departments. Consequently, non-mathematics students may feel out of place when coming to the MLSC.

2.4.5 PERCEIVED TO BE NOT APPROPRIATE FOR NON-STEM STUDENTS

Data from the survey interviews revealed that students from non-STEM backgrounds do not perceive the MLSC as a place where they can obtain support. In particular, 8 students expressed such opinions. Specifically, three students were taking a Management degree, three students were taking a Psychology degree and two students were taking a Geography degree. On these courses, students will study at least one statistics module. However, these students indicated that they perceived the MLSC as a place for students who study ‘real maths’. They did not feel that they could approach the MLSC with problems that occur with the statistics that is covered on their courses.

However, this is not the case, since the MLSC provides support for any students across the university. Indeed, at the time of this research, the MLSC recently extended its statistics support facilities specifically to help support students studying such degree courses. Moreover, the central campus location of the MLSC is positioned in close proximity to the Social Sciences department, Human Science department and Business School and is aimed at supporting these particular students. However, it appears that the MLSC is still sometimes perceived to be a support mechanism for Engineering and Science students.

2.5 SUMMARY

Analysis of the data has revealed that the lack of uptake of support by failing students cannot be pinpointed to one direct cause. Instead there are a number of factors that discourage students from accessing support via the MLSC, and in many cases students relate their lack of usage to more than one of these factors. Consequently, students who were aware of their weaknesses would seek other methods of support, namely, their peers and/or their lecturers.
Student A: “I’d probably go and ask one of the post grads because I feel I can go talk to them better than a lecturer.”

Students, perhaps understandably, considered their friends to be more approachable and easier to talk to than a lecturer or staff member. In addition, students felt that friends could easily relate to and empathise with individual problems of the student, since they were taking the same course and may have experienced similar problems. Conversely, students who favoured seeking support from their own lecturers preferred to do so because the staff member was familiar to them. It was also indicated that a course lecturer could provide more specific help relevant to their degree programme since they are responsible for setting the assessment for the mathematics or statistics module. Unfortunately these alternative support mechanisms were not effective for all students since 17 had failed a mathematics module.

It appears that for some students their lack of engagement with mathematics support can be attributed to ‘simple’ barriers, such as a lack of awareness of the MLSC’s location or facilities. However, some of the barriers are much more complex. In particular, some students are failing to monitor and direct their own learning and consequently they are unaware of any mathematical difficulties.

Whilst there is no suggestion that the students answered the questions untruthfully, it may be that they have not analysed their own actions on a deep level. Students may have been unaware of the location of the MLSC but they did not take many steps to find it. Likewise students who were unaware of the nature of the support services available were not proactive in seeking to discover this information. It may be thought that if students were aware that the MLSC existed and also were aware that they had difficulties with mathematics and were in danger of failing their mathematics module then they would have taken steps to find out where the MSLC is located and whether or not it could help them. This analysis suggests that some of the reasons expressed by the students were only symptoms rather than the root cause.

To understand how some of the barriers discussed in this section might be overcome, and moreover, to understand the types of students who regularly engage with mathematics support, regular users of the centre were also interviewed. A discussion of their responses will be given in the next section.
3. REGULAR USERS OF MATHEMATICS SUPPORT

This section will discuss the outcome of a number of interviews conducted with regular users of the mathematics support provided by the MLSC. It will first provide details of the study, including details of the methodology used and a description of the participants. It will then discuss the barriers that prevent students engaging with the support, as described in Section 2, from the perspective of students who had regularly used the Centre. It will also examine how such students engaged with the support and how this contributes to their learning of mathematics to build a ‘student profile’ of typical regular users.

3.1 METHODOLOGY

For this stage of the research, STEM and non-STEM students were targeted who had used the MLSC ten or more times in 2006/7, and hence were classified as ‘regular’ users (see Chapter 4 for further details). 105 students met these requirements, although 27 of these students were no longer studying at Loughborough University. The remaining 78 students were contacted via e-mail, on two separate occasions, in November 2007 (Semester 1 of the academic year 2007/8). It should be noted that a small incentive of cakes and soft drinks was used to encourage participation. Nine students responded and were subsequently interviewed.

To ensure that the views of the regular users were fairly represented, further participants were recruited by approaching students in the MLSC on several occasions. Students were again offered an incentive of refreshments to take part in an informal interview to discuss their experiences of using the support. Recruiting additional participants in this manner ensured that such students were familiar with the support facilities since they were actively engaging with the support at that time. However, since participants were recruited ‘on the spot’, not all students met the initial requirements, namely that they had used the support ten times or more in the academic year 2006/7. A further eight participants were recruited in this manner (in November 2007) although only four met the initial requirements.

The original population of 78 students were e-mailed for a third time in February 2008 (Semester 2, after the Semester 1 examination period). On this occasion an incentive
of a 1GB USB stick was offered for participation in order to attract more students. An additional two students were recruited from the second e-mailing process. Finally, additional participants were again recruited ‘on the spot’ by approaching students using the MLSC on several more occasions by offering the incentive of a 1GB USB stick. A further 10 participants were recruited in this manner, although none of these students met the initial requirements.

It should be noted that of the 14 students who did not meet the initial requirements, seven were current first year undergraduates and were later identified as regular users of the MLSC in the academic year of 2007/8. The remaining seven students (who were not current first years) were also identified as regular users in 2007/8 or in 2005/6. To summarise, 29 students were interviewed regarding their experience of using the MLSC. All students were identified as regular users of the support. However, only 15 of these students met the initial requirements (a regular user during the academic year of 2006/7). The remaining 14 students were identified as regular users of the support in 2005/6 or 2007/8.

Each participant was interviewed using a semi-structured method incorporating an interview guide (which can be found in Appendix D). In particular, students were asked specifically if the barriers, as outlined in Section 2, had influenced their usage. These results will be discussed in Section 3.2. In addition, the interview participants were asked further questions in relation to their experience of using the MLSC and their general attitudes towards using mathematics support. The aim of these questions was to provide a better understanding of the type of students who regularly engage with the support and how this support is used. These results will be discussed in Section 3.3 in order to build a ‘student profile’ of typical regular users. It should be noted that each interview lasted for approximately 20-30 minutes resulting in a rich data set. All sessions were led by the researcher, and the discussions were recorded using a digital voice recorder. Owing to the large amount of data generated from the interviews and time limitations, the researcher elected to take a selective transcription approach, as suggested by Creswell (2002). This method involved using written notes as a guide and subsequently picking out relevant passages that held importance from the audio data. The results of the subsequent analysis will now be discussed.
3.2 RESULTS - OVERCOMING INITIAL BARRIERS

The analysis of data in Section 2 revealed a number of barriers that may explain the lack of engagement with mathematics support by failing students. However, in some respects these barriers can be perceived as fairly superficial. For example, if a student needs medical support then they would actively seek out that help, even if they did not initially know where it was located. It may be suggested that reasons given by the students, such as being unaware of the location, actually mask much deeper explanations. Therefore, qualitative data from interviews with regular users will now be examined to explore this issue further. A summary of their responses is given in Table 5.3, which may be compared with the responses given by non-users in Table 2. Generally, the table shows that the barriers suggested by non-users of the support had initially prevented some of the regular users from accessing the support. However, these proportions are comparatively smaller (with the exception of the second barrier) and, moreover, these barriers were overcome by such students.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Number of responses (out of 29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of awareness of the location of the MLSC</td>
<td>5</td>
</tr>
<tr>
<td>Lack of awareness of the facilities available in the MLSC</td>
<td>17</td>
</tr>
<tr>
<td>Lack of awareness of the need of mathematics support</td>
<td>7</td>
</tr>
<tr>
<td>Too many problems that need addressing</td>
<td>2</td>
</tr>
<tr>
<td>Fear of embarrassment / intimidation / demoralisation</td>
<td>5</td>
</tr>
<tr>
<td>Mathematics support perceived as not appropriate for non-STEM* students</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 5.3: Responses given by regular users of the MLSC

A more detailed discussion of the regular users’ perceptions will now be given by taking each barrier in turn.

3.2.1 LACK OF AWARENESS OF THE MLSC’S LOCATION AND FACILITIES

Very few of the regular users (5 out of 29) felt that a lack of awareness of the MSLC had prevented them from using the centre. For the remaining 24 students, this was not
an issue since they had already known where it was before they needed to use it. Those from the Mathematics and Physics departments indicated that they were aware of the MLSC’s location because the centre is within their department building and so they pass it on a day-to-day basis when attending their lecture/tutorial sessions. Others were aware of its location due to the rigorous advertising of the centre, particularly during the first week of term when the students are introduced to the facilities on campus which may be helpful to their degree.

The five students who felt that they did have to overcome this barrier said that they had actively sought out the MLSC’s location - they took the initiative to find the centre. These students regarded themselves as generally motivated individuals and so when they felt the need for mathematics support, they went out to find the centre.

Student H: “I made a point of going to find out where it was... motivation to get to know what support there was and because I like to have constructive areas for working in. I needed to go and see what there was... Not knowing didn’t put me off in anyway.”

In terms of awareness of the MLSC’s facilities and resources, 17 students agreed they had not known such details about the centre before they had used it. However, these students felt that this was not a barrier, since they were aware that some type of support in mathematics was available and this information was enough to motivate them to investigate the centre.

3.2.2 Lack of Awareness of the Need for Help

The 29 regular users of the centre were asked if they were ever unaware of their need for mathematics support, which may have prevented them from using the centre at some point. Only seven of the students felt this had been a barrier. The responses from the remaining 22 students indicated that these individuals were academically engaged and motivated, since they had attended their lectures/tutorials regularly and had frequently completed problem sheets. This suggests that, unlike some of the non-users of the centre, these students were monitoring and directing their own learning and were aware of the need for help. In addition, five of the students said that since they had felt weak in mathematics during their prior education, they were aware that they
would need support at university and had therefore intended to use the MLSC from the outset.

Student I: “I knew I had to get the help, so I knew from then on...I had a maths club at school as well, which was two nights a week where you could come with questions you were stuck on...so if there was the opportunity for something similar here [at university] I was going to use it.”

Student J: “I really needed help with maths so it was something I had to motivate myself to come and do to begin with.”

3.2.3 Too many problems

For most regular users the issue of having too many problems was not a barrier since they had kept on top of their work and had sought any help immediately. There were two students who had at times felt that the amount of problems they were encountering was overwhelming. However, this had not prevented them from seeking the support that they had required.

Student K: “I had lots of questions, I had to tone it down a bit like I had to take little bits at a time and didn’t say ‘look I don’t get any of this, can you help me with all of it’ because I thought that was a bit unfair...but the way I am with my maths if I can’t see an answer I’ll go to the support centre anyway.”

Unlike the non-users, regular users who did have numerous problems were motivated to seek out help from the MLSC as they felt that without it they would undoubtedly fail. These students indicated that once they had made their first visit they had felt welcomed to come back with their problems, despite being behind in their work.

3.2.4 Embarrassment, intimidation and demoralisation

Only five students felt that they had had to overcome feelings of embarrassment before using the centre. They had initially felt intimidated to ask for support but their need for help and the advantages of receiving the support outweighed their misgivings. In particular, such students felt that the pressure of the amount of work and the fear of failure were more important to them than feeling embarrassed. Indeed, two of the students also indicated that the encouragement of a friend helped them to overcome such feelings.
Student L: “I was a little bit embarrassed but I know inside me it’s silly and that if I need to know the answer then I need to go and ask...I just told myself I had to go and do it.”

Student M: “Whenever I’ve come down there’s always been a few of us so it’s never been embarrassing.”

The remaining 24 students said that they did not mind asking for help for a number of reasons. Some students were familiar in asking and receiving extra support from their experience prior to university. Others indicated that they preferred to ask for help from a tutor in the centre. For some students this was because they felt the MLSC was a safe place where all students had mathematics problems. Hence, they had felt reassured to ask for help. For other students, they perceived the MLSC staff as more friendly and approachable than their own lecturers.

Student N: “I think it’s easier that the fact that none of the lectures who are here [the MLSC] aren’t my lecturers. Sometimes with the lecturers from my modules, when I get stuck with something, I feel a bit daft going and asking them for help because it’s such a simple thing or something we’re supposed to know.”

Student O: “I find it easier to come here than to ask a question in a lecture. Because I know that everybody in here is here because they generally need help, so I’m not really bothered anymore.”

3.2.5 PERCEIVED TO BE NOT APPROPRIATE FOR NON-STEM STUDENTS

Of the 29 students interviewed, only four were from non-STEM departments. Of these four, three students indicated that initially they had felt that the MLSC was not for them because of their discipline. These students overcame this barrier largely due to encouragement from MLSC staff and friends. In particular, all three students said that a tutor from the centre had advertised the MLSC during one of their lecture slots, encouraging students from their department to use the support. It was also indicated by the students that they had felt it was easier to come to the centre with a group of friends, since they provided moral support.

Student M: “When we did that maths [diagnostic] test we were told [by a staff member] that everybody was welcome regardless of how minor or significant the problem was... We come together, like today four or five of us decided to meet up and come and do some work.”
Analyses of the responses given by the regular users of the MLSC indicate that such students are generally more motivated and engaged. Hence, their motivation to receive help outweighs any of the barriers that may prevent them from using it. To investigate this further, the next section will examine how students engage with the MLSC to build a ‘student profile’ of the typical students who regularly use the support.

3.3 RESULTS - STUDENT PROFILE OF REGULAR USERS

3.3.1 MOTIVATION TO MAKE THE INITIAL VISIT

From the analysis conducted in Section 2, it appears that for many students making the initial visit to obtain mathematics support can be a difficult one. Consequently, it is anticipated that if students are encouraged to make this ‘first step’, they will be more inclined to use the support throughout the year. In terms of regular users of the support, interview participants were specifically asked what had motivated them to first come to the MLSC and their experience of that initial visit.

For most regular users of the centre (19 out of 29), students were motivated to make their first visit because they had a specific problem that they felt needed addressing. In particular, four students expressed that they had anticipated that they would need help with mathematics at university due to a perceived lack of ability, and, consequently, had visited the centre in the first few weeks of term for general one-to-one help with basic mathematical subjects (such as algebra). An additional four students expressed that they had made their first visit after encountering difficulties with a problem sheet associated with a mathematics module on their course. The remaining 11 students were motivated to seek help due to an assessment. Seven of which required guidance with answering a coursework question and four required extra support in answering past exam questions. Although an impending exam or coursework deadline prompted these students to first visit the MLSC, unlike the non-users of the support, generally these regular users felt that they had not encountered any mathematical difficulties until this point. The assessment had alerted these students to their problems and hence they had sought the relevant support immediately.

Student Y: “I was stuck on coursework. I was like let’s try out the maths support centre and see what it’s like... Especially going from A-level maths to university maths, I felt a bit out of my depth... So I thought I’ll go and seek help and this was
the first place I came to. We got the coursework quite early on [in term]...in week 1 or 2."

Student U: "I was struggling with my maths...I was struggling in my labs and I had just been given a coursework assignment in IT skills and the subject I got given was error analysis. So I came in [to the MLSC] and talked to one of the lecturers here...it was the first time that it had cropped up that I had needed help specifically."

When making their first visit to the centre, other regular users were motivated by different reasons. Indeed, five students indicated that they had first visited the centre because they had come to collect a HELM (Helping Engineers Learn Mathematics) workbook required for their mathematics module, three students had come to find out more information about the MLSC after they had been told about it during their lecture and two students had come to use the MLSC as a quiet place to work, since this was more appealing than the library.

Analysis of the regular user's responses indicated that these students were engaged with their mathematics module from the outset. The students were consequently aware of their problems immediately and they had sought the relevant help when needed.

3.3.2 BECOMING A REGULAR USER

Although making the initial visit to the MLSC is undoubtedly important in introducing students to the support, return visits are equally important. Not only does this indicate that the student feels sufficient benefit from the first visit to warrant a further visit but, moreover, it is possible that the student may need to make regular visits to be effectively supported.

Regular users of the support were therefore asked specifically what had motivated them to make a return visit and why they had continued to use the support. From the interviews it was found that students returned for two main reasons. The first was that students were satisfied with the support they had required initially and this had motivated them to obtain help when they had encountered any further difficulties. The second was that students liked the atmosphere of the MLSC and continued to use this as a convenient place to work, rather than merely a 'drop-in' facility. Indeed, 13 out of the 29 students questioned came back for a second visit (and in all cases for
subsequent visits here after) to use the centre as a quiet place for working on material associated to the mathematics on their courses.

Student I: "It wasn’t long after [the first visit] I came to just come and work here. It was quite a nice place to come and sit doing the tutorials [sheets] with no distractions."

Student P: "After that [the first visit], I started coming in the break on a Friday just to like do some work and keep on top of things... You don’t really get distracted here."

Analysis of the interview data also indicates that regular users are generally motivated students who are engaged with their university courses. Students indicated that they regularly attended their lecture and tutorial sessions and would complete problem sheets on a weekly basis. They would also ensure that revision was not left until the ‘last minute’. For some students, their motivation to succeed compelled them to actively engage with mathematics and their course. Consequently, such students engage with the MLSC since they believe this will help them succeed further.

Student Q: “I want to get a good grade so I really needed to go [to the MLSC]. Because if I don’t understand it I’m not going to be able to do it in the exam... if I can’t do it I’ll lose out and I don’t want to be in that position. So I’ll come here [the MLSC] and get it all cleared up really.”

Student R: “This year I’ve really been trying by coming here... I got my semester 1 results and they weren’t as high as I thought they would be so that kind of knocked the wind out of my sails.”

For other regular users of the centre, they were motivated by fear of failure. In terms of these students, they were aware of their weaknesses and, consequently this motivated them to monitor and direct their learning accordingly. Therefore, it is possible to conjecture that such students will avail themselves of as much help as possible in order to avoid failure.

Student S: “I was struggling with my maths, because I had taken a gap year so... I basically needed help with maths.”

Student T: “ Mostly because I didn’t do A-level maths I was leaps and bounds behind everyone. So I used the one-to-one to help me along and give me that extra boost... the maths is just so much more complicated, so I used it to get those extra hours in and things like coursework.”
3.3.3 How do regular users engage with mathematics support?

In the section above, analysis of the interview data has indicated that students who regularly engage with mathematics support will use this as a way to scaffold their learning rather than a ‘quick fix’ to their problems. To investigate this further, regular users were asked to describe a typical visit to the MLSC and how this had contributed to their learning of mathematics. Out of the 29 students interviewed, 25 indicated that they typically came to the centre with some general mathematics work, such as a problem sheet. It appears that regular users use the support centre as a “learning space”, that is, a place where students will engage with mathematics and learning will take place. The concept of a ‘learning space’ extends from situated learning theory, whereby students are able to socialise in a wider community of proactivity that involves membership, identity formation and experience in the activities of practice, Kolb & Kolb (2005). The environment of the MLSC as a ‘learning space’ is conducive to the students’ learning and this impacts on their behaviour. In particular, students are motivated to engage with mathematics so that they are able to focus on specific learning goals and can effectively monitor and direct their own learning to achieve those goals. For the regular users of the MLSC, the support centre is a convenient and effective place to engage with mathematics. Students associate the space with learning and are motivated by the ‘working environment’.

Student H: “It’s a great place to work. It’s helped me make time and space in my day to get work done.”

Student ZA: “I use it as a working environment. It’s quiet and quite closed off. There’s only usually mathematicians who are here, it’s not anybody else. And in the library sometimes you just get people come to socialise half the time.”

Student U: “It’s kind of helped me keep on top of things. Just get everything done, like if you’re struggling or something I’ll get it sorted rather than leave it until I really have to, like just before a test.”

It appears that using the MLSC as a learning space creates a heightened sense of emotional security amongst students, which encourages them to engage with the mathematics. Students eagerly ask for help and clarification of ideas in this learning environment when they might otherwise remain mute in a typical classroom setting. Indeed, comments made by the regular users of the MLSC indicate that such students
will use the support for mathematics problems which they feel may not be addressed in their lectures.

Student V: “I feel that having this extra support and somebody to ask questions who’s not your lecturer is great...because knocking on your actual lecturers door is the most terrifying thing on earth...but you’re kind of anonymous here.”

Student W: “When you’re one on one with someone and you can ask them to stop quite easily or just explain something it’s quite a lot more easily applied than in a lecture.”

Student X: “I go away from here knowing more from my lectures to be honest. Maybe because they can take the time to explain it, and if I get stuck I can ask them to stop at any point. Because it’s more personal isn’t it.”

During the interviews, students were asked to reflect on their feelings following a typical visit to the centre. All students attributed a positive attitude to their visit. Many felt that they had ‘achieved’ something and that they had spent their time ‘productively’. Students also indicated that they felt reassured and hence more confident in their mathematical abilities. Consequently, this motivated them to return to the centre and to generally engage with the mathematics on their courses.

Student Y: “I feel more confident. If I understand it then I feel like it was worthwhile and like I’ve gained something out of it. Then it helps you do other things if you’ve got a bit of confidence.”

Student H: “Sitting down in the centre and getting work done makes me feel more confident...in understanding a method, in getting questions done. It helps build confidence in the specific module you’re taking at the time.”

Student N: “Most of the time I come away realising I knew how to do it, it’s just made me feel a bit more sure about what I’m doing, so that I know that I’m doing right. So that just gives me a bit more confidence to go away, yeah, it leaves me feeling more confident to go away and tackle other problems.”

Analysis of the responses from the regular users suggests that such students will engage with the support on a ‘Deep’ level (as opposed to a ‘Surface’ level). For example, rather than using the support to merely obtain ‘answers’ or a method to a mathematics problem that could be taken away and replicated, students expressed that they required a ‘deeper’ understanding to the problem at hand. In particular, the regular users would clarify ideas with the lecturers on duty and ask questions that would help them understand the problem in a broader context.
Student V: "Understanding is the intention really. Because generally if I’m asking a question, a lot of the time it’s for revision for exams or for coursework, which I will then have to relate to a different problem so I have to understand how it works in the first place really."

Student Z: "I go for a general understanding really. Just trying to get that sorted out and then you can apply that to all the other questions because no two questions are really the same."

Student U: "I think in most things you’re able to use it [the help] in another context. You gain more of an understanding of it when you ask. You understand it more than just guessing yourself."

Finally the regular users of the centre were asked how the MLSC had helped their learning of mathematics at university. All students expressed that using the Centre had had a positive impact on their performance in their mathematics module, and in some cases with other modules on their courses. By regularly engaging with the support such students felt more confident in their abilities and felt it had contributed to their understanding of mathematics. In particular, the students felt that the support had helped them to take control of their own learning, in that they were motivated to work on their mathematics outside timetabled sessions and felt much more confident in trying to solve problems on their own.

Student K: "It’s [the MLSC] helped with motivation. If you understand something then it propels you to keep working, especially maths... it makes you work and makes you want to keep doing it. Then you’ll practice that because you get the satisfaction of being able to do the problem then."

Student ZA: "Instead of coming across a problem where I’ll panic and then I’ll just leave it...now it’s [the MLSC] pushed me to do all the work and give it all a go and if I come up against a problem then, I’ll go and get help."

The analysis above suggests that students who regularly engage with mathematics support have a very different mindset to those who do not. Regular users appear to be motivated individuals who are engaged with mathematics and their courses. Consequently, the MLSC is used as a learning space to help scaffold their learning and enhance their motivation and personal performance in mathematics.
4. DISCUSSION

From student feedback, at face value there are a number of straightforward explanations as to why some students are not accessing the support provided by the MLSC. This chapter has discussed a number of reasons why failing students are not engaging with mathematics support. These include a lack of awareness of the location and of the facilities available in the MLSC and a lack of awareness of the need for help. In particular, it appears that many non-users are failing to monitor and direct their own learning throughout the year, which means students are not aware of individual weaknesses until they come to prepare for an exam. In addition, some students feel embarrassed or intimidated about using the support for fear of being demoralised or mocked for their lack of mathematical competency. Symonds et al (2007) suggested action to improve the uptake of support including increased advertising via posters, leaflets and lecturer recommendation (particularly within non-STEM departments), actively seeking out students who need mathematics support and recruiting MLSC staff who are familiar to the students (lecturers from other departments, besides Mathematics, and post-graduate helpers).

However, analysis of the responses from the regular users indicates that such reasons had initially prevented a number of these students from using the centre. Nonetheless, these 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 be enough to improve the uptake of support amongst failing students?

A common theme that emerged from the analysis of the regular users’ responses was that of motivation and engagement. Generally, students who use the centre regularly tend to be frequently attending timetabled lecture and tutorial sessions and regularly monitoring their own learning by completing problem sheets. Consequently they are aware of any mathematics difficulties and the need of support. Indeed, eight out of the 17 students who had failed a mathematics module did not use the centre because they were unaware of their problems. In comparison, only two out of the seventeen regular users of the centre felt that a lack of awareness of their problems had prevented them from using the centre at some point. However, unlike the non-users, once the regular
users were alerted to their weaknesses they were motivated to obtain the support required.

In addition such students are motivated to seek help by a desire to improve their performance. These students are aware that they must work hard to achieve their goals; indeed, many aspire to the top grades. Whilst, on one level, all the students interviewed wanted to pass their mathematics module, amongst the non-users of the centre, it appears that their motivation to pass was not enough to make them avail themselves of the support offered by the MLSC. Similarly, Brown & Rodd (2003) in their study investigating successful undergraduate mathematicians, found that successful students were motivated by the prospect of achieving excellence. In particular, their data suggests that for some students, enjoyment of the subject is correlated with success. Hence, this internal desire motivates them further.

Analysis of the interview data indicates that the non-users of the support perceive the MLSC as a ‘quick fix’ for short-term problems as opposed to a long-term solution in supporting their lack of mathematical competency. Since some students feel that they have too many problems to address, they do not feel that these could be solved by visiting the MLSC. However, the regular users essentially use the support as a way to scaffold their learning. The MLSC has become a ‘learning space’ for the regular users, where by students are motivated and engaged with mathematics due to the ‘working environment’. Consequently, the students are active participants in their own learning. Since students are regularly completing the work they are able to identify their weaknesses and obtain the support immediately. This in turn builds confidence which encourages students to engage further with the mathematics and the support. This coincides with the work of Brown & Rodd (2003), in that successful students appear to have a greater focus, determination and self-discipline, compared to failing students, which reinforces their motivation.

In terms of the students who fail to engage with mathematics support and who also fail a mathematics module, it appears that such students lack some form of intrinsic motivation. Regular users are generally driven by some desire to study mathematics, which is often related to an enjoyment of engaging with the subject. Hence, they are engaged with mathematics support and with their course as a whole from the outset. Indeed, Macrae et al (2003), in their study of failing undergraduate mathematicians,
found that failing students often lacked intrinsic motivation and, moreover, students’ general lack of motivation was reinforced by their peers. They report that demotivated students often socialise with other failing students who are equally demotivated or failing students tend to be socially isolated. The more successful students, on the other hand, have friends to help with and motivate them through the bad times.

However, if a student is not intrinsically motivated, as in the case of the non–users, then it may be possible to provide extrinsic motivation. If such students are provided with an outside influence or reward in order to encourage them to put in more effort than they may be more inclined to engage with mathematics support. Since the external reward of passing the exam does not seem to be a strong enough extrinsic factor in improving motivation and engagement with the support provided, then we must consider alternative methods of extrinsically motivating students. For example, at Coventry University, incentives such as free calculators were used to encourage students to visit the Mathematics Support Centre. It was anticipated that if students were encouraged to make the ‘first step’ they would be more inclined to use the support throughout the year. Therefore, in the first week of term leaflets advertising the centre and containing a voucher for a new calculator were distributed around campus. This was clearly successful in alerting students to the available support and making them discover the location of the centre since 390 students used their voucher in the first two weeks of term.

In light of these findings it is apparent that action needs to be taken to motivate students to not only access mathematics support, but initially to engage with the learning of mathematics on their courses. As indicated from the findings presented here, and within other research such as that by Macrae et al (2003), students who fail to engage (and fail in mathematics) are ill-prepared in terms of learning, in that they lack the study skills and cognitive skills needed to engage successfully with the learning of mathematics at university. Whilst on one level relatively ‘simple’ action can be implemented, such as increased advertising of the MLSC to encourage students to use it, it is believed that addressing the problem on a deeper-level is required to significantly improve student engagement. In particular it appears that action should be taken to raise students’ general engagement levels (not just engagement with mathematics support). This may involve changing the way in which mathematics is delivered to the students to encourage them to engage with their courses. It is
anticipated that if the teaching methods are changed with a view to motivate students to engage with the mathematics then this will also foster engaging with mathematics support. Such methods could involve changing the general teaching approach of mathematics at university by introducing student-centred instructional methods, which are claimed to significantly enhance motivation and engagement. For example, Problem-based learning (PBL), Perdersen (2003) and Bragg (2005), is an organisation of learning around real world tasks. Students work in small self-directed teams to define, carry out and reflect upon a research task, which can often be a 'real-life' problem. Since students see a strong and direct connection between their learning and a real world situation they are empowered to contribute to, they are motivated to engage with learning. Not only would this encourage students to monitor and direct their own learning, so that they become aware of mathematical difficulties, but it is also hoped that they would be motivated to seek out and use the mathematics support available to them.

Another example of a student-centred approach is Inquiry-based learning, Crabtree (2004). As the term suggests, Inquiry-based learning is a process of inquiry, which actively involves participants in learning by encouraging discussion, questioning and investigation. This approach helps foster feelings of interest and a desire to acquire knowledge. In a way similar to PBL, extrinsic motivation is fostered by linking task performance to consequences that students can value. Within the context of using an inquiry approach, these consequences may be in the form of rewards (such as future success) that are achieved through competition with others.

It is apparent that further research is needed to investigate if these actions would be successful in motivating students to engage with mathematics support. The findings in this chapter suggest that simple actions (such as improved advertising) may bring about some improvement in the uptake of support, however, for many students the reasons for not engaging with support are not the root cause, but are merely symptoms of a much deeper problem.

Since many students fail to engage with mathematics support because they do not take the initiative of using it, Chapter 6 and Chapter 7 will describe a proactive method of providing mathematics support and will investigate the issues of student engagement and motivation with such support. It was anticipated that the introduction of proactive
anticipated that if the teaching methods are changed with a view to motivate students to engage with the mathematics then this will also foster engaging with mathematics support. Such methods could involve changing the general teaching approach of mathematics at university by introducing student-centred instructional methods, which are claimed to significantly enhance motivation and engagement. For example, Problem-based learning (PBL), Perdersen (2003) and Bragg (2005), is an organisation of learning around real world tasks. Students work in small self-directed teams to define, carry out and reflect upon a research task, which can often be a ‘real-life’ problem. Since students see a strong and direct connection between their learning and a real world situation they are empowered to contribute to, they are motivated to engage with learning. Not only would this encourage students to monitor and direct their own learning, so that they become aware of mathematical difficulties, but it is also hoped that they would be motivated to seek out and use the mathematics support available to them.

Another example of a student-centred approach is Inquiry-based learning, Crabtree (2004). As the term suggests, Inquiry based learning is a process of inquiry, which actively involves participants in learning by encouraging discussion, questioning and investigation. This approach helps foster feelings of interest and a desire to acquire knowledge. In a way similar to PBL, extrinsic motivation is fostered by linking task performance to consequences that students can value. Within the context of using an inquiry approach, these consequences may be in the form of rewards (such as future success) that are achieved through competition with others.

It is apparent that further research is needed to investigate if these actions would be successful in motivating students to engage with mathematics support. The findings in this chapter suggest that simple actions (such as improved advertising) may bring about some improvement in the uptake of support, however, for many students the reasons for not engaging with support are not the root cause, but are merely symptoms of a much deeper problem.

Since many students fail to engage with mathematics support because they do not take the initiative of using it, Chapter 6 and Chapter 7 will describe a proactive method of providing mathematics support and will investigate the issues of student engagement and motivation with such support. It was anticipated that the introduction of proactive
support initiatives, such as small group teaching, would help to support students who lacked the motivation to seek out ‘drop-in’ support. Details of these support initiatives are discussed in the next chapter.
CHAPTER 6 – PARALLEL CASE STUDIES OF PROACTIVE SUPPORT

1. INTRODUCTION

In this thesis it has been recognised that the provision of mathematics support to undergraduate students can be effective in improving students’ mathematical skills and competency. However, the success of this support is largely affected by students’ engagement with the support initiative. The support provided by a Mathematics Support Centre is reactive, in that students must take the initiative in accessing the facilities and resources. Consequently, if no students come to use the support it cannot be deemed to be successful. This initiative requires students to be motivated (either intrinsically or extrinsically) so that they react to their difficulties and, hence, engage with the support. However, analysis of quantitative and qualitative data at Loughborough University has revealed that many students who are failing the mathematical component of their degree are not accessing the support, primarily due to a lack of motivation and disengagement. Therefore, Loughborough and Coventry Universities introduced proactive support initiatives to provide support to students who lack the motivation to seek out ‘drop-in’ support.

This chapter outlines two proactive support initiatives (one at Loughborough University and one at Coventry University) for first year students who were deemed as being mathematically less well-prepared for university mathematics. The support implemented at each of the universities will be taken in turn, beginning with Loughborough University. In Section 2, a brief background to the targeted cohorts of students at Loughborough University is given. In particular, it describes details of the support initiative and the method used to identify the students who were mathematically less well-prepared. It then proceeds to describe the implementation of the support initiative, including practical problems and attendance figures. A comparison is made of the results for the less well-prepared students who received support in 2005/6 and 2006/7 with results for the less well-prepared students (who were not supported) in 2004/5. A similar examination of the support initiative at Coventry University is then given. Again a detailed description of the implementation
is given, followed by a comparison of the results for the supported less well-prepared students in 2005/6 and 2006/7 against less well-prepared students in 2004/5. Finally, this chapter compares the support initiatives at both universities and comments upon their effectiveness, with particular reference to student engagement with the support.

2. Loughborough University

This section provides details of the support initiative implemented at Loughborough University with first year Physics students. A brief background is given before discussing the implementation of the support. The support was implemented on three separate occasions, namely Semester 1 in 2005/6, Semester 2 in 2005/6 and Semester 1 in 2006/7. The results of these will be discussed in turn. In particular, it will compare module results and attendance data of less well-prepared students who were supported in 2005/6 and 2006/7 with the less well-prepared students who received no support in 2004/5.

2.1 Background

At Loughborough University, a proactive support initiative was implemented within the Physics department. Over recent years, this department had recognised a high failure rate on the mathematics modules in its courses. Most physics students study a core mathematics module each semester for the first two years of their course and they also study other modules that incorporate mathematics. However, during recent years, first year mathematics module marks have been low. It was feared that this would cause students to lack confidence in their mathematical ability, resulting in reduced effort and hence the possibility of performing poorly in future mathematics modules and other modules which use mathematics.

Whilst no direct causality for the high failure rate had been established, there are two factors which may have contributed: the mathematical preparedness of students and the course regulations. All physics courses at Loughborough University state an entry qualification of an A-level mathematics grade ‘B’ or a non-traditional mathematics qualification at an equivalent level. In practice many students entered their physics courses with widely varying mathematical backgrounds. Students are recruited from Access courses or accepted onto the course with lower grades in A-level mathematics
or possibly with AS-level mathematics. As a result, students exhibit different levels of preparedness, and those who are less well-prepared may be in danger of failing the mathematical component of their course. Furthermore, it is possible for students to progress to their second year by passing (i.e. achieving more than 40%) ten of their twelve modules and just failing (i.e. achieving less than 40% but more than 30%) the remaining two modules. This means that students can fail both mathematics modules in the first year but still progress to the second year. Consequently, for students who find mathematics difficult motivation towards the mathematics modules could be low.

In order to tackle this problem, sigma introduced a new support initiative for the first year undergraduates of 2005/6. Details of this support are provided below.

2.2 THE SUPPORT INITIATIVE

After discussions between the physics department and sigma, it was decided that the best approach would be to teach the less well-prepared students separately in a ‘supported’ group. The students were identified prior to the commencement of their course and an additional lecturer, from the School of Mathematics, was assigned to teach the ‘supported’ group. This lecturer was also part of the Mathematics Education Centre support staff and so had previous experience in working with students who exhibit weak mathematics skills. It was anticipated that the students would feel at ease within their group and this would promote learning. A different lecturer (also part of the Mathematics Education Centre support staff) was assigned to the supported group in Semester 2 of 2005/6 and Semester 1 of 2006/7 (this is discussed in Section 2.2). The main group was taught by the member of staff who taught this module (to the whole cohort) in the previous year using the same teaching style and materials as in 2004/5. In Semester 1 and Semester 2 of 2005/6 and in Semester 1 of 2006/7, the two groups were taught separately for the entirety of the module.

It was decided that the splitting of the group would take place immediately, from the first week of the academic year, and that the students would be informed of the details before being placed into their respective groups. In order to overcome any perception by the students (from either group) that they may be disadvantaged, it was important that both groups recognised that students in both groups would receive teaching
appropriate to their needs. In addition to this, care was to be taken when referring to the groups to prevent the suggestion of a difference in ability. Therefore, the groups were labelled with a letter referring to the respective lecturer’s surname.

The main group was timetabled for two hours lecture time and an hour for a tutorial session. To support the less well-prepared students, the ‘supported’ group was timetabled for an extra hour’s lecture time. The additional lecture time was used to teach certain difficult concepts that the students often struggle with. The students also benefited as the extra contact time with the lecturer provided additional opportunities to ask for help. Instead of lecture notes the supported students received “Helping Engineers Learn Mathematics” (HELM) workbooks, Green et al. (2003). In these workbooks mathematics topics are broken down into manageable sections, beginning with the basics; then new theories and methods are gradually introduced. The numerous examples and exercises are designed to help engage the students, and the books themselves act as a clear and concise set of notes, making them particularly useful for revision. These modifications helped to create a teaching environment rather than a lecturing environment, designed to help some students with the transition from school to university. In addition, a postgraduate student (the author of this thesis) was recruited to assist the lecturer for the tutorial sessions with the less well-prepared students in order to ensure these students would receive help when needed. Both groups of students were encouraged to use the Mathematics Learning Support Centre (MLSC), but the less well-prepared students were given more encouragement. However, since the students were registered for the same module, the same syllabus was used for both groups and all students completed the same coursework and took the same examination.

It should be noted that some modifications were made to the support prior to implementation in 2006/7. These are discussed in Section 2.6.

2.3 IDENTIFYING THE LESS WELL-PREPARED STUDENTS

In order to identify the students who were mathematically less well-prepared, a close examination of their mathematical competence at the start of the course was needed. Since these students came from a diverse range of mathematical backgrounds, with
varying levels of preparation, it seemed appropriate to use their previous mathematics qualifications to divide the group. Based on the previous years’ results a suitable cut-off point appeared to be an A-level grade C, i.e. all students with A-level grades A, B and C in mathematics were deemed as being mathematically well-prepared. As can be seen in Figure 6.1, in 2004/5 there was a higher failure rate amongst students who had achieved an A-level grade D or E than those who had achieved an A-level grade A, B or C. There was also a high failure rate amongst students with non A-level mathematics backgrounds. This suggests that the A-level grade C is a suitable benchmark.

![Figure 6.1: Identifying the less well-prepared students by comparing the 2004/5 cohort’s previous mathematics qualifications against their module marks.](image)

All students with mathematics A-level grades A-C (28 out of 63 students) were classified as well-prepared. In addition, Foundation year students who had attended Loughborough University were also deemed as well-prepared. Although the results of 2004/5 suggested that these students may be marginal, it was felt that the mathematics that they had covered was of a similar content to the mathematics module, which would prepare them for their course. Students who had only achieved a grade D or E at A-level or who had entered their course via a vocational route, a non-Loughborough University foundation year, a college access course or had achieved Scottish Highers were also identified as being less well-prepared. The latter were deemed as being less well-prepared since it was felt that their previous courses did not mathematically prepare them as well as a good grade at A-level (Lawson 2000).
Finally, students who were re-sitting the module were also classified as being less well-prepared since their record of failure suggested that they were in danger of failing the module again. This approach also tied-in with research into similar initiatives with Engineering students at the University of Liverpool, Bullough (2003). First year engineering students were split into two separate groups, based on their mathematics qualifications, and were taught separately for their mathematics module.

Using this classification, the 2005/6 cohort consisted of 30 (out of 63) less well-prepared students (details of the composition of the 2006/7 cohort are given within Section 2.3) and the 2006/7 cohort consisted of 21 (out of 55) less well-prepared students (details of the composition of the 2006/7 cohort are given within Section 2.6)

In addition, the students were given a diagnostic test during the first week of the semester in order to test the students' mathematical skills on entry, identifying their strengths and weaknesses. A benchmark of 50%, which has previously been used at Loughborough University to identify students in need of additional support, was used to permit a small number of students to move between groups.

2.4 Implementation 2005/6 (Semester 1)

2.4.1 Practical Problems

Although the sigma staff and the Physics department had extensively planned the support provision prior to its instigation, problems arose during the implementation of the plan. 30 students were identified as being less well-prepared, however, six of these students were taught throughout the Semester in the main group. Since the room allocated for teaching the 'supported' group could not hold 30 students, an upper limit of 25 had to be placed on the size of the 'supported' group. Therefore, the two students who were re-sitting the module and had been classified as being less well-prepared were taught in the main group since they had prior knowledge of the material. Out of the remaining four students, one student asked to be moved from the 'supported' group to the main group since he had achieved a high score on the diagnostic test (97%). The remaining three less well-prepared students were taught in the main group due to administrative errors. In addition, and at his request, a well-
prepared student was taught in the ‘supported’ group. In summary, one well-prepared student was taught in the ‘supported’ group and six less well-prepared students were taught in the main group.

2.4.2 ATTENDANCE

A particular concern the Physics Department had expressed was with regard to attendance. Although attendance figures were not previously recorded, the lecturer had reported poor attendance from the 2004/5 cohort. It was felt that attendance and student engagement with the module affected each other. Therefore, in order to monitor these factors, student attendance was regularly checked during the ‘supported’ group’s lecture and tutorial sessions and attendance was also taken during the main group’s tutorials, for a comparison. Table 6.1 shows attendance figures of Weeks 1-11 of Semester 1 relating to the 2005/6 cohort.

The data in Table 6.1 shows that the majority of students in the ‘supported’ group were attending timetabled sessions, whereas just over half of the students from the main group were attending their tutorial sessions. As can be seen from the table, the ‘supported’ group were attending lectures 73% of the time and attending tutorials 79% of the time. This suggests that the method had a positive impact on the less well-prepared students in the ‘supported’ group, since their regular attendance suggests that the group were engaged on a behavioural level.

<table>
<thead>
<tr>
<th>Number of Students</th>
<th>Tutorial Attendance (%)</th>
<th>Lecture Attendance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Group</td>
<td>38</td>
<td>51</td>
</tr>
<tr>
<td>Supported Group</td>
<td>25</td>
<td>79</td>
</tr>
</tbody>
</table>

TABLE 6.1. Average lecture and tutorial attendance of the main and ‘supported’ groups.

In addition, there were some concerns with regards to the attendance of two particular lecture slots for the ‘supported’ group. These occurred on a Monday morning and a Friday afternoon. Originally the Friday lecture slot was set-aside for the tutorial, but unfortunately due to room allocation the tutorial had to be switched with a lecture slot. In addition, the students had few other timetabled sessions for that day, which could have made them less inclined to attend the session. Also, the Monday lecture was timetabled for 9am. As can be seen in Table 6.2, there is a difference between the
percentage of attendees for the Friday and Monday lectures and the percentage of attendees for the Thursday lecture and the Tuesday tutorial. On average a third of the students from the ‘supported’ group did not attend the Friday lecture and only one or two more students were attending the Monday lecture.

<table>
<thead>
<tr>
<th>Attendance (%)</th>
<th>Monday (lecture)</th>
<th>Tuesday (tutorial)</th>
<th>Thursday (lecture)</th>
<th>Friday (lecture)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>72</td>
<td>79</td>
<td>79</td>
<td>67</td>
</tr>
</tbody>
</table>

**TABLE 6.2. Distribution of attendance rates for the ‘supported’ group.**

However, the ‘supported’ group exhibits higher attendance in all four sessions compared to the main group’s tutorial session. It should be noted that the main group’s tutorial session was scheduled for a Friday afternoon, whereas the ‘supported’ group tutorial was scheduled for a Tuesday afternoon. According to the main group lecturer, tutorial attendance of the main group was similar to that of the whole group in 2004/5. It is possible that in 2004/5, the well-prepared students, who could succeed with poor tutorial attendance, created a culture of not attending tutorials that was followed by the less well-prepared students. Unfortunately these students really needed the input from the tutorials in order to succeed and this may have been a factor in the high failure rate amongst the less well-prepared students in 2004/5. The separation into two groups in 2005/6 succeeded in keeping attendance relatively high amongst the less well-prepared students.

### 2.4.3 COMPARISON OF RESULTS

This section now discusses the outcomes of the support initiative in terms of the students’ success, or otherwise, in the module.

#### 2.4.3.1 COMPOSITION OF THE GROUPS

Before comparing the overall performance of the two cohorts (i.e. 2004/5 and 2005/6) it is necessary to also compare the composition of the groups, in terms of previous qualifications, as shown in Figure 6.2.
Eleven more students were registered for the module in 2005/6 compared to the 2004/5 cohort. In total, seven more students were identified as being mathematically less well-prepared. However the number of less well-prepared students who were supported in 2005/6 was similar to the total number of less well-prepared students in 2004-5. Hence, Figure 6.2 compares the previous mathematics qualifications of the less well-prepared students from 2004/5 and the less well-prepared students who received support in 2005/6. These profiles are broadly similar with the majority of each cohort having mathematics A level grade D or E and the remainder having a range of other qualifications with only a handful having any particular qualification.

2.4.3.2 Comparison of Pass/Failure rates in 2004/5 & 2005/6

To measure the effect the support system had on the less well-prepared students, Table 6.3 compares the less well-prepared students from 2004/5 against the less well prepared students who received support in 2005/6. Data with regards to the students from the main group in 2005/6 is also provided for comparison. It should be noted that in order to pass the mathematics module, students must achieve a minimum of 40% in their combined exam/coursework mark (where 20% of the mark is allocated from the
Eleven more students were registered for the module in 2005/6 compared to the 2004/5 cohort. In total, seven more students were identified as being mathematically less well-prepared. However the number of less well-prepared students who were supported in 2005/6 was similar to the total number of less well-prepared students in 2004-5. Hence, Figure 6.2 compares the previous mathematics qualifications of the less well-prepared students from 2004/5 and the less well-prepared students who received support in 2005/6. These profiles are broadly similar with the majority of each cohort having mathematics A level grade D or E and the remainder having a range of other qualifications with only a handful having any particular qualification.

2.4.3.2 Comparison of Pass/Failure Rates in 2004/5 & 2005/6

To measure the effect the support system had on the less well-prepared students, Table 6.3 compares the less well-prepared students from 2004/5 against the less well prepared students who received support in 2005/6. Data with regards to the students from the main group in 2005/6 is also provided for comparison. It should be noted that in order to pass the mathematics module, students must achieve a minimum of 40% in their combined exam/coursework mark (where 20% of the mark is allocated from the
coursework and 80% from the exam). Therefore it is possible for a student to fail either the coursework or the exam (but not both) but pass the module.

The data in Table 6.3 suggest that the less well-prepared students who did receive additional mathematics support were more likely to pass the module compared to the less well-prepared students (who did not receive support since none was provided) from the 2004/5 cohort. Indeed, 67% of the less well-prepared students who received support in 2005/6 passed the module, compared to 48% of the less well-prepared students in 2004/5. Since the pass rate of the students has increased by 19 percentage points, it appears that the support system did benefit the less well-prepared students.

Another significant aspect is the decrease in the number of students who withdrew from the course. In this case, the support system seems to have had a positive effect since no students from the 2005/6 cohort withdrew from the course, during Semester 1, compared to 3 students from the 2004/5 cohort, all of whom were students deemed to be less well-prepared. This suggests that the support system did help the less well-prepared students to engage with the module.

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th>2005/6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Less well-prepared students (not supported)</strong></td>
<td><strong>Less well-prepared students in the 'supported' group</strong></td>
<td><strong>Well-prepared students in the main group</strong></td>
</tr>
<tr>
<td>No. of students</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Withdrew</td>
<td>3 (13%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Passed</td>
<td>11 (48%)</td>
<td>16 (67%)</td>
</tr>
<tr>
<td>Failed (≥30&lt;40)</td>
<td>2 (9%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Failed (&lt;30)</td>
<td>7 (30%)</td>
<td>6 (25%)</td>
</tr>
</tbody>
</table>

**TABLE 6.3.** Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6

It is also worth noting that the overall pass rate has increased from 69% to 73% and in fact that this has occurred when the percentage of less well-prepared students has increased from 44% to 48%. In addition, the pass rate of the well-prepared students is similar over both years at 86% in 2004/5 and 85% in 2005/6. Furthermore, the 2005/6
cohort of well-prepared students are better qualified than the previous year’s, in terms of previous mathematics qualifications (since there were four A-level grade A students and ten A-level grade B students in 2005/6 compared to one A-level grade A student and eight A-level grade B students in 2004/5).

Finally, recall that the main group contained six students who were initially deemed to be less well-prepared. All six students completed the module, however, only two of these students passed. In addition, the ‘supported’ group contained one student who was deemed to be well-prepared by virtue of his previous A-level grade. This student performed well and passed the module.

2.4.3.3 COMPARISON OF EXAM, COURSEWORK AND MODULE MARKS IN 2004/5 & 2005/6

Since we wish to measure the effect that the support system has had, Table 6.4 compares marks of the less well-prepared students who received support in 2005/6 to the less well-prepared students in 2004/5. There is an increase in all marks, but particularly the average coursework mark. It can be seen that the less well-prepared students who received support (the ‘supported’ group) out perform the less well-prepared students in 2004/5 by 11 percentage points in the coursework assessment. However the difference in the exam marks, between the less well prepared students who received support in 2005/6 and the less well-prepared students in 2004/5, is smaller (an increase of 4 percentage points). In addition, the less well-prepared students, from both cohorts, performed poorly in the exam compared to the well-prepared students. Table 6.4 shows that the main group outperformed the ‘supported group’ in the exam assessment. Indeed, in the exam assessment, the well-prepared students in 2004/5 outperformed the less well-prepared students (from the same cohort) by 19 percentage points and in 2005/6 the well-prepared students outperformed the supported less well-prepared students also by 19 percentage points. However, it should be noted that, in 2005/6, the ‘supported’ group performed better (by 5 percentage points) than the main group in the coursework. This suggests that the less well-prepared students may not have been suited to the exam assessment, and, furthermore, since the exam assessment was worth 80% of the overall module mark the well-prepared students outperformed the less well-prepared students in the module overall.
TABLE 6.4. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th>2005/6</th>
<th>2005/6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well-prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Well-prepared students in the main group</td>
</tr>
<tr>
<td>No. of students</td>
<td>23</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>Avg. Coursework (%)</td>
<td>53</td>
<td>64</td>
<td>59</td>
</tr>
<tr>
<td>Avg. Exam (%)</td>
<td>39</td>
<td>43</td>
<td>62</td>
</tr>
<tr>
<td>Avg. Module (%)</td>
<td>42</td>
<td>47</td>
<td>62</td>
</tr>
</tbody>
</table>

It should be noted that all differences have been tested for statistical significance by performing the Mann-Whitney U-test using SPSS software. This test showed no statistical differences between the 2004/05 and 2005/6 cohorts' marks. However, the Mann-Whitney U test is strongly influenced by the sample size, and due to the nature of the research the sample sizes of the data are statistically small. This could have an effect on how significant the results are and so practical differences may not have been detected by this test.

2.4.3.4 FAILURE PROFILE

Tables 6.5 and 6.6 show the performance of students from the 2005/6 cohort and the 2004/5 cohort in the mathematics module and in the other 5 modules they took in Semester I. In addition, the tables separate the students who failed the module at the 40% level and the 30% level since students could progress to their second year having failed (achieving less than 40%) two modules out of twelve but achieving at least 30%. For example, the table shows that three less well-prepared students had failed the mathematics module at the 40% level and that on average they had failed no other modules. A significant aspect of Table 6.5 and Table 6.6 is the number of other modules failed by the well-prepared students. The data shows that the well-prepared students who failed the mathematics module were inclined to fail their course as a whole, in particular those students who achieved less than 30%. This is also reiterated in their Semester I averages. Hence, it appears that, the well-prepared students who were not engaging with the mathematics module were not engaging with their degree program as a whole.
In comparison, the data show that the less well-prepared students were less likely to fail other modules on their course. From both the 2004/5 and the 2005/6 cohorts, the less well-prepared students who failed Semester 1 mathematics failed, on average, less modules than the well-prepared students who failed Semester 1 mathematics. In terms of the students who failed at the 40% level, the data indicates that the less well-prepared students were primarily struggling with the mathematics module and that efforts directed to helping these students in mathematics are worthwhile in terms of their overall potential to progress.

2.5 IMPLEMENTATION 2005/6 (SEMESTER 2)

The support initiative was continued into the second semester for the second mathematics module. As in Semester 1, the less well-prepared students were taught separately from the main group for the entirety of the second mathematics module. The students were also taught for an extra hour each week using a different teaching approach and different materials (see Section 2.1.1 for more details). In addition, a different lecturer to that of Semester 1 taught the supported group in Semester 2.

It should be noted that not all students who took the mathematics module in Semester 1 took the follow on module in Semester 2. Students studying the course 'Sports
Science and Physics’ do not take the second mathematics module until their second year, and hence current second year ‘Sports Science and Physics’ students were now registered for the second module. Since new students were introduced to the support for the first time, all students were given the option to change groups if they desired. Thus, two students who were originally identified as well-prepared (and taught in the main group), were moved to the supported group. Out of the 57 students registered for the second mathematics module, 31 were deemed as well-prepared and 26 were deemed as less well-prepared, 19 of which were taught in the supported group.

However, it was feared, that due to a lack of confidence amongst the less well-prepared students and the poor exam marks, repercussions may appear during the second semester. Despite encouragement from the lecturer, results from attendance data and exam, coursework and module marks confirm that the students did fail to engage with their second mathematics module. This will now be discussed below.

2.5.1 ATTENDANCE

Table 6.7 shows attendance figures of the supported group from Semester 1 and Semester 2 in 2005/6. As can be seen from the table, average attendance (combined lecture/tutorial) for both the main group and the supported group was worryingly low since under half of the students were attending timetabled sessions. In comparison to attendance figures from the first semester, although the attendance of the main group is similar (48% in Semester 2 compared to 51% in Semester 1), nearly half of the less well-prepared group who did attend in Semester 1 failed to attend in Semester 2 (decrease of 33 percentage points). This suggests that an increasing number of the less well-prepared students did not engage with the second module. Moreover, it appears that the majority of the less well-prepared students were not using the support offered to them in the supported group.
TABLE 6.7: Comparison of Semester 1 and Semester 2 attendance for the main group and the supported group.

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Students</td>
</tr>
<tr>
<td></td>
<td>(combined lecture/tutorial)</td>
</tr>
<tr>
<td>Main Group</td>
<td>38</td>
</tr>
<tr>
<td>Supported Group</td>
<td>25</td>
</tr>
</tbody>
</table>

2.5.2 Comparison of Results

2.5.2.1 Comparison of Pass/Failure Rates in 2004/5 & 2005/6 (Semester 2)

Comparison of the pass rates and the module marks for the second mathematics module provides further evidence to support the assertion of lack of engagement. Table 6.8 shows that both the main group and the supported group did not perform as well in the second semester compared to the first semester. Out of the 19 less well-prepared students who were supported, only 32% passed the module, compared to 67% in the first semester (Table 6.3) and 69% in the second semester of 2004-05. In addition two students from the less well-prepared group eventually withdrew from the module.

<table>
<thead>
<tr>
<th>2004/5</th>
<th>2005/6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less well prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
</tr>
<tr>
<td>No. of students</td>
<td>16</td>
</tr>
<tr>
<td>Withdrew</td>
<td>1 (6%)</td>
</tr>
<tr>
<td>Passed</td>
<td>11 (69%)</td>
</tr>
<tr>
<td>Failed (≥30&lt;40)</td>
<td>1 (6%)</td>
</tr>
<tr>
<td>Failed (&lt;30)</td>
<td>3 (19%)</td>
</tr>
</tbody>
</table>

TABLE 6.8 Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 (Semester 2)
In the main group, the pass rate amongst the well-prepared students has also fallen from 85% in Semester 1 to 71% in Semester 2. However, this cohort has performed similarly to the well-prepared students in 2004/5 (pass rate of 68%). This suggests that there could be underlying issues preventing success amongst the less well-prepared students.

2.5.2.1 COMPARISON OF COURSEWORK, EXAM AND MODULE MARKS IN 2004/5 & 2005/6 (Semester 2)

The exam, coursework and module marks for the less well-prepared students reiterate the difficulties the supported group appeared to have with the exam assessment in Semester 1, as can be seen in Table 6.9. In comparison to the 2004/5 cohort, the students performed similarly on the coursework assessment (57% 2005/6 compared to 59% 2004/5). However there is a decrease of 10 percentage points in the exam assessment, since the students in 2005-06 averaged just 28% (recall that this percentage is a definite fail). Furthermore, of the 16 less well-prepared (and supported) students who had passed the first semester module, ten of these took the second semester module. However, only 5 of these 10 students passed in the second semester.

The breakdown of results for the well-prepared group is very similar in 2005-6 compared to 2004/5. This suggests that the module assessments were neither easier nor more difficult than in the previous year. Although the first semester proved successful in terms of results amongst the supported less well-prepared students, the exam assessment seems to have produced a lack of confidence amongst the supported group and, hence, a lack of engagement with the second mathematics module.

<table>
<thead>
<tr>
<th>2004/5</th>
<th>2005/6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less well-prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
</tr>
<tr>
<td>No. of students</td>
<td>16</td>
</tr>
<tr>
<td>Avg. Coursework (%)</td>
<td>59</td>
</tr>
<tr>
<td>Avg. Exam (%)</td>
<td>38</td>
</tr>
<tr>
<td>Avg. Module (%)</td>
<td>43</td>
</tr>
</tbody>
</table>

TABLE 6.9. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 (Semester 2)
2.6 IMPLEMENTATION 2006/7

2.6.1 MODIFICATIONS OF THE SUPPORT

The support initiative was implemented again in October 2006 to support the new intake of first year Physics students. However, due to the lack of engagement and retention of students during the second semester in 2005/6, various changes were made to the support. In particular, Computer Aided Assessments (CAA) replaced the written coursework to encourage engagement. Previously, a written piece of coursework covering half of the module topics was distributed to students during Week 8 of Semester 1. The students were given two weeks to complete the coursework, which was worth 20% of the module assessment. In 2006-7, this was replaced by four CAA tests. Every 3 weeks the students were required to take a CAA test that covered a particular topic from the module. For example, in Week 4, students took the first test that covered the topic of Vectors. The second test, covering Functions, Limits and Differentiation, was taken in Week 7. The third test, covering Integration, was taken in Week 10 and the final test, covering Series and Complex Numbers, was taken in Week 12. Each test comprised 5% of the module assessment.

Since the 2006/7 cohort had been tested regularly and the tests covered all topics in the module, it was anticipated that this would better prepare the students for the end of year exam. Students would have a basic knowledge of all topics covered in the exam assessment and would have practised answering mathematics questions under test conditions.

In addition, students in the supported group were asked to sign a ‘Learning Contract’ on commencement of the mathematics module (see Appendix L). By signing the contract students agreed to attend all timetabled sessions, to complete the necessary work in tutorials and to seek additional support if they continued to struggle with the mathematical material. It was anticipated that the students would perceive the mathematics module as an important part of their course and that the contract would act as a constraint, thus encouraging students to engage with the module.
2.6.2 COMPARISON OF 2004/5, 2005/6 AND 2006/7 COHORTS

2.6.2.1 COMPOSITION OF 2006-7 COHORT

Before analysing the results from the 2006-7 cohort, it is necessary to analyse the composition of the groups and to compare this with the composition of the 2005-6 and 2004-5 cohorts. Figure 6.3 shows the composition of the supported group and main group from 2006-7. It can be seen that out of the 55 students, 21 students were identified as being less well-prepared. However, it should be noted that six less well-prepared students were taught throughout the semester in the main group. Although these students had been allocated to the supported group, the students had stated a preference to be taught in the main group. Since three of the students had achieved a diagnostic score of 63% or higher (against a benchmark of 50%) and two were re-sitting the module, these students were allocated to the main group. The remaining one student was also allocated to the main group but was advised to seek support if needed.

![Figure 6.3: Composition of the 2006-7 cohort depending on the students' previous mathematics qualification.](image)

In comparison to the previous years, the 2006-7 cohort comprised eight fewer students than the 2005-6 cohort but three more than the 2004-5 cohort. In terms of the students' preparedness, 21 students were recognised as mathematically less well-prepared in comparison to 30 students in 2005-6 and 23 students in 2004-5. Figure 6.4 compares the previous mathematics qualifications of the less well-prepared students...
from 2004/5 and the less well-prepared students who received support in 2005/6 and 2006-7. These profiles are broadly similar with the majority of each cohort having A-level grade D or E and the remainder having a range of qualifications with only a handful of students having any one particular qualification. It should be noted that there was a notable number of re-sit students in the 2006/7 cohort (the same as in 2004/5). All four students were less well-prepared students who had been supported in the previous year.

![Figure 6.4: Composition of the 2004/5 cohort, the 2005/6 cohort and the 2006/7 cohort depending on the students' previous mathematics qualifications.](image)

### 2.6.2.2 COMPARISON OF THE PASS/FAILURE RATES IN 2004/5, 2005/6 AND 2006/7

To evaluate the effectiveness of the support in 2006/7, Table 6.10 compares the less well-prepared students from 2004/5 against the less well-prepared students who received support in 2005/6 and 2006/7. Data with regards to the students from the main group in 2005/6 and 2006/7 are also provided for comparison.

The data in Table 6.10 suggests that the alterations made to the support initiative did not improve the pass rate amongst the less well-prepared students. Indeed, 47% of the less well-prepared students who received support in 2006/7 passed the module, compared to 67% of the less well-prepared students in 2005/6 and 48% in 2004/5. In addition, retention in 2006/7 did not improve in comparison to 2005/6, since one
student withdrew from the course in 2006/7, compared to no students in 2005/6. Although there is a slight improvement compared to 2004/5 (three students withdrew from the course).

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th>2005/6</th>
<th>2006/7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well-prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Less well-prepared students in the main group</td>
</tr>
<tr>
<td>No. of students</td>
<td>23</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>Withdrew</td>
<td>3 (13%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Passed</td>
<td>11 (48%)</td>
<td>16 (67%)</td>
<td>28 (85%)</td>
</tr>
<tr>
<td>Failed (≥30&lt;40)</td>
<td>2 (9%)</td>
<td>2 (8%)</td>
<td>3 (9%)</td>
</tr>
<tr>
<td>Failed (&lt;30)</td>
<td>7 (30%)</td>
<td>6 (25%)</td>
<td>2 (6%)</td>
</tr>
</tbody>
</table>

TABLE 6.10. Comparison of the less well-prepared students from 2004/5 (Semester 1) with the less well-prepared students who received support and the main group in 2005/6 and 2006/7 (Semester 1).

On the other hand, the pass rate amongst the well-prepared students has notably improved, since 100% of the students in this group passed the module in 2006/7. This has increased by 14 percentage points from 2004/5 and 15 percentage points in 2005/6. This shows that the amendments to the support initiative, particularly the regular CAA testing, have had a positive effect on the pass rate amongst this cohort. However, since the pass rate amongst the less well-prepared students has not improved, this suggests that there could be other factors contributing to their poor performance.

Finally, recall that the main group contained six students who were initially deemed as being less well-prepared. The three students who had performed well in the diagnostic test passed the module. Out of the two re-sit students, one had passed but one had withdrawn from the course. The remaining student, who was permitted to move but advised to seek support if needed, failed the module.
2.6.2.3 **Comparison of Exam, Coursework and Module Marks in 2004/5, 2005/6 and 2006/7**

To further evaluate the effect of the support initiative in 2006/7, Table 6.11 compares the exam, coursework and module marks of the less well-prepared students who received support in 2006/7 and 2005/6 with those students who did not receive support in 2004/5.

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th></th>
<th>2005/6</th>
<th></th>
<th>2006/7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well-prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Well-prepared students in the main group</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Well-prepared students in the main group</td>
<td></td>
</tr>
<tr>
<td>No. of students</td>
<td>23</td>
<td>24</td>
<td>33</td>
<td>15</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Avg. Coursework (%)</td>
<td>53</td>
<td>64</td>
<td>59</td>
<td>60</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Avg. Exam (%)</td>
<td>39</td>
<td>43</td>
<td>62</td>
<td>36</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Avg. Module (%)</td>
<td>42</td>
<td>47</td>
<td>62</td>
<td>36</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

**Table 6.11.** Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 and 2006/7

Comparison of the marks from 2006/7 with 2005/6 and 2004/5 indicates that the support initiative was not effective in supporting the less well-prepared students with mathematics. There is a decrease in all marks amongst the less well-prepared students. Furthermore, despite the additional support, this cohort has performed worse compared to the less well-prepared students in 2004/5 who received no support.

However, the changes made to the module assessment in 2006/7 had a positive effect on the well-prepared students’ coursework marks. This cohort outperformed the well-prepared students in 2005/6 by 10 percentage points in the coursework assessment.

It was anticipated that the introduction of CAA tests would better prepare the students for their final examination on completion of the module. However, the data in Table 6.11 suggest that this did not occur since both the well-prepared and less well-prepared students performed worse in the exam assessment compared to the 2005/6 cohort. There is a decrease of 7 percentage points amongst the well-prepared students in the exam assessment and a decrease of 7 percentage points amongst the less well-prepared students in the exam assessment. However, it is also possible that the exam taken by the 2006/7 cohort was more difficult than the exam taken by the 2005/6
cohort, particularly since the 2006/7 well prepared students did not perform well in this assessment compared to the 2005/6 cohort.

Finally, we would expect that the additional mathematics support would have helped to promote engagement amongst the less well-prepared cohort. This was apparent in 2005/6 since no students withdrew from the course (compared to three in 2004/5) and the pass rate increased from 48% to 67%. However, the data suggest that the support has had a negative effect on the 2006/7 cohort since the 2006/7 students performed worse than students from 2004/5 who were not supported. The well-prepared students performed similarly overall in the module compared to the previous years (58% average module mark in 2006/7 compared to 62% in 2005/6 and 60% in 2004/5), which indicates that the module was neither harder nor easier than previous years. Therefore, it is possible that there are other factors contributing to the less well-prepared students' poor performance in 2006/7.

2.6.3 Attendance

Recall that poor attendance in 2004/5 contributed to the introduction of a support initiative. Attendance was recorded in 2005/6 and 2006/7 to monitor behavioural student engagement. Table 6.12 compares attendance figures of the supported group in 2005/6 with those from 2006/7. It should be noted that in 2006/7 the students attended one two-hour lecture session and one combined two-hour lecture/tutorial session. Therefore, the attendance figure for the lecture/tutorial sessions is used to compare tutorial attendance. It is possible that the structure of lectures and tutorials in 2006/7 had impacted upon the success of the support, particularly in terms of student engagement. For example, if a student had missed one session, then they had essentially missed two hours (or half) of their timetabled sessions.

Indeed, the data in Table 6.12 suggests that students in the supported group in 2006/7 had failed to engage with the mathematics module. There is a significant difference (35 percentage points) in the percentage of students attending timetabled sessions in comparison to the 2005/6 cohort. As can be seen in the table, the 'supported' group were attending lectures 39% of the time and attending tutorial sessions 42% of the
time. This suggests that the majority of less well-prepared students were not using the support offered to them in timetabled sessions.

<table>
<thead>
<tr>
<th>Supported Group</th>
<th>Number of Students</th>
<th>Average Lecture Attendance (%)</th>
<th>Tutorial Attendance (%)</th>
<th>Lecture Attendance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-6</td>
<td>25</td>
<td>75%</td>
<td>79</td>
<td>73</td>
</tr>
<tr>
<td>2006-7</td>
<td>15</td>
<td>40%</td>
<td>42%</td>
<td>39%</td>
</tr>
</tbody>
</table>

**TABLE 6.12.** Average lecture and tutorial attendance of the ‘supported’ groups in 2005/6 and 2006/7 (semester 1).

Further investigation indicates that disengagement (as indicated by poor attendance) leads to poor results. As can be seen in Figure 6.5, students who attended sessions more than 80% of the time, performed well in the module. This suggests that the support did help these students to pass the module. It can also be seen that students who attended the sessions less than 80% of the time, were more likely to fail the module (75% of less well-prepared students failed). It is possible that if these students had attended the timetabled sessions, then they would have benefited from the support and passed the module.

To encourage engagement with the mathematics module, students from the supported group were asked to sign a ‘Learning Contract’. Although this was presented to students at the beginning of the term, due to a lack of attendance, only nine out of the fifteen students signed a learning contract. Out of the six students who did not sign the contract, four were poor attendees (on average attended 5% of the time) and, perhaps inevitably, they failed the module (average module mark of 12%). The other two students passed the module (40% and 44% respectively) and exhibited various attendance rates (24% and 53% respectively). It should also be noted that the attendance rate of the cohort dropped towards the end of the semester, after the coursework assessment had been submitted but before the written examination. This may have contributed to the students' poor exam results.

In comparison, the students who had signed a learning contract were more likely to attend timetabled sessions (average of 65%) and pass the module (average module mark of 46%). This could suggest that the learning contracts did have some positive
effect in engaging the less well-prepared students. However, it is possible that such students would have attended the sessions without the contract if they were generally motivated and engaged.

![Graph showing comparison of attendance figures against module marks amongst the less well-prepared students in the supported group in 2006/7.](image)

**Figure 6.5:** Comparison of attendance figures against module marks amongst the less well-prepared students in the supported group in 2006/7.

### 2.6.4 Failure Profile

Table 6.13 shows the performance of students from the 2006/7 cohort in the mathematics module and in the other 5 modules they took in Semester 1. In addition, the tables separate the students who failed the module at the 40% level and the 30% level since students could progress to their second year having failed (achieving less than 40%) two modules out of twelve but achieving at least 30%. For example, the table shows that three less well-prepared students in 2005/6 had failed the mathematics module at the 40% level and that on average they had failed no other modules.
Recall, that in 2005/6, the less well-prepared students who failed Semester 1 mathematics (at the 40% level) failed no other Semester 1 modules, indicating that they were primarily struggling with the mathematics module. However, this does not appear to be the case in 2006/7. The data shows that the less well-prepared students who failed the mathematics module in 2006/7 were inclined to fail at least one other module. Moreover, students who achieved less than 30% in the mathematics module in 2006/7 were inclined to fail their degree course as a whole, since on average a student had failed nearly four more modules. This is also reiterated in the students’ Semester 1 averages. Hence, it appears that, the less well-prepared students who were not engaging with the mathematics module were not engaging with their degree program as a whole.

These results suggest that there are other factors relating to a lack of engagement amongst the less well-prepared students that cannot be solved by the introduction of a mathematics support initiative. Therefore, in terms of supporting mathematically less well-prepared students it appears that additional action (and possibly other means of support) is needed. The quantitative data cannot be used to determine what has caused this lack of engagement and so it appears that further investigation, by qualitative means, is needed. Such data was collected and is presented in Chapters 7 and 8.

Finally, since the module results indicated that the support was not successful in improving pass rates and retention in Semester 1 of 2006/7, compared to 2004/5 when no support was provided, the support was not continued in Semester 2 of 2006/7.
2.7 CONCLUSIONS

The support initiative has had mixed success over the two year period. The support showed some signs of success in Semester 1 of 2005/6 with an increase in pass rate from 48% to 67%, and a marked improvement in the performance of less well-prepared students in the supported group, noticeably in their coursework marks with an increase of 11.6 percentage points. In Semester 1 of 2005/6 the students engaged well with the support. The less well-prepared students performed well in the coursework and perhaps this helped to build their confidence. However, the less well-prepared students’ newly found confidence was undermined by their poor performance in the exam assessment. It is likely that this contributed to a negative attitude towards mathematics at university and, consequently, a lack of engagement in the second semester.

Indeed, in terms of behavioural engagement, 48% of the supported less well-prepared students attended the timetabled sessions compared to 74% in Semester 1 of 2005/6. Consequently, poor examination results suggested that this may have impacted upon their performance in the module. Indeed, the support did not improve pass rates or retention amongst the less well-prepared students compared to Semester 2 in 2004/5 (when no support was received). However, a different lecturer taught the supported group in Semester 2 than in Semester 1. In addition, in Semester 2, students were timetabled for two 2-hour sessions compared to four 1-hour sessions in Semester 1. It is possible that this disparity may have impacted upon student engagement with the support.

The support initiative was modified before implementation in 2006/7. This entailed replacing the written coursework with regular Computer Aided Assessments to better prepare students for the end of year examination and introducing ‘Learning Contracts’ with the less well-prepared students to promote engagement.

However, despite the modifications, the support initiative did not improve engagement or the retention of students. The pass rate amongst the supported less well-prepared students was lower than in Semester 1 of 2005/6 (47% in 2006/7 compared to 67% in 2005/6). Furthermore, the 2006/7 supported less well-prepared
students performed to a similar standard in the mathematics module as the less well-prepared students in 2004/5 who did not receive support. Analysis of attendance indicated that a factor contributing to the lack of success of the support is a lack of *behavioral* engagement with the module. On average 42% of less well-prepared students in 2006/7 were attending timetabled sessions compared to 75% in 2005/6. This means that the majority of these students in 2006/7 were not using the support offered to them. Although the supported students were asked to sign Learning Contracts in 2006/7, only nine out of 15 students signed these contracts. These nine students did regularly attend their timetabled sessions. However, it is possible that such students would have been motivated and engaged without signing the contracts.

However, 100% of the 2006/7 well-prepared cohort passed the module compared to 85% in 2005/6 and 86% in 2004/5. There was also a notable improvement in the coursework marks, since the average mark had increased from 59% in 2005/6 to 69% in 2006/7. This suggests that there are underlying issues that have exacerbated the less well-prepared students’ poor performance.

These results indicate that the support initiative was not successful in engaging and retaining students in 2006/7. The data suggests that the method of the examination assessment may have contributed to the poor results amongst the less well-prepared students. However, since the pass rate amongst the well-prepared students improved in Semester 1 of 2005/6 compared to 2004/5 (despite relatively low marks in the exam assessment) it appears that there may be other factors contributing to the poor performance of the less well-prepared cohort. In particular, poor attendance suggests that some students from this cohort failed to engage with the module from the commencement of their degree courses. Moreover, a closer examination of the students’ performance in the Semester 1 modules has revealed that the less well-prepared students were failing to engage with their courses as a whole. It appears that the support was not successful in Semester 1 of 2006/7 compared to Semester 1 of 2005/6 owing to fundamental differences in the characteristics of the students in each of the cohorts. In particular, the data suggests that the 2005/6 cohort were relatively engaged since they exhibited good attendance and generally worked hard at all their modules. However, on the other hand, the data from the 2006/7 cohort indicates that these students were generally disengaged at university since they failed to attend their
mathematics sessions regularly and were generally failing their whole degree programmes. Clearly, student engagement is crucial to the success of the support.

The reasons for the lack of engagement amongst the 2006/7 cohort may be relatively simple, for example social or financial factors, or it is possible that there may be more complex reasons preventing the students from engaging at university. However, such factors are not evident from the analysis of the quantitative data in this chapter. It appears that there are underlying issues affecting the less well-prepared students’ engagement and, consequently, their performance in the module, which require further investigation. In order to gain an insight into the student perspective, this will be investigated in Chapter 7 and Chapter 8 by examining the students’ attitudes and their learning strategies in mathematics.

3. Coventry University

This section provides details of the support initiative implemented at Coventry University. A brief background is given before discussing the implementation of the support. The support was implemented on two separate occasions, in 2005/6, and in 2006/7. The results of these will be discussed in turn. In particular, the discussion will compare module results of less well-prepared students who were supported in 2005/6 and 2006/7 with the less well-prepared students who received no support in 2004/5.

3.1 Background

At Coventry University, a department that has directly benefited from the new support initiatives is the Engineering department. All first year engineering students registered for a Chartered Engineering degree take a core mathematics module during their first year. Students also take a diagnostic test on entry to university so that individual weaknesses can be identified early and students can be encouraged to seek appropriate support from the Mathematics Support Centre (MSC). However, during recent years, the Engineering department had noticed a high failure rate not only on the mathematics module but within other first year engineering modules that incorporate mathematics. It was feared that this could cause repercussions in subsequent years, since students need to use and build upon this mathematical knowledge in future modules.
Whilst no direct causality for the high failure rate has been established, there are factors that may have contributed, particularly the mathematical preparedness of students. All engineering courses at Coventry University state an entry requirement of 200-260 tariff points from 2 or more 6-unit GCE awards including Mathematics, Physics, Chemistry and Design Technology, or a non-traditional mathematics qualification at an equivalent level. In practice many students enter their engineering courses with widely varying mathematical backgrounds. Approximately only 50% of students enter with a traditional A-level mathematics qualification (which can range from an A to E grade), approximately 20% will have a vocational qualification in mathematics (such as a GNVQ or BTEC) and the remainder will be overseas students with a range of international educational backgrounds. As a result, students exhibit different levels of preparedness, and those who are less well-prepared may be in danger of failing the mathematical component of their course.

It was anticipated that results from a mathematics diagnostic test would alert students to their individual mathematics weaknesses and they were encouraged to seek support from the Mathematics Support Centre (MSC). However, it appeared that students were not actively seeking the support they needed and so, to remedy this, the University introduced a new system of diagnostic testing. Students are now required to pass all seven areas of mathematics on the diagnostic test, by repeated testing, in order to pass the mathematics module. Whilst this gave some students motivation to work upon their weaknesses, the failure rate amongst the engineering cohort did not noticeably improve.

In order to tackle this problem, *sigma* introduced a new support initiative for the first year undergraduates of 2005/6. Details of the support are provided below.

### 3.2 The Support Initiative

A similar support initiative to that at Loughborough University was implemented with first year Engineering students at Coventry University in 2005/6 and 2006/7. As at Loughborough University, students who were identified as being mathematically less well-prepared were taught separately from the main group for the entirety of the first
year mathematics module. The students were identified on the commencement of their degree course and an additional teacher, recruited as a part-time member of staff, was assigned to teach the ‘supported’ group. It was decided that the splitting of the group (in 2005/6 and 2006/7) would take place almost immediately, once results from a mathematics diagnostic test were available. In order to overcome any perception by the students (from either group) that they may be disadvantaged, it was decided that the students would not be informed as to how the group had been split. Instead, the students were told that the teaching rooms were not adequate for the size of the group, and so a selection of students would be taught separately.

The main group were taught using the same approach as in previous years. As such a lecturer from the mathematics department taught the group during the first term (the same as in previous years), and a second staff member, also from the mathematics department, taught the group during the second term. Both staff members used a lecturing style to teach the mathematics material to the mainstream group. As in previous years, the mainstream group was timetabled for two hours per week, which comprised one hour’s lecture time and an hour for a tutorial session.

A slightly different approach was used with the ‘supported’ group. Firstly, it was anticipated that the composition and size of the ‘supported’ group would benefit the less well-prepared students. Since the students would be of a similar ability, it was expected that this would diminish any feelings of intimidation or demoralisation amongst the students. In addition, since these students would be taught in a much smaller group, it was hoped that they would feel a sense of belonging, and if a student failed to attend a session then this absence would be noticeable. In the previous year, it was recognised that a group of students were failing to attend timetabled sessions, in particular the tutorial sessions. These could possibly have been students who were deemed as being less well-prepared. Therefore, by separating out this small group and teaching them separately it was hoped that this would improve student engagement with the module. In addition to this, the lecturer employed to teach the supported group was a new member of staff at the university whose experience was as a school teacher. It was anticipated that the staff member would help the students feel at ease within their group and this would promote learning.
Similar to the main group, the ‘supported’ group also received two timetabled hours to cover the module material. However, the students in this group were taught using a ‘classroom’ approach whereby mathematical concepts and topics were taught to the students interspersed with practical time so that the students could practise these concepts using examples and tutorial questions. These modifications helped to create a teaching environment rather than a lecturing environment, designed to help some students with the transition from school to university.

Both groups of students were encouraged to use the Mathematics Support Centre (MSC), but the less well-prepared students were particularly encouraged to use this support. However, since the students were registered for the same module the same syllabus was used for both groups. Also, the same teaching materials were used with both groups, namely “Mathematics for Engineers: A Modern Interactive Approach”, Croft and Davidson (2003), and all students completed the same coursework and took the same examination.

3.3 IDENTIFYING THE LESS WELL-PREPARED STUDENTS

In order to identify the students who were mathematically less well-prepared, a close examination of their mathematical competence at the start of the course was needed. Since these students came from a diverse range of mathematical backgrounds, with varying mathematics qualifications, it was thought that using their previous mathematical qualifications to determine preparedness would be too difficult. Therefore, their score in a mathematics diagnostic test was used to divide the group, since prior research had shown that this was a good indication of a student’s mathematical strengths and weaknesses, which in turn could be used to determine their mathematical preparedness. At Coventry University, a threshold mark of 50% is set. Students who fall below this threshold mark are therefore deemed as ‘at risk’ of failing the mathematics on their courses and are deemed as being mathematically unprepared.

As can be seen in Figure 6.6, in 2004/5 there was a higher failure rate amongst students who achieved 50% or less on the diagnostic test than those who had achieved greater than 50%. This suggests that 50% is a suitable benchmark.
In 2005/6, all students who achieved less than 50% on their first attempt of the diagnostic test were classified as less well-prepared. This resulted in a group of 31 out of 109 students (28%). In addition, the students were given a ‘phase’ test after four weeks into the semester in order to examine how students were coping with the mathematics module. These results were used to permit two students, initially deemed well-prepared, to move to the ‘supported group’. Therefore, 33 less well-prepared students were initially allocated to the ‘supported group’. Similarly, in 2006/7, 39 out of 97 students were identified as less well-prepared (by virtue of their diagnostic test mark). Further details of the composition of the groups in 2005/6 and 2006/7 will be discussed in Section 3.4 and Section 3.5 respectively.

3.4 IMPLEMENTATION 2005/6

3.4.1 PRACTICAL PROBLEMS

Although the sigma staff and the Engineering department had extensively planned the support provision prior to its instigation, problems arose during the implementation of the plan. 33 students were initially identified as being less well-prepared (31 by virtue of their diagnostic score and two by virtue of their phase test score). However, only 14
of these students were taught throughout the year in the ‘supported’ group. Since the students were unaware that they had been allocated to the ‘supported’ group because they had been deemed as mathematically less well-prepared, 19 students choose to be taught in the main group. Furthermore, out of the 109 students originally registered for the module, only 71 took the diagnostic test in Week 1. Four students who had not taken the test in Week 1, but had taken it at a later date, were eventually deemed as being less well-prepared. However, since their scores were not available when the group was split, these students were not placed in the ‘supported group’. In addition, 23 students did not take the diagnostic test at any point (and hence inevitably failed the module), thus it is possible that a number of these students were mathematically less well-prepared but were not identified. Finally, one student who had achieved a diagnostic test score of 64% and one student who had not taken the diagnostic test were also taught in the supported group.

In summary, the supported group consisted of 16 students, 14 of which were deemed as being less well-prepared, one well-prepared student and one unclassified student.

3.4.2 COMPARISON OF RESULTS

This section now discusses the outcomes of the support initiative in terms of the students’ success, or otherwise, in the module.

3.4.2.1 COMPOSITION OF THE GROUPS

Before comparing the overall performance of the 2004/5 and 2005/6 cohorts it is necessary to also compare the composition of the groups. Hence, Figure 6.7 shows the composition of the engineering cohorts and their diagnostic test percentage averages.

Three more students were registered for the module in 2005/6 compared to the 2004/5 cohort, with 30 students being identified as less well-prepared in 2004/5 and 33 students in 2005/6. Figure 6.7 shows that the less well-prepared students from the 2004/5 and 2005/6 cohorts performed similarly on the diagnostic test. This data suggests that a fair comparison can be made between the two cohorts of students.
3.4.2.2 **Comparison of Pass/Failure Rates in 2004/5 & 2005/6**

To measure the effect the support system had on the less well-prepared students, Table 6.14 compares the less well-prepared students from 2004/5 against the less well-prepared students who received support in 2005/6. It should be noted that in order to pass the mathematics module, students must achieve a minimum of 35% in both the coursework and exam. The combined module mark (25% from the coursework and 75% from the exam) must also be 40% or greater in order to constitute a pass.

The data in Table 6.14 suggests that the support system has made a small difference to the average performance of the less well-prepared students. It can be seen that the pass rate of the coursework assessment, exam assessment and the module have all increased since the introduction of the support system. However, these differences are small. There has been a small increase in the proportion of less well-prepared students who passed the mathematics module (3 percentage points) and who passed the coursework (4 percentage points). The largest increase has occurred in the proportion of students who passed the exam assessment. This has increased from 37% amongst the less well-prepared students (who were not supported since none was provided) in 2004/5 to 43% of the supported less well-prepared students in 2005/6. In comparison, less well-prepared students who were taught in the main group in 2005/6 were less
likely to pass the coursework and less likely to pass the exam compared to the less well-prepared students who were taught in the 'supported' group. However, interestingly they were more likely to pass the module.

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th>2005/6</th>
<th>2005/6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Less well-prepared students in the main group</td>
</tr>
<tr>
<td>No. of students</td>
<td>30</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Withdrew</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>6 (35%)</td>
</tr>
<tr>
<td>Passed Cwk</td>
<td>20 (67%)</td>
<td>10 (71%)</td>
<td>7 (41%)</td>
</tr>
<tr>
<td>Passed Exam</td>
<td>11 (37%)</td>
<td>6 (43%)</td>
<td>5 (29%)</td>
</tr>
<tr>
<td>Passed Module</td>
<td>10 (33%)</td>
<td>5 (36%)</td>
<td>7 (41%)</td>
</tr>
</tbody>
</table>

TABLE 6.14. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support in 2005/6

Another noticeable (but small) feature is the number of students who withdrew from the course. No students from the supported group in the 2005/6 cohort withdrew from the course, compared to 1 student from the 2004/5 cohort, who was deemed as being less well-prepared. In comparison, 14 students from the main group withdrew from the course in 2005/6, six of whom were mathematically less well-prepared. Although there is no statistically significant improvement between the 2004/5 and 2005/6 less well-prepared cohorts, the support system may have encouraged retention amongst the 2005/6 less well-prepared students compared to the 2005/6 students who were taught in the main group.

Finally, recall that the main group contained 17 students who were initially deemed to be less well-prepared. Ten out of the 17 students failed the module (six of whom withdrew from the course). In addition, the 'supported' group contained two students who were not deemed as being less well-prepared, one who was deemed as being well-prepared and one who could not be classified. Both students performed well and passed the module.
3.4.2.3 *COMPARISON OF EXAM, COURSEWORK AND MODULE MARKS IN 2004/5 & 2005/6*

To further investigate the effect of the support initiative, Table 6.15 compares marks of the less well-prepared students who received support in 2005/6 to the less well-prepared students in 2004/5.

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th>2005/6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well-prepared students</td>
<td>Less well-prepared students</td>
</tr>
<tr>
<td></td>
<td>(not supported)</td>
<td>in the 'supported' group</td>
</tr>
<tr>
<td>No. of students</td>
<td>30</td>
<td>14</td>
</tr>
<tr>
<td>Avg. Coursework (%)</td>
<td>48</td>
<td>59</td>
</tr>
<tr>
<td>Avg. Exam (%)</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>Avg. Module (%)</td>
<td>35</td>
<td>36</td>
</tr>
</tbody>
</table>

**TABLE 6.15. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6**

In terms of the average exam and module marks, there has been virtually no difference in the performance of the two cohorts. Each of these marks differ by 1 percentage point amongst the 2005/6 cohort. However, this is not large enough to suggest that the support initiative had an effect. However, there is a notable increase in the coursework mark. It can be seen that the less well-prepared students who received support (the 'supported' group) outperform the less well-prepared students in 2004/5 by 11 percentage points in the coursework assessment. Moreover, this has occurred when the coursework average amongst the main group has decreased by 5 percentage points. In addition, the less well-prepared students, from both cohorts, performed poorly in the exam compared to the well-prepared students. Table 6.15 shows that the well-prepared students in the main group outperformed the 'supported group' in the exam assessment. Indeed, in the exam assessment, the well-prepared students in 2004/5 outperformed the less well-prepared students (from the same cohort) by 17 percentage points and in 2005/6 the well-prepared students outperformed the supported less well-prepared students also by 17 percentage points. This could suggest that the less well-prepared students may not have been suited to the exam assessment, and, furthermore, since the exam assessment was worth 75% of the overall module mark, the well-prepared students outperformed the less well-prepared students in the module overall. Recall, that these results are similar to results at Loughborough
University. It appears that supported less well-prepared students are able to perform well in the coursework but they have difficulty with the exam assessment.

It should be noted that all differences have been tested for statistical significance by performing the Mann-Whitney U-test. This test showed no statistical differences at the 95% confidence interval between the 2004/05 and 2005/6 cohorts’ marks. However, the Mann-Whitney U test is strongly influenced by the sample size, and due to the nature of the research the sample sizes of the data are statistically small. This could have an effect on how significant the results are and so practical differences may not have been detected by this test.

3.5 IMPLEMENTATION 2006/7

The support initiative was implemented again in October 2006 to support the new intake of first year Engineering students. Although the support was limited in its success in 2005/6 no major modifications were made to the support.

It should be noted that the staff members who had implemented the support in 2005/6 did not continue to teach the respective groups in 2005/6. Consequently, this means there is the possibility of some discontinuity in the way the groups were taught in 2006/7 compared to 2005/6.

As in the previous year, the group of less well-prepared students were identified on commencement of their degree courses and were taught separately from the main group for the entirety of the mathematics module (see Section 3.2 for details).

3.5.1 COMPARISON OF RESULTS

This section now discusses the outcomes of the support initiative in terms of the students’ success, or otherwise, in the module.
3.5.1.1 COMPOSITION OF THE GROUPS

Fewer students were registered for the module in 2006/7 compared to the 2004/5 and 2005/6 cohort (10 and 12 fewer respectively), with 39 students being identified as less well-prepared in 2006/7 (as can be seen in Figure 6.8). Interestingly, there are a similar number of well-prepared and less well-prepared students in the 2006/7 cohort (38 and 39 students respectively). It can also be seen that both the less well-prepared students from the 2004/5, 2005/6 and 2006/7 cohorts performed similarly on the diagnostic test. These data suggests that a fair comparison can be made between the three cohorts of students.

It should be noted that although a total of 39 students were identified as being mathematically less well-prepared, only 20 were taught in the supported group. Since part of the support initiative was the benefit of being taught in a small group setting, it was felt that there should be a restriction on the number of students in the supported group. Therefore, students with a diagnostic test score of 40% or lower (as opposed to 50% or lower in 2005/6) were allocated to this group. Finally, four students who were identified as being well-prepared and four students who could not be classified (since they had not taken the diagnostic test) were also taught in the supported group. In summary, the supported group consisted of 20 less well-prepared students, four well-prepared students and four unidentified students.

![Figure 6.8: Composition of the 2004/5, 2005/6 and 2006/7 cohorts depending on the students' diagnostic test results.](image-url)
3.5.1.1 Composition of the Groups

Fewer students were registered for the module in 2006/7 compared to the 2004/5 and 2005/6 cohort (10 and 12 fewer respectively), with 39 students being identified as less well-prepared in 2006/7 (as can be seen in Figure 6.8). Interestingly, there are a similar number of well-prepared and less well-prepared students in the 2006/7 cohort (38 and 39 students respectively). It can also be seen that both the less well-prepared students from the 2004/5, 2005/6 and 2006/7 cohorts performed similarly on the diagnostic test. These data suggests that a fair comparison can be made between the three cohorts of students.

It should be noted that although a total of 39 students were identified as being mathematically less well-prepared, only 20 were taught in the supported group. Since part of the support initiative was the benefit of being taught in a small group setting, it was felt that there should be a restriction on the number of students in the supported group. Therefore, students with a diagnostic test score of 40% or lower (as opposed to 50% or lower in 2005/6) were allocated to this group. Finally, four students who were identified as being well-prepared and four students who could not be classified (since they had not taken the diagnostic test) were also taught in the supported group. In summary, the supported group consisted of 20 less well-prepared students, four well-prepared students and four unidentified students.

Figure 6.8: Composition of the 2004/5, 2005/6 and 2006/7 cohorts depending on the students' diagnostic test results.
3.5.1.2 COMPARISON OF THE PASS/Failure RATES IN 2004/5, 2005/6 AND 2006/7

To measure the effect the support system had on the less well-prepared students, Table 6.16 compares the less well-prepared students from 2004/5 against the less well-prepared students who received support in 2005/6 and 2006/7. Recall, that in order to pass the mathematics module, students must achieve a minimum of 35% in both the coursework and exam. The combined module mark (25% from the coursework and 75% from the exam) must also be 40% or greater in order to constitute a pass.

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th>2005/6</th>
<th>2006/7</th>
<th>2006/7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well-prepared students (not supported)</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Less well-prepared students in the 'supported' group</td>
<td>Less well-prepared students in the main group</td>
</tr>
<tr>
<td>No. of students</td>
<td>30</td>
<td>14</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Withdraw</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>3 (15%)</td>
<td>4 (21%)</td>
</tr>
<tr>
<td>Passed Cwk</td>
<td>20 (67%)</td>
<td>10 (71%)</td>
<td>13 (65%)</td>
<td>14 (74%)</td>
</tr>
<tr>
<td>Passed Exam</td>
<td>11 (37%)</td>
<td>6 (43%)</td>
<td>2 (10%)</td>
<td>6 (32%)</td>
</tr>
<tr>
<td>Passed Module</td>
<td>10 (33%)</td>
<td>5 (36%)</td>
<td>3 (15%)</td>
<td>6 (32%)</td>
</tr>
</tbody>
</table>

TABLE 6.16. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support in 2005/6 and 2006/7.

The data in Table 6.16 suggests that the support system has made no difference to the average performance of the less well-prepared students. Indeed, fewer students passed the module with support in 2006/7 compared to the students who had received no support in 2004/5. Although the majority (65%) of supported less well-prepared students were able to pass the coursework component of the mathematics module, the majority of students struggled with the written examination. Consequently, all but three students failed the module in 2006/7. There has also been an increase in the number of withdrawals from the course, since three students did not complete the module in 2006/7 compared to no students in 2005/6 and just one student in 2004/5. Moreover, in comparison, the less well-prepared students who were taught in the main group in 2006/7 were more likely to pass the coursework and more likely to pass the exam compared to the less well-prepared students who were taught in the 'supported' group. This may indicate that the students who were supported were too weak and that
the support would be more effective if students who had achieved 40-50% in the diagnostic test were targeted.

Finally, recall that the main group contained 19 students who were initially deemed to be less well-prepared. Four out of the 19 students withdrew from the course and a further nine students failed the module. In addition, the ‘supported’ group contained eight students who were not deemed as being less well-prepared; four who were deemed as being well-prepared and one who could not be classified. The four well-prepared students passed the module and the four unidentified had withdrawn from their courses.

3.5.1.3 COMPARISON OF EXAM, COURSEWORK AND MODULE MARKS IN 2004/5 & 2005/6

To further evaluate the effect of the support initiative in 2006/7, Table 6.17 compares the exam, coursework and module marks of the less well-prepared students who received support in 2006/7 and 2005/6 with those students who did not receive support in 2004/5.

<table>
<thead>
<tr>
<th></th>
<th>2004/5</th>
<th></th>
<th>2005/6</th>
<th></th>
<th>2006/7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less well-prepared students (not supported)</td>
<td>Less well-prepared students in the ‘supported’ group</td>
<td>Well-prepared students in the main group</td>
<td>Less well-prepared students in the ‘supported’ group</td>
<td>Well-prepared students in the main group</td>
<td></td>
</tr>
<tr>
<td>No. of students</td>
<td>30</td>
<td>14</td>
<td>46</td>
<td>20</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Avg. Coursework (%)</td>
<td>48</td>
<td>59</td>
<td>61</td>
<td>53</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Avg. Exam (%)</td>
<td>31</td>
<td>30</td>
<td>47</td>
<td>23</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Avg. Module (%)</td>
<td>35</td>
<td>36</td>
<td>48</td>
<td>31</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 6.17. Comparison of the less well-prepared students from 2004/5 with the less well-prepared students who received support and the main group in 2005/6 and 2006/7

Comparison of the marks from 2006/7 with 2005/6 and 2004/5 indicates that the support initiative was not effective in supporting the less well-prepared students with mathematics. There is a decrease in all marks amongst the less well-prepared students. Furthermore, despite the additional support, this cohort has performed worse (overall) compared to the less well-prepared students in 2004/5 who received no support. However, it should be noted that the well-prepared students in 2006/7 also performed
poorer in both the exam and coursework compared to the 2005/6 and 2004/5 cohorts. This may indicate that the module assessment in 2006/7 was more difficult to that in the previous years.

Although the 2006/7 cohort (and 2005/6 cohort) outperform the 2004/5 cohort in the coursework assessment, the average exam grade is worryingly low. Indeed, the data show that on average the students did not achieve enough marks to pass the written examination. Unfortunately, since the exam assessment was worth 75% of the overall module mark, this had a notable negative effect on the students’ overall module grade.

Undoubtedly the data provide further evidence to suggest that the written examination causes many students to fail the mathematics module. Although the less well-prepared students have received mathematics support throughout the year, it appears that this is not adequate in preparing them for the final method of assessment.

3.5.2 ATTENDANCE

A record of attendance was taken amongst the supported group to monitor and promote student engagement with the module. Recall, that an important aspect of the support initiative was that such a method is proactive, in that mathematically less well-prepared students, who may not necessarily seek out the support available, are able to receive the support appropriate for their needs. However, if students do not attend their timetabled sessions then they are not able to benefit from this support.

Analysis of attendance data reveals that students were attending their sessions on average 62% of time. Whilst there is no data from previous years to compare, this does indicate that many students had missed a substantial amount of material covered in the module, since the students only received one timetabled session each week (comprising of two hours).

Further investigation indicates that poor attendance may lead to poor results. As can be seen in Figure 6.9, there is a small correlation between attendance and module grade. This suggests that the support did contribute in some way in helping students to pass the module. However, since some students were regular attendees and still did
not pass the module it is likely that there are other factors contributing to this. Recall, amongst the Loughborough cohort, the majority of students who had attended well had passed the module, indicating that engagement amongst these students was related to their performance in the module. However, at Coventry, the attendance data provides further evidence that the cohort of less well-prepared students were perhaps too weak to benefit from the support.

![Figure 6.9: Comparison of attendance figures against module marks amongst the less well-prepared students in the supported group in 2006/7.](image)

### 3.6 CONCLUSIONS

Comparison of the 2005/6 cohorts module marks with the previous years’, shows that the support system had a small effect in retaining and engaging students. No less well-prepared students withdrew from the module in 2005/6 compared to one student in 2004/5 and 14 students from the main group in 2005/6. The data also show an improvement in the performance of the less well-prepared students in the supported group, noticeably in their coursework marks with an increase of 12 percentage points. In addition, the pass rate amongst the ‘supported’ less well-prepared students in 2005/6 increased for the coursework and exam assessments (4 and 6 percentage points respectively), in comparison to the less well-prepared students (not supported) in 2004/5. Consequently, 36% of the less well-prepared students in the supported group
in 2005/6 passed the module, compared to 33% of the less well-prepared students (who did not receive support) in 2004/5.

However, the less well-prepared from both years performed poorly in the exam compared to the well-prepared students. There was a large improvement in the coursework marks amongst the supported less well-prepared students both at Loughborough and Coventry Universities. However, this was followed by a poor performance in the exam. This could indicate that it is not necessarily a lack of mathematical skills that are the root of the students’ problems but a lack of examination skills. However, in order to investigate this issue further additional data would be needed. A more qualitative approach is needed to provide a descriptive account.

The same support was implemented with the new cohort of first year students in 2006/7, although the teaching staff for each of the groups had changed from the previous year. In terms of retention and engagement the data indicates that the support was not successful. Indeed, the 2004/5 cohort of less well-prepared students (who had received no support) performed on average better than the 2006/7 cohort who were supported. In particular, only three such students passed the module in 2006/7.

Similar to the 2004/5 and 2005/6 cohorts, the less well-prepared students performed poorly in the written examination. The majority of students failed to pass this component of the assessment with a group average of just 23%. Since the average coursework mark for the same group was significantly higher (53%), it appears that there are some issues with regards to this mode of assessment.

4. SUMMARY AND DISCUSSION

Within this chapter the method of a proactive mathematics support initiative has been introduced. The method, which involved identifying mathematically less well-prepared students and teaching them separately to the main group (and in one case using alternative teaching methods), was implemented and developed at two institutions. At Loughborough University the support was introduced to first year Physics students and at Coventry University the support was introduced to first year Engineering students. Less well-prepared students were supported in this manner to
encourage students, who were at risk of failing the mathematical component of their course, to engage with mathematics support and to improve retention rates amongst such students.

The success of the small group teaching support initiatives has been mixed at both institutions. In the first year of implementation the pass rate amongst the mathematically less well-prepared students increased at both Loughborough and Coventry Universities. In 2005/6, at Loughborough University, the pass rate amongst the less well-prepared students increased to 67% in the first semester compared with 48% in 2004/5. Similarly at Coventry University, the pass rate also improved although by a much smaller amount (from 33% in 2004/5 to 36% in 2005/6). The support was also successful in engaging students since no students withdrew from the module, compared to three at Loughborough University and one at Coventry University (all less well-prepared) in 2004-5.

At Loughborough University, a closer investigation of the 2004/5 and 2005/6 cohorts’ performances in the mathematics module and several other Semester 1 modules indicates that well-prepared students who had failed the mathematics module were also failing to perform in their other modules. On the other hand, the less well-prepared students who had failed the mathematics module tended to fail very few other modules. This indicates that taking measures to support these students in their mathematics is very worthwhile in terms of promoting retention and progression.

However the success of the support initiatives was not sustained. At Loughborough University during the second semester, there was a notable lack of student engagement amongst the Physics students. Whereas students were attending their first semester timetabled sessions on average 75% of the time, in the second semester this had dropped to just 41%. Moreover, student attendance did not improve amongst the new cohort in 2006-7 since students attended an average of 42% of the time. Without regular attendance many students struggled to cope with the mathematical material and, consequently, the pass rate amongst the less well-prepared students dropped to 32% in the second semester in 2005-6. Moreover the pass rate in 2006/7 had dropped to 47% amongst the new cohort of students. Since 48% of students in 2004/5 passed the module but did not receive support, it appears that the support initiative had no effect on the 2006/7 cohort.
At Coventry University, only 15% of the less well-prepared students passed the module in 2006-7 and three students had withdrawn from the course (as well as an additional four students whose mathematical preparedness was unidentified but who were taught in the supported group). Similarly to the results at Loughborough University, this means that students who did not receive support in 2004/5 outperformed students who did receive support in 2006/7. In addition, students from the 2006/7 cohort were only attending their timetabled sessions on average 62% of the time, indicating a lack of engagement with the support initiative. However, since the less well-prepared students had achieved relatively low scores on the diagnostic test (less than 40%), it is likely that these students were too weak to gain any benefit from the support.

Analysis of the data has also revealed some unforeseen results with regards to the assessment of the module. The less well-prepared students from the 2005/6 and the 2006/7 cohorts, performed better in the coursework assessment than the 2004/5 cohort. This was evident amongst the Physics students at Loughborough and the Engineering students at Coventry. Furthermore the less well-prepared students from 2005/6 and 2006/7 performed similarly or better in the coursework than the well-prepared students from 2005/6. It could be that the less well-prepared students are not able to perform well under exam conditions, and as a result their final module marks are affected, hence, the poor pass rate.

An additional factor is that of attendance. In most cases the attendance rate of the less well-prepared students dropped towards the end of the module, after the coursework assessment had been submitted but before the written examination. Therefore, students were regularly engaging with the mathematics module prior and during their coursework assessment. This indicates that the success of the support initiative is dependent upon students being engaged and motivated with mathematics.

Clearly a lack of engagement amongst the less well-prepared students is a major issue within both institutions. It was anticipated that by introducing a proactive support initiative, students who do not avail themselves of the available mathematics support but who are at risk of failing, would receive the necessary mathematics help. However, this was not the case since the majority of students failed to attend their
timetabled sessions and hence could not benefit from the support. Results from the 2005/6 and 2006/7 cohorts indicates that the support can be effective in improving pass rates and promoting retention and progression in mathematics. However, in order to be successful students must be encouraged to engage with the mathematics module.

The quantitative data analysed in this chapter does not indicate the reasons why there is an issue of lack of engagement amongst the less well-prepared students. Consequently, the next chapter will give details of a qualitative research approach. The connection between student engagement, student motivation and mathematics support will be examined further by analysing students’ attitudes, beliefs and learning approaches to mathematics and mathematics support at university.
CHAPTER 7 – STUDENTS’ ATTITUDES TO MATHEMATICS

1. INTRODUCTION

In Chapter 6 a proactive support initiative was evaluated using quantitative data. It was anticipated that the support with regards to this, which involved teaching mathematically less-well prepared students separately from the main group, would encourage students to engage with mathematics support since they did not have to take the initiative themselves. However, analysis of the data revealed that this method had limited success in improving pass rates and retention amongst the less well-prepared cohorts. Moreover, a lack of student engagement emerged as a key issue in the success of the support, since a substantial number of students failed to attend their timetabled sessions and hence could not benefit from the support initiative. Whilst some manner of disengagement may be expected with regards to reactive support initiatives, perhaps more surprisingly this was also the case with regards to this proactive support initiative. Results from the quantitative data cannot provide an insight as to why this is the case, therefore, qualitative data were collected and analysed.

Data were collected in two stages. The first stage sought to collect preliminary data with regards to the 2005/6 cohort of physics students, in order to identify any issues that could be investigated further. A questionnaire was administered to this cohort to investigate how the students had perceived the support, particularly by examining their attitudes towards mathematics and the support initiative. This was followed by a number of in-depth interviews with some of the students, designed to examine interesting findings in more depth. Findings from this stage will be discussed, with particular reference to students’ mathematics confidence and their ability to adapt to learning at university.

The second stage of the research involved the administration of a further questionnaire and further follow-up interviews with the 2006/7 cohort of physics students. This stage was designed to conduct a deeper investigation into students’ attitudes and their
learning approaches to mathematics. In particular, analysis was carried out to
determine the relationship between these constructs and student engagement.

This chapter will use findings from the qualitative data to examine students’ attitudes
towards mathematics, with particular reference to how their attitudes relate to
engagement (particularly in terms of cognition) with mathematics and the proactive
support initiative (the following chapter will present data with regards to students’
learning approaches). It will examine a number of factors that have influenced the
students’ attitudes and will investigate whether the students’ attitudes have changed
since being at university. A comparison of the responses of the well-prepared students
and less well-prepared students is made throughout to understand how these cohorts
differ and how this may affect their engagement with and performance in mathematics
at university.

2. ATTITUDES OF THE 2005/6 PHYSICS STUDENTS

This section will discuss the outcomes of a questionnaire, given to the first year
Physics students (in 2005/6) on completion of their first mathematics module. The
data are analysed to determine factors that may have contributed to a lack of
engagement in the second semester. In particular, the students’ attitudes towards
mathematics prior to university will be compared to their attitudes after the first
semester. Discussion will also be given of students’ attitudes towards the assessment
methods of the module. This is followed by a detailed analysis of the responses given
during a series of follow-up interviews, conducted towards the end of the second
mathematics module. The interviews were carried out in order to conduct a deeper
investigation into the students’ attitudes. Analysis of these data investigates how
students adapted to university and how this may relate to their engagement with and
the success of the proactive support initiative.

2.1 QUESTIONNAIRE

2.1.1 METHODOLOGY

On completion of the first semester mathematics module (February 2006), a
questionnaire was distributed to the first year Physics students (see Appendix A for
copy of the questionnaire). Since not all students who took the mathematics module in Semester 1 take the follow on module in Semester 2, different means of distributing the questionnaire were used, as shown in Figure 7.1. It can be seen that the questionnaire was distributed to 63 students in total. The questionnaire was distributed to the 47 students, who were registered for the second mathematics module, during a lecture slot for the second mathematics module during Week 1 of the second semester. Since a lecture slot was chosen during the first week of the new term, it was anticipated that attendance numbers would be substantial. For the remaining 16 students, who were not taking the second semester module, the questionnaire was mailed into their departmental pigeon holes.

Once the questionnaire had been distributed, both by hand during the lecture and by post to the pigeon holes, and replies had been received, it was recognised that poor attendance and response rate had resulted in a small number of replies (29 out of 63 possible replies, 10 (out of 25) from the less well-prepared (LWP) group, 19 (out of 38) from the well-prepared (WP) group). Therefore, in order to receive additional replies the questionnaire was mailed into the remaining students' departmental pigeon holes during week 2 of semester 2. This resulted in seven more replies (3 from LWP
students and 4 from WP students). Therefore, 36 out of 63 possible replies were received, which accounted for 57% of the students who were originally registered for the first module. Of these replies 13 (out of 25 i.e. 52%) were from the LWP group and 23 (out of 38 i.e. 61%) were from the WP group. It should be noted that the questionnaire was completed before the students were aware of their examination marks for the first mathematics module. Therefore, the students only had their own ideas of how they had performed in the module.

2.1.2 RESULTS

Analysis of the responses to the questionnaire revealed a number of key issues, which may be related to the effectiveness of the support initiative and a lack of engagement amongst students in the second semester. This section, therefore, discusses the responses to some specific questions from the questionnaire, based upon these issues. The first relates to students’ attitudes, with particular reference to feelings of enjoyment and confidence amongst students. Students’ attitudes towards mathematics prior to university are compared with their attitudes after the first semester of university. In particular, students’ attitudes towards the first mathematics module will be examined. The second issue addresses the assessment methods and the students’ attitudes relating to those assessments. Analysis of the responses to these questions will be used to determine how these issues relate to a lack of engagement in the second semester.

2.1.2.1 ATTITUDES TOWARDS MATHEMATICS PRIOR TO / WHILST AT UNIVERSITY

Table 1 shows the responses to some questions from the questionnaire relating to the students’ attitudes towards mathematics prior to and whilst at university. It was anticipated that these questions would reveal an insight into how the students’ attitudes towards mathematics may have changed over time. However, it should be noted that responses to the pre-university question could have been subconsciously influenced by the students’ experience at university.

Table 7.1 shows the percentage of students who chose each response. The well-prepared students and less well-prepared students are compared within the table. As might perhaps be expected, the data in Table 7.1 show major differences between the
attitudes of the less well-prepared and the well-prepared students. They also show a notable difference in the changes in these attitudes during the first semester of their course. Prior to university, the majority of well-prepared students enjoyed mathematics and felt confident with mathematics. Since studying mathematics at university, there is no change in the well-prepared students’ enjoyment of mathematics and only a small increase (4%) of those who regard themselves as good as mathematics. However, there has been a more notable change in relation to their confidence with mathematics which increases by 8%.

<table>
<thead>
<tr>
<th>Response</th>
<th>% of less well-prepared who chose each statement (13 students)</th>
<th>% of well-prepared who chose each statement (23 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prior to uni</td>
<td>At uni</td>
</tr>
<tr>
<td>I enjoy maths</td>
<td>31%</td>
<td>46%</td>
</tr>
<tr>
<td>I feel good at maths</td>
<td>15%</td>
<td>23%</td>
</tr>
<tr>
<td>I feel confident with maths</td>
<td>46%</td>
<td>31%</td>
</tr>
</tbody>
</table>

Table 7.1: Students’ responses in relation to their attitudes to mathematics before and during university.

An additional interesting feature of the table is the percentage of well-prepared students who regarded themselves as being ‘good’ at mathematics prior to university, with only 35% agreeing with this statement. Recall that such students had received at least an A-level grade C in mathematics. It is likely that most people in the population would regard this as an indication of being ‘good’ at mathematics. However, it appears that the majority of these students do not share this view. A possibility for this data could be that the well-prepared students did not feel ‘good’ at mathematics compared to other students in their class; students who may have chosen to study mathematics further, at university. There is also the possibility of a general polarisation amongst students that being ‘good’ at mathematics is a natural talent rather than a skill that can be developed. Therefore, students may not perceive themselves as having this ‘talent’.

On the other hand, prior to university, very few of the less well-prepared students enjoyed mathematics and fewer regarded themselves as being good at mathematics (31% and 15% respectively). In addition, less than half felt confident with the subject.
The first semester experience produces a substantial increase in the percentage of students who enjoy mathematics (15%) and a moderate increase in those who feel good at mathematics (8%). However, there is a notable decrease (15%) in the percentage of students who have confidence with mathematics.

This suggests that, for the less well-prepared students, the support system can be related to an increase in the overall level of enjoyment of mathematics in this group. However, the impact of the first semester on confidence is very different. Prior to university the gap between the less well-prepared and well-prepared groups was only 11 percentage points. After the first semester this has risen to 34 percentage points. So, although the less well-prepared students are growing (comparatively) in enjoyment, their confidence is dropping rapidly. This suggests that there is an, as yet, unidentified factor contributing to their lack of confidence.

2.1.2.2 FEELINGS TOWARDS THE MODULE AND THE EXAM ASSESSMENT

In order to investigate the issue of confidence further, analysis of the responses with regards to the module and exam will now be discussed. Table 7.2 shows the responses by the students in relation to the mathematics module and the mathematics exam (it should be noted that only 12 students from the LWP group responded to these questions).

In comparison to the well-prepared students, the less well-prepared students respond far more positively towards the enjoyment of the mathematics module. Since 83% of the less well-prepared students indicate that they enjoyed the module, compared to 46% who enjoy mathematics at university (Table 7.1), this suggests further evidence towards the value of the support system. Furthermore, these students indicated that they had felt much more confident in the mathematics topics covered by the module (58%) in comparison to their general feelings of mathematics confidence (31%, Table 7.1).
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>% of less well-prepared who agreed with each statement (12 students)</th>
<th>% of well-prepared who agreed with each statement (23 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module</td>
<td>Enjoyed module</td>
<td>83%</td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>Felt confident in topics covered</td>
<td>58%</td>
<td>65%</td>
</tr>
<tr>
<td>Exam</td>
<td>Felt prepared</td>
<td>33%</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>Felt confident with performance</td>
<td>25%</td>
<td>52%</td>
</tr>
</tbody>
</table>

Table 7.2: Students responses in relation to how they felt about the first semester mathematics module and the exam assessment.

However, the apparent lack of confidence exhibited by the less well-prepared students (in Table 7.1) can also be seen from these responses (in Table 7.2), and in particular their confidence in their exam attempt. (It should be noted that five out of the 12 less-well prepared students had actually failed the exam, although the results had not been declared at this point).

Only 25% of the less well-prepared students indicated that they had felt confident with their exam attempt, despite the fact that seven out of the twelve students had actually passed the exam. It appears that these students have little faith in their own mathematics ability, possible due to their prior failures. Since 58% of the less well-prepared students felt confident with the mathematics topics covered by the module, the data suggests that the lack of confidence amongst these students has been largely affected by the exam assessment.

However, of the less well-prepared students who indicated that they had felt prepared for the exam, one student had not performed well in this assessment. This student had felt confident with his exam attempt but surprisingly he had failed this assessment and, consequently, the module. However, since this student had performed well in the coursework it may be that this success helped to create the feeling of confidence in preparation for the exam. It appears that the less well-prepared students have difficulty in judging how well they are coping with the mathematics module. In general, the data suggests that the lack of mathematics confidence, amongst the less well-prepared students, is affected by the exam assessment. Since the less well-prepared students
achieve good coursework marks (a group average of 59%, compared to an average of 61% amongst the well-prepared students), this could explain the increase in responses with regards to a feeling of confidence in the topics covered. Therefore, it is likely that the exam assessment has had an effect on the less well-prepared students’ general feelings of mathematics confidence.

To summarise, the data from the questionnaire shows that the support system has been positive in terms of the less well-prepared students’ attitudes towards mathematics. In particular, there is an increase in feelings of enjoyment of mathematics generally and of the module. However, feelings of confidence amongst the less well-prepared students have decreased since being at university. Further analysis shows that the exam assessment is a likely cause of this undermining of confidence of the less well-prepared students. Therefore, it is possible that these issues have directly contributed to a lack of engagement with the mathematics module in the second semester. To investigate this further, interviews were conducted with a number of students. Details of these will be discussed in the subsequent section.

2.2 FOLLOW-UP INTERVIEWS

2.2.1 METHODOLOGY

To follow-up a number of general issues that had arisen from analysis of the responses to the questionnaire, particularly whether the mathematics examination had affected students’ feelings of mathematics confidence, a number of students (who had completed the questionnaire) were interviewed during the second semester. Initially, only students who had failed the mathematics module were targeted, since prior findings (as presented in Chapter 6) had indicated that such students were likely to disengage with the module. Two e-mails were sent during Weeks 4 and 5 of the second semester requesting volunteers. However, only one student responded. This apparent lack of willingness to share the student perspective may indicate that the students who had failed the mathematics module were not comfortable in discussing their thoughts about mathematics or their ability in this subject. Therefore, since recruiting participants proved difficult, further attempts to encourage participation were carried out by targeting students who had been interviewed at the start of the mathematics module, whether they had passed or failed the module. Finally, six
students agreed to participate in an interview, in addition to the one student who had responded previously. Out of these seven students, one student was deemed as being well-prepared and had achieved 92% in the first mathematics module. The remaining six students were deemed as being less well-prepared, three of them had failed the module, two had passed but had achieved marks close to the pass mark (40%) and one student had performed well with a mark of 73%. Since students had demonstrated varying degrees of success, it was anticipated that analysis of the interview data could be used to compare the attitudes of the students who had failed the module with those who had passed and, in addition, a more general examination of the less well-prepared students’ attitudes could be conducted.

In addition, since only one well-prepared student was interviewed, the analysis of his interview will not be discussed. This particularly student was actively engaged with the mathematics module in terms of behaviour and cognition. He conveyed a positive attitude to mathematics, felt confident in his own mathematical ability and he was aware of and monitored his own learning processes to ensure success. The researcher felt that since it is likely that this student was atypical in terms of the cohort of well-prepared students and that the attitudes of the less well-prepared students were of general interest, an in-depth analysis of this student was not required.

The students were interviewed during Weeks 11 and 12 of Semester 2 at which time they were due to complete the second mathematics module. Each interview lasted for approximately 20-30 minutes. The interviews were semi-structured and open-ended questions were put to the participants. All sessions were audio taped. The researcher carried out the interviews and transcribed the audio recordings.

Each participant was asked the same questions, which concentrated on a number of issues which the researcher wished to investigate (see Appendix M for the interview guide). These issues were categorised into the students’ previous mathematics experience, university experience of mathematics and their feelings towards their mathematics module marks and the assessment methods. The results from the interviews will be discussed under headings reflecting these issues accompanied by illustrative quotes from the less well-prepared students (LWP 1-6)).
2.2.2 Results

2.2.2.1 Previous Mathematics Experience

The six less well-prepared students interviewed exhibited various mathematical backgrounds. Analysis of the interview data suggests that the students' experiences of pre-university mathematics have had some influence on how they first perceived mathematics on entering university. In particular, the issue of mathematics confidence arose during the interviews. Two mature students who, due to their recent lack of experience with mathematics, expressed a lack of confidence in their mathematical abilities, had entered university fearful of the prospect of mathematics.

LWP 6: "Because I didn't have the A-level background I found that the maths side of it really really frightened me ... I have always felt this way, particularly with maths, that I'm ten steps behind everyone else."

One other student had had a negative A-level experience with mathematics and as a consequence his attitudes towards mathematics reflected this. The remaining three students expressed a fondness towards mathematics. These students had had a positive experience in their mathematics education, prior to university, and this seemed to influence their personal views of mathematics.

LWP 1: "I enjoyed it [maths] more at school but that's more because in the second year I was just re-sitting AS so I got 4 lessons a week in that class. The atmosphere was amazing, because there was only about 5 of us."

This student had initially struggled with mathematics at AS-level and as a result he had to re-sit the year. Consequently, his subsequent mathematics classes were taught in a small group of a similar ability. This approach created an enjoyable learning environment for the student and consequently this motivated the student to engage (behaviourally and cognitively) with school mathematics. As suggested by the responses above, if a student is confident in their mathematical ability then it is more likely that they will be engaged with mathematics. Therefore, it is likely that if a less well-prepared student enters university with an already negative attitude then a lack of engagement may emerge from this, despite support intervention.
2.2.2.2 *University Mathematics*

Analysis of the questionnaire suggested that the exam assessment and the resulting lack of confidence may have contributed to a lack of engagement amongst the less well-prepared students. It is likely that this may have been caused by the way in which the students had approached their learning of mathematics, particularly in terms of metacognitive skills. In general, the less well-prepared students did not feel confident in learning new mathematics topics and relied heavily upon help from their peers. It was apparent from the interviews that the less well-prepared students need the support of their peers in order to tackle mathematics problems with some amount of confidence. Unfortunately, since these students seek help from each other, their learning strategies are often unsuccessful. Similar findings have been found by other researchers. For example, Macrae et al. (2003), in an ESRC study: *Students’ Experiences of Undergraduate Mathematics*, found that failing students frequently socialised with other failing students. Moreover, these students conveyed a general lack of motivation, which was reinforced by their peers. In hindsight, grouping the less well-prepared students together could have helped to nurture these friendships.

In addition, these students failed to monitor and direct their own learning of mathematics during their first semester. Consequently, their learning strategies were generally unsuccessful. The following comments are representative of the less well-prepared students who were interviewed:

LWP 4: “I probably should have worked a lot harder ... I’m not gonna go out of my way to look stuff up.”

LWP 5: “You can’t learn maths without doing the problems ... but I’ve been really lazy. I don’t do any work when I go home.”

LWP 1: “I didn’t really put in enough effort in the first semester. I should have done more work basically.”

In addition, three less well-prepared students, two of whom had failed the module, revealed that they had found the workload too heavy for the mathematics module and so they had only learnt the basics of topics or selected topics that they had felt confident with.

Arguably, for students, the extent of their engagement does not only relate to the amount of hours they put into their studies, but also the amount of reflection they
engage in as learners and their understanding of their positions as learners. Since these students did not engage well in practising the mathematics it is possible that, at that time, they were not aware that their learning strategies required change. Consequently, due to their unchanged and unsuccessful learning strategies these students did not perform well in the mathematics module. Similarly, Hofer and Pintrich (2002) have reported that students’ conceptions of knowledge and learning (‘personal epistemologies’) are related to their educational achievements.

It is worth discussing the relationship between a student’s ability, their engagement and their success in the subject. It may be argued that success in mathematics requires a certain level of ability, and perhaps talent, in that subject. Therefore, active engagement may not necessarily result in success if the student lacks the inherent skills needed. In terms of the present research, this relationship was not investigated further. It is possible that some of the less well-prepared may have failed the module despite being in engaged in terms of behaviour and cognition. However, for others, their failure could be attributed to their apparent lack of motivation. When the students were asked why they hadn’t worked harder the common response was due to laziness or a lack of internal motivation. When the

LWP 5: “...you’re not under the same constraints as you are at school. You’re more relaxed; it’s up to you whether you do the work. You’re not driven by the lecturers like you are by the teachers.”

This comment reinforces the notion that the less well-prepared students find it difficult to adapt to an independent way of learning at university. They have no intrinsic desire to learn mathematics (intrinsic motivation) and without the support of a teacher and less pressure to work (extrinsic motivation), it appears that the less well-prepared students find it hard to motivate themselves to engage with mathematics. Hence, such students fail to engage with mathematics on a cognitive level. It is possible that this behaviour is a repeat of their previous experience, in that the students lacked the motivation to work at school and so they failed to engage which resulted in a poor performance in their exam.
It appears that there is some relationship between the way in which students approach their learning of mathematics, student engagement and their performance in the subject and this requires further investigation.

2.2.2.3 Mathematics Module Assessment

During the interviews the students were asked how they had felt about their module marks for the first mathematics module and their attitudes towards the two assessment methods, namely the coursework and the exam. The three students who had failed the module (all less well-prepared students) expressed feelings of unhappiness with their module marks. These students had expected to pass the module prior to the examination. However, they knew that they had performed poorly in the exam and were then not surprised when they failed.

The general consensus of the less well-prepared students was that they believed that they understood and could 'do' more of the module content than was reflected in their exam mark. There was also a general preference towards the coursework assessment than to the exam assessment. This is not surprising since the less well-prepared students performed much better in the coursework than in the exam.

LWP 1: “I liked the coursework...I could go away and research stuff. In fact I like that better than the exam because I learnt more from that.”

LWP 4: “You’d put more effort into working on a 100% coursework than you would revising for an exam.”

In terms of LWP 1, this student is clearly intrinsically motivated, with regards to the coursework, which results in a cognitive level of engagement. Perhaps this may account for his success in the coursework. Since the less well-prepared students favoured the coursework over the exam, this suggests that the exam assessment has certainly contributed to a lack of mathematics confidence amongst these students.

However, a common perception amongst the less well-prepared students, with the exception of the student who had performed well in the module, was that these students had no high expectations in mathematics.

LWP 4: “I mean I would like to do reasonably well, but I look at it more pass/fail than suppose to what level.”
LWP 6: "I won't be desperately upset if I don't do especially well." "I'm gonna have to try and scrape through... I'm gonna try and pass it."

This reinforces the notion that the students have entered their degree programme with little faith in their own mathematics ability (based upon their previous experience).

In terms of revision and the exam assessment, three students, two of whom had failed the module, revealed that their approach to revising for the end of term exam was unsuccessful. These students expressed how they had either learnt only the basics of topics or only those topics that they had felt confident with;

LWP 3: "There was a lot of topics and I couldn't revise them all. I probably did the easy bits of all the topics, and then when it came to the questions all the marks were at the end and I thought 'I don't know how to do that bit', and that was it."

LWP 6: "I find the bits that I'm comfortable with and hopefully the bits that are worth the most marks generally on [the] paper."

Since the students appear to have lacked motivation to study and failed to monitor and direct their learning, they found that they were not able to revise all the material for the exam. This could also be a legacy from their previous mathematics experience. It is possible that the less well-prepared students did not achieve a higher mathematics qualification since they used this strategy of only learning topics that they felt comfortable with. However, by only learning the basics, the less well-prepared students proved unsuccessful, once again, in their learning approach to mathematics.

Although the less well-prepared students struggled with the exam assessment, it is perhaps their attitudes towards the exam and their learning approaches that have resulted in a poor performance rather than the difficulty of the exam questions. Since the students held no high expectations (based on their previous experience) to achieve particularly high marks and, moreover, because they had failed to take control over their own learning, it is likely that this is the real root of their problems.

Finally, on reflecting upon their experience of mathematics in the first year, the less well-prepared students generally felt quite disheartened. Some students felt that 'more effort' would be required in order to succeed. However, one wonders how these students define 'effort'. Although for some students, it is possible that 'working
harder' would have helped them achieve a higher mark, it is likely that they will also need to adapt their learning approaches in order to ensure long-term success.

On the other hand, one student clearly believed that if they continued in the same manner then eventually everything will become right and they would be at the same level as everyone else.

LWP 2: “I'm hoping that in time it will all start to fall into place. And then I'll be on the same level as everybody else.”

This comment enforces the lack of metacognitive skills amongst the less well-prepared students since this student conveys a lack of reflection on their learning and hence does not actively seek a way of adapting their learning approach to ensure success.

2.4 CONCLUSION

A proactive support system was implemented with a group of less well-prepared physics students with the expectation that if these students were supported effectively then they would feel more able to ‘do’ mathematics, and hopefully a feeling of enjoyment and confidence would emerge from this. To some extent this did occur. Results from the questionnaire showed an increase in feelings of both success and enjoyment in mathematics at university, amongst the less well-prepared students, in comparison to their feelings of school mathematics. However, the students did not respond so positively in their feelings of confidence in mathematics, which may be attributed to the exam assessment.

The use of qualitative research methods has also revealed that many of the less-well prepared students entered university lacking faith in their own mathematics ability. Hence, these students did not expect to perform well in mathematics at university. In terms of the assessment methods, the less well-prepared students expressed a preference for the coursework and many felt that their exam attempt had contributed to their poor performance in the module. However, further analysis of the interview data suggests that their difficulty with the exam may be due to the learning approaches they adopted at university. It appears that the less well-prepared students have lacked
the motivation and understanding needed to adjust to the new style of learning, possibly due to their negative attitudes towards mathematics. It was found that the less well-prepared students felt that they did not apply enough effort in their mathematics modules and hence were not engaging fully with the module or their learning of mathematics. Since the students failed to adopt successful learning strategies, by the time they are examined, at the end of the module, the less well-prepared students must compensate for their lack of effort throughout the semester by choosing topics that they feel confident with to learn for the exam. However, this too usually proves unsuccessful, and a poor exam performance follows. Unfortunately, for the less well-prepared students in this study, their already fragile self-concept was damaged further, resulting in a lack of confidence and, consequently, a lack of engagement in the second semester.

In conclusion, the analysis suggests that a lack of engagement is related to students’ attitudes and the way in which students approached their learning of mathematics. In particular, the less well-prepared students lack cognitive engagement, since they lack some motivation to learn mathematics.

However, it is acknowledged that the issues presented in this section have drawn upon findings from a small scale-study. In particular, only one well-prepared student was interviewed. Whilst the analysis has revealed some key issues that are of importance in understanding student engagement with mathematics and mathematics support, further research is needed. Therefore, the next section will provide a deeper investigation by analysing qualitative data from the 2006/7 cohort of physics students. In particular, findings will be used to examine and discuss the relationship between attitudes and student engagement on a cognitive level, whilst Chapter 8 will present the construct of learning approaches and student engagement.

3. Attitudes of the 2006/7 Physics Students

This section will discuss the attitudes of the 2006/7 cohort of physics students to examine how this construct relates to student engagement with mathematics. Data was collected using an open-ended questionnaire. Details of the methodology and participants will be given before providing a detailed discussion of the results. The
results will be presented by considering the construct of attitudes within five strands: namely, Self-concept of ability, Enjoyment, Motivation, Experience of Teaching and Value/Worth (as highlighted by the literature review in Chapter 2). The section will discuss how the issue of cognitive engagement relates to these constructs.

3.1 METHODOLOGY

3.1.1 THE QUESTIONNAIRE

To further investigate the attitudes and learning approaches of first year Physics students, a questionnaire was designed and administered to the 2006/7 cohort of students. Prior analysis, as discussed in the previous section, indicated that the students’ attitudes towards mathematics may be related to student engagement, particularly in terms of their confidence and enjoyment. It was anticipated that a comparison of the responses from the well-prepared students with the responses from the less well-prepared students would provide an insight as to why the less well-prepared students had failed to engage with the proactive support initiative and how this relates to the success of the support.

It should be noted that a questionnaire was chosen as the method of data collection for a number of practical reasons. The first is that this method would ensure data would be collected quickly and efficiently, since the questionnaire was distributed to the population of students during a lecture slot (as opposed to mailing out the questionnaire). Therefore, response was immediate. Primarily the questionnaire sought to collect qualitative data. However, responses to the questionnaire could also be quantified, framing the results in a scientific construct. Whilst qualitatively the data would provide a narrative layering of textual meaning to the issues at hand, quantifiably the numbers would ‘speak’ for themselves in order to enhance an understanding of the data. In addition, this method was chosen as opposed to interviews or focus groups since such methods had previously proven difficult and time-consuming (see Section 2.2 and Chapter 4), in particular difficulties with recruiting a substantial number of participants. It was anticipated that a questionnaire would reduce some of these issues.

The questionnaire was distributed to the 2006/7 cohort of Physics students on two
occasions. The first distribution occurred on commencement of their degree courses, whilst the second distribution occurred on completion of the first mathematics module. Therefore, responses from the two distributions could be compared to identify whether students' attitudes (and learning approaches) had changed since being at university. A pilot of the questionnaire was carried out in order to test its reliability, validity and practicability. The pilot questionnaire was distributed to eight first year engineering students and two post-graduate students. Results from the pilot revealed that a few minor changes were needed to ensure that students would interpret the questions correctly (see Appendix C for Pilot Questionnaire and Appendix B for Final Questionnaire). Overall, the pilot responses suggested that the questionnaire would provide a rich data-set for analysis.

In terms of the construct of attitudes, the students were asked to respond to the question:

1. *When you were at school, how did you feel about studying mathematics?*

in the first distribution, and:

1. *At university, how do you now feel about studying mathematics?*

in the second distribution. The questionnaire also asked students to supply their Student ID numbers or their previous mathematics qualification, to ensure that all students could be categorised depending upon their mathematical preparedness.

Attitudes (and learning approaches) to mathematics have generally been investigated using quantitative data from questionnaires (eg. ATM scales, see a review of the literature in Chapter 2). However, this study will use qualitative data. The questionnaire used in this study was constructed as a way of collecting a rich data set which could be administered quickly and efficiently. It was anticipated that the data collected would provide similar information to that from an ATM scale questionnaire. Although research involving ATM scales provides a descriptive approach to classifying/measuring attitudes and affect, they do not provide a deeper understanding into how attitudes develop over time. For example, when students are reflecting on
their past experiences, an attitude scale cannot determine which experiences the students are relating to. However, a qualitative response from a student can provide more information on how their attitude has developed at various points in time and to what extent. It is anticipated that qualitative data will provide a basis for further understanding in order to develop existing theories in this field, or at least with the intention of supporting prior research findings.

3.1.2 THE PARTICIPANTS

3.1.2.1 FIRST DISTRIBUTION

The final questionnaire was distributed to all students during a tutorial slot in Week 2 of Semester 1. All students were encouraged to supply their Student ID number. However, students could remain anonymous by omitting this information. Students were also informed that completion of the questionnaire was voluntary. Due to some absences, this resulted in 44 out of 55 possible responses (or 80%), of which 25 (out of 33 or 76%) replies were from the well-prepared students, 14 (out of 22 or 64%) replies from the less well-prepared students and 5 which could not be classified since these students did not supply their Student ID.

Table 7.3 gives details of previous mathematics qualifications of the 39 students who could be classified as well-prepared or less well-prepared.

<table>
<thead>
<tr>
<th>Group</th>
<th>Qualification</th>
<th># of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>LWP</td>
<td>A-level 'D'</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Access course</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Transferred from another university (after failure)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Resit</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Foundation Year (Not Loughborough)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mature student</td>
<td>1</td>
</tr>
<tr>
<td>WP</td>
<td>A-level 'A'</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A-level 'B'</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>A-level 'C'</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Foundation Year (Loughborough)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>International Baccalaureate</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7.3: Previous mathematics qualifications of the respondents to the first distribution of the questionnaire.
3.1.2.2 **SECOND DISTRIBUTION**

The questionnaire was distributed by hand during a lecture slot of the second mathematics module in Week 3 (Semester 2). It should be noted that the support provided for the less well-prepared students was withdrawn at the end of the first semester (see Chapter 6). Therefore, the well-prepared and less well-prepared students were taught together for the second mathematics module. In addition, four students who were registered for the course ‘Sports Science and Physics’ did not take the second mathematics module in their first year. Therefore, the questionnaire was mailed into their department pigeonholes.

The questionnaire was distributed to 53 students in total, since two less well-prepared students had withdrawn from the course. Due to poor attendance, 29 responses were collected in the lecture slot and no students responded to the mailed questionnaire, despite encouragement via e-mail. As in the first distribution, students were informed that completion of the questionnaire was voluntary and that if they wished to remain anonymous they should refrain from supplying their Student ID numbers. Out of the 29 responses, 20 (out of 33) were classified as mathematically well-prepared and 9 (out of 20) were classified as less well-prepared. In addition, 27 out of the 29 students supplied their Student ID number. Thus these responses could be paired to responses from the first distribution.

It should be noted that it is likely that the students who responded to the second distribution of the questionnaire were more likely to be engaged with the mathematics module, since these students account for the 55% of the cohort who had attended the lecture slot. Although attendance regarding the mathematics modules was recorded only amongst the supported group in Semester 1, analysis of these data indicates that the students who responded to the second distribution from the ‘supported’ cohort were regular attendees. Indeed, these students attended sessions, on average, 68% of the time compared to a group average of 40% for the whole cohort of ‘supported’ students (with not one individual student attending less than 47% of the time). Since it appears that these students were generally engaged then it is likely that the whole cohort who responded to the second distribution were also engaged. In addition, it is also likely that these students had a more positive attitude towards mathematics compared to students who were disengaged (this will be discussed in Section 3.2).
3.1.3 Analysis

The analysis of the questionnaire data was originally conducted with the broad aim of identifying key themes rather than specific categories of description. However, during the analysis process it was apparent that responses from the students could be categorised as described by previous research. Therefore, the responses were analysed by categorising quotes that related to attitudinal factors associated with attitudes towards mathematics. It should be noted that in most cases the students’ comments displayed characteristics of more than one attitudinal factor. Therefore, one comment may have been categorised under multiple factors.

Throughout the analysis comparisons were made between the responses given by the less well-prepared students and the well-prepared students.

3.1.4 Practical Problems

Whilst analysing the responses given by the students it should be noted that a number of practical problems arose, which will now be discussed. Due to the nature of this research, the methodology used in this study differed from that used by other researchers. Whilst the literature typically uses some form of inventory (using Likert Scales) to categorise students, this research opted to use a qualitative open-ended approach. This would ensure students were not prompted towards a certain attitude and would ensure a rich data source for further investigation.

However, when investigating which attitudinal factors may have contributed to the students’ attitudes, their qualitative responses may not provide a complete picture. For example, a student may not have commented upon how much they enjoyed or disliked mathematics, possibly because this was not a factor that they readily associated with their experience of mathematics at the time of writing the response. However, this does not mean that the factor should be disregarded when investigating the students’ general attitude towards mathematics. In addition, it should be noted that the responses given by the students were less descriptive in the second distribution compared to the first distribution. This limited the potential analysis of the students’ attitudes in relation to their university experience.
Although the method of data collection has limitations, the use of an inventory would also have its own drawbacks. For example, the questions used in an attitudes inventory often forces the student to respond to a factor, say 'Value/Worth', when it may not be particularly important to them in practice. However, the free-response approach used in this study means that factors a student identifies are important to them. Consequently, a subjective view was imperative when analysing the responses in this study since the responses given may not have been accurate representations of the views and feelings held by the students who gave them. A totally objective interpretation may have resulted in an incomplete picture of their true feelings due to the potential inability of students to accurately describe their perceived beliefs and emotions through written language.

### 3.2 RESULTS - ATTITUDES OF STUDENTS

This section will discuss the students' general mathematics attitudes in relation to their experience of mathematics prior to university and their experience of mathematics at university. It is perhaps obvious that a student who possesses a particularly negative attitude towards mathematics will avoid engaging with the subject, which could lead to failure. Indeed, Dweck (1986, cited in Corral & Antia (2002)) describes how repeated failure often results in a sense of helplessness and distorted perception of reasons for failure and, similarly, Ernest (2000) has outlined how the achievement–attitude link forms self-reinforcing cycles, as can be seen in Figure 7.2. According to Ernest, repeated failure often results in a negative attitude and low confidence towards mathematics and this often leads to an avoidance of the subject.

![Figure 7.2: The failure and success cycles in mathematics, Ernest (2000).](image-url)
However, these cycles do not necessarily apply to all students. Indeed, failure may actually spur a student to work harder and success could cause a student to become complacent, as illustrated in Figure 7.3.

![Diagram](image)

**Figure 7.3: Student behaviour in terms of failure or success in mathematics.**

Nevertheless, this notion suggests that there is some relationship between a student’s attitude, engagement and performance. Therefore, in terms of this study, the attitudes of the less well-prepared students are fundamental in examining their engagement with mathematics and the proactive support initiative.

It is anticipated that the data analysed in this section will reveal what factors were associated with the students’ attitudes, which may relate to their learning of and engagement with mathematics. It is also anticipated that differences in the attitudes of the well-prepared and less well-prepared students will reveal which attitudinal factors may have contributed to the less well-prepared students’ poor performance. The subsequent sections will describe a number of attitudinal factors analysed from the data, which will be supported by illustrative quotes from the well-prepared students (WP), less well-prepared students (LWP) and unidentified students (U).

### 3.2.1 Self-concept of Ability

Analysis of the responses to the questionnaire revealed that a number of students referred to a belief in their perceived ability, which was associated with their perceived competence in mathematics. As such, this was identified as the attitudinal factor of ‘self-concept of ability’. Hence, a student who is not confident in their ability in the subject and feels they have little or no understanding of the subject is regarded as having a negative attitude in terms of their ‘Self-concept of ability’.
Perhaps not surprisingly, such attitudes differed between the well-prepared and less well-prepared students. Recall, that preliminary analysis (in relation to the attitudes of the 2005/6 cohort) indicated that the less well-prepared students generally lacked confidence. Moreover, their experience of university mathematics had reinforced these feelings. The responses from the 2006/7 cohort of less well-prepared students provide further evidence of this. It appears that their experience of mathematics at school influenced their self-concept of ability in mathematics and hence contributed to a negative self-concept.

LWP(S35) "I then moved to a new school...it was a selective sixth form college, so most of the students could pass A-level without teaching. This meant I have struggled with maths since."

LWP(S37) "I used to like studying maths although my attitude was poor. This caused me to be placed in a low teaching set for GCSE maths and although I received an A grade, my knowledge of maths was abysmal. This caused A-level maths to become somewhat of a nightmare and I lost all my enthusiasm."

Furthermore, only two out of the 14 students who were deemed as being less well-prepared expressed any real confidence in their mathematics ability. On the other hand, many of the well-prepared students (approximately 67%) expressed feelings of confidence in their mathematics ability and conveyed a positive self-concept in mathematics. For example:

WP(S13) "Whilst at school maths was one of my more preferred subjects, as I have a natural ability at the subject and GCSE maths came very easy to me.

As summarised in Table 7.4, of the 39 students who could be classified as well-prepared or less well-prepared, 20 students (51%) referred to their self-concept of their ability. 14 (or 58%) comments were related to a positive attitude and 10 (or 42%) were related to a negative attitude. It can be seen that the majority of the responses from the well-prepared group were related to a positive attitude (11 out of 14 or 79%) and that more responses from the less well-prepared group were related to a negative attitude (7 out of 10 or 70%).
<table>
<thead>
<tr>
<th></th>
<th>No. of students</th>
<th>No. of students</th>
<th>No. of comments*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(39)</td>
<td>(25)</td>
<td>+ve</td>
</tr>
<tr>
<td>Self-concept of</td>
<td></td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>ability</td>
<td>20</td>
<td>-ve</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ve</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-ve</td>
<td>7</td>
</tr>
<tr>
<td>WP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14)</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.4: Breakdown of responses with regards to Self-Concept of Ability (1st distribution).

*NB: This column represents the number of comments categorised under this factor and does not reflect the number of students. For example, 20 students were categorised as conveying this attitudinal factor in their response and 11 of those students were well-prepared. However, there are 14 comments relating to these students. Three students commented on a memory portraying a positive self-concept and also a memory portraying a negative self-concept.

It should be noted that the students’ self-concept of ability is influenced, in part, by the ‘external judgment’ of their ability in terms of their previous exam results. Therefore, we would expect students who have not performed well in the subject to hold a negative self-concept of ability since their previous exam performance confirms this.

Comparing the responses received from the second distribution of the questionnaire, as summarised in Table 7.5, it appears university has not helped to improve the less well-prepared students’ attitudes since 60% of the responses, which were categorised to this attitudinal factor, portrayed a negative self-concept.

LWP (S39): “...putting knowledge into practice has proven a major downfall, thus not being prepared well enough going into the exam.”

Further analysis indicates that two of the three less well-prepared students who conveyed a negative self-concept, failed the mathematics module. This could be an indication that the exam had contributed to their negative attitude.

However, all responses from the well-prepared group (from the second distribution) relate to a positive self-concept. Such students emphasised feelings of confidence in mathematics at university, as illustrated by this student:

WP (S6): “Happy! I am now feeling more confident about studying maths, at uni.”

The data suggests that mathematics at university has reinforced a positive self-concept amongst the well-prepared students. However, this is not the case amongst the less
well-prepared group, since some students still do not feel confident in their mathematical abilities. It is likely that this is a result of the ‘Failure Cycle’.

<table>
<thead>
<tr>
<th></th>
<th>No. of students (29)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-concept of ability</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WP (20)</td>
<td>7</td>
<td>+ve</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ve</td>
<td>0</td>
</tr>
<tr>
<td>LWP (9)</td>
<td>5</td>
<td>+ve</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ve</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 7.5: Breakdown of responses with regards to Self-Concept of Ability (2nd distribution).

### 3.2.2 ENJOYMENT

An additional attitudinal factor of ‘Enjoyment’ was identified from analysis of the questionnaire data. In particular, it appears that enjoyment or a lack of enjoyment of mathematics was particularly important in relation to the physics students’ attitudes since this was identified as a common theme amongst their responses. Indeed, from the first distribution of the questionnaire, this factor was identified amongst the highest number of responses, with 25 in total (see Table 7.6 below).

Prior to university it appears that the majority of students held a largely positive attitude in relation to enjoyment of the subject.

WP(S3) “I really enjoyed it [maths], I have always had a passion for the sciences so that has helped when studying maths.”

LWP(S39) “I was very eager to do maths and enjoyed learning it”

Such comments reinforce the notion that ‘enjoyment’ can loosely be translated as attitude, as suggested by Aiken (1972, pg 229) "...term attitude means approximately the same thing as enjoyment, interest and to some extent, anxiety.” Furthermore, it is apparent that if a student enjoys mathematics then they will hold some intrinsic desire to engage with the subject. Since a large proportion of the physics cohort indicated some enjoyment of studying mathematics then it is likely that they were actively engaged in their learning of the subject.
Further analysis indicates that enjoyment in mathematics was closely linked to a student’s prior achievement in the subject (extending from the notion that success is likely to result in a positive attitude).

LWP(S35) “I enjoyed mathematics until I finished my GCSE’s...I have struggled with maths since and hence don’t enjoy it anymore.”

Although this is not always the case (for example a student may have achieved a good grade despite struggling through the subject, which they did not enjoy), many of the students who were identified as well-prepared in mathematics described a fondness and enjoyment of engaging with mathematics and many of those who were identified as less well-prepared did not enjoy studying mathematics and had often struggled with it. However, in their responses, the less well-prepared students tended to compare these experiences with an experience when they felt they had not struggled with mathematics, for example LWP(S35). Again, this reinforces the idea of a relation between a student’s ability (and perhaps performance) in mathematics and their enjoyment of the subject, since generally the less well-prepared students enjoyed mathematics when they felt they could ‘do’ it, but once they started struggling they no longer felt enjoyment. This can be seen in Table 7.6. Although 10 out of the 11 less well-prepared students made a positive comment with regards to enjoyment of the subject, five of these students followed this with a negative comment (such as LWP(S35)).

<table>
<thead>
<tr>
<th>Enjoyment</th>
<th>No. of students (39)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>WP (25) 14</td>
<td>+ve 13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (14) 11</td>
<td>+ve 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- ve 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- ve 5</td>
</tr>
</tbody>
</table>

Table 7.6: Breakdown of responses with regards to Enjoyment (1st distribution).

On the other hand, for some students (both well-prepared and less well-prepared) a sense of enjoyment derived from the ‘challenge’ of mathematics.

WP(S7): “I enjoyed maths...at college maths was more challenging and therefore more rewarding.”
LWP(S41): “I enjoyed studying maths, I liked the challenge.”

However, analysis of the responses from the second distribution reveals a major shift in the attitudes of the students, as can be seen in Table 7.7. In relation to mathematics at university, only five students referred to the subject as ‘enjoyable’ or otherwise (four of whom were from the well-prepared group and one from the less well-prepared group). Moreover, these are the attitudes of students who are possibly more engaged with mathematics. Recall, that the responses to the second distribution were much less detailed compared to those from the first distribution. Hence, this could account for the small number of comments with regards to ‘Enjoyment’. However, it is also possible that some of the variation can be attributed to the importance of this attitudinal factor, particularly in that ‘Enjoyment’ has had less influence with regards to the students’ attitudes towards mathematics at university, compared to their prior experience.

The responses given by the students do not provide clear-cut reasons as to why enjoyment did not particularly influence the students’ attitudes toward mathematics at university. However, it is possible that the students have not yet adapted to mathematics at university and, consequently, are still shaping their opinions and attitudes. In particular, much of the material that the students cover in the first semester is revision of A-level Mathematics, which many students would have already covered. This may have an effect on their enjoyment of mathematics at university, since they may perceive the mathematics as ‘revision’ rather than university material, as illustrated below:

S19 (WP): “Quite enjoy it now [Semester 2] due to the fact that we are now covering new material, whereas last semester was 90% revision.

However, reassuringly, the five responses were related to a positive attitude towards mathematics, indicating that some students have found pleasure in studying mathematics at university. Since these students were engaged with the mathematics module, then it is likely that students who were actively engaged will have a positive attitude with regards to ‘Enjoyment’.
Table 7.7: Breakdown of responses with regards to Enjoyment (2nd distribution).

<table>
<thead>
<tr>
<th>Enjoymemt</th>
<th>No. of students (29)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP (20)</td>
<td>4</td>
<td>+ve 4</td>
<td>- ve 0</td>
</tr>
<tr>
<td>LWP (9)</td>
<td>1</td>
<td>+ve 1</td>
<td>- ve 0</td>
</tr>
</tbody>
</table>

3.2.3 MOTIVATION

In terms of student engagement, motivation is of particular importance, since the two constructs are closely linked. From analysis of the first distribution of the questionnaire it appears that motivation played an important role in relation to the students' attitudes towards mathematics. However, this factor did not emerge in as many responses as the attitudinal factors of Self-concept of ability or Enjoyment. For example the comments below suggest that prior to university these students had a genuine interest in mathematics and a desire to pursue it further.

WP (S29): “I was intrigued since it was all very logical and factual...I wanted to know more.”

WP (S5): “I wanted to be able to do more – to solve more questions in the world and my mind.”

Clearly these students are intrinsically motivated to study mathematics and hence engage with the subject.

Conversely, students who conveyed a lack of motivation had no eagerness to study the subject. Only a small proportion of the students expressed a negative attitude in relation to motivation in mathematics. However, of this small proportion, their attitudes towards mathematics were extremely negative. For example:

LWP (S38): I did not choose to study mathematics, it was a requirement for the course I wanted to study at university. I did not enjoy the lessons as I found the pace we were working at un-bearably fast. The pure mathematics was a problem as I found that after the AS year it became a lot harder.

The above quote also illustrates the existence of a relationship between the different attitudinal factors. For example, since this student does not enjoy mathematics he is
not motivated to engage with the subject. It is likely that a positive combination of several attitudinal factors will contribute to a positive attitude in terms of motivation.

Table 7.8 shows that 11 students (28%) referred to motivation in mathematics. It can be seen that the less well-prepared students were more inclined to comment upon their motivation, or lack of it, in the subject, compared to the well-prepared students. Indeed, three of the less well-prepared students were identified as having a negative attitude in relation to motivation (although one of these also indicated positive motivation). A lack of motivation amongst these students suggests that such students may be less likely to engage with mathematics at university since they already hold a negative attitude.

<table>
<thead>
<tr>
<th>Motivation</th>
<th>No. of students (39)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP (25)</td>
<td>5</td>
<td>+ve</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-ve</td>
<td>1</td>
</tr>
<tr>
<td>LWP (14)</td>
<td>6</td>
<td>+ve</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-ve</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 7.8: Breakdown of responses with regards to Motivation (1st distribution).

Further analysis of the questionnaire responses from the second distribution indicates that ‘Motivation’, as an attitudinal factor, was not as significant compared to the first distribution, since only three students referred to this (see Table 7.9 below), two of whom were identified as being well-prepared and one as being less well-prepared.

Although none of the comments were negative, indicating that the student would like to avoid using mathematics in the future, the majority of students did not indicate that they were particularly motivated to study mathematics at university either. This could suggest that such students are not intrinsically (or extrinsically) motivated to study mathematics, which may affect their engagement with the subject. In terms of the less well-prepared students only one student referred to motivation (in a positive manner) at university compared to four prior to university. However, since it is likely that the students who responded to the second distribution were generally more engaged with mathematics, we would expect them to be more motivated. Since the attitudes of these students generally relate to positive responses, then it is likely that engaged students
will have a more positive attitude towards ‘Motivation’ compared to those that are not engaged.

<table>
<thead>
<tr>
<th></th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motivation</strong></td>
<td><strong>No. of students</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(29)</td>
<td></td>
</tr>
<tr>
<td>WP (20)</td>
<td>2</td>
<td>+ve 2</td>
</tr>
<tr>
<td>LWP (9)</td>
<td>1</td>
<td>- ve 0</td>
</tr>
</tbody>
</table>

Table 7.9: Breakdown of responses with regards to Motivation (2nd distribution).

### 3.2.4 EXPERIENCE OF TEACHING

An interesting factor that emerged from the students’ comments was the students’ attitudes with regards to their experience of the teaching of mathematics. Prior to university, the comments from the students suggest that a good teaching experience is related to a positive attitude towards mathematics and a poor teaching experience is related to a negative attitude towards mathematics. For example;

WP (S8): “I enjoyed studying maths at school due to the quality of the teaching available and dedication of the teachers to answer many questions in their free time.”

WP (S18): “It [maths] was actually fun at school with more interaction between students and teachers... Teachers would explain things a lot more thoroughly going through lots of examples for every sort of question which would be asked in an exam.”

LWP (S37): “I only enjoyed maths when it was being taught by one of my [school] teachers.”

The above comments emphasise the importance of the role of a teacher and how this will affect their attitudes. Indeed, Furner and Berman (2004) state that it is important for teachers to design positive experiences in mathematics classes to help develop positive attitudes in mathematics. The way in which the mathematics is delivered by the teacher can influence the students’ attitudes in terms of their self-concept of ability, enjoyment, motivation etc. In particular, for a number of students in this study who had had a negative experience of mathematics, their initial response was to recall their attitude towards the teaching of the subject:
WP (S9): “When I did the first year of A-level maths I found it a big jump from GCSE and lost the fun in maths...there was a really bad teacher. I realised having a good teacher in maths does really effect the studying and overall achievement.”

WP (S20): “When the teacher would tell us how to do it constantly and repeatedly I would get bored and annoyed as I gained little benefit.”

LWP (S39): “Teaching was performed mainly using slideshow presentations which in reality became a strain, merely copying out text.”

In particular, student WP (S9) is conscious of the effect that the teaching method can have on the way in which he approaches his study of mathematics and his overall achievement in the subject. It is, therefore, likely that if a student has a negative attitude towards the teaching of mathematics then they will fail to engage with the learning of the subject. Again, this emphasizes the important relationship between the different attitudinal factors. It is likely that a positive teaching experience of mathematics will foster feelings of enjoyment of the subject, which in turn will motivate the student to engage further. Hence, a positive attitude will develop and we would expect success and more effort, as described by the Success Cycle (Figure 7.2).

Table 7.10 shows that a higher proportion of the responses were related to a positive attitude than a negative attitude (63% and 37% respectively). In terms of the less well-prepared group, these students commented upon a similar number of good and bad teaching experiences. However, the table shows that this attitudinal factor emerged in a higher proportion of the well-prepared students’ responses compared to the less well-prepared students (60% and 36% respectively). This could suggest that this attitudinal factor played a more important role in influencing the well-prepared students’ attitudes.

<table>
<thead>
<tr>
<th>Experience of Teaching</th>
<th>No. of students (39)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP (25)</td>
<td>15</td>
<td>+ve</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ve</td>
<td>6</td>
</tr>
<tr>
<td>LWP (14)</td>
<td>5</td>
<td>+ve</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ve</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 7.10: Breakdown of responses with regards to Teaching (1st distribution).
Analysis of the responses from the second distribution show similar results. This attitudinal factor was identified in a higher proportion of the responses, in comparison to the other factors. Furthermore only one of the responses attributed to a negative attitude towards mathematics (well-prepared student).

The remaining eleven students felt satisfied with mathematics at university, which they related to the way in which the mathematics was taught. For example:

S9 (WP): "...the lecturers are, in a way, more enthusiastic and teach really well...The lecturers are more organised and easily accessible."

This indicates that the role of a 'teacher' continues to influence the students' attitudes at university. Reassuringly, the responses suggest that the majority of students, so far, have had a positive experience with regards to the teaching of mathematics on their degree courses. In comparison to the first distribution, a larger proportion of less well-prepared students commented upon a positive teaching experience (five responses compared to three). In terms of these students, this could suggest that the role of the 'teacher' has become more important to the less well-prepared students or that this experience of teaching is worth commenting upon.

<table>
<thead>
<tr>
<th>Experience Teaching</th>
<th>No. of students (29)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP (20)</td>
<td>12</td>
<td>7</td>
<td>+ve 6</td>
</tr>
<tr>
<td>LWP (9)</td>
<td></td>
<td>5</td>
<td>+ve 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- ve 0</td>
</tr>
</tbody>
</table>

Table 7.11: Breakdown of responses with regards to Teaching (2nd distribution).

3.2.5 VALUE/WORTH

The final attitudinal factor that was identified during the analysis of the questionnaire responses was that of the perceived value and worth of mathematics. With regards to students' experience of mathematics prior to university, the value of mathematics was commented upon less frequently in comparison to the other attitudinal factors, as can be seen in Table 7.12. However, the related comments from the students were of particular interest. Only one student, who had been deemed as being less well-
prepared, did not particularly feel mathematics to be valuable. However, this was in relation to statistics, which he found “annoying and silly”.

The remaining comments from the Physics students were positive in relation to the value of mathematics, even amongst the less well-prepared. For example;

WP (S13): “Whilst at school maths was one of my preferred subjects... Maths is a key subject to be educated in so it was always an important subject to study.

LWP (S36): “When I was at school I saw mathematics as an essential subject, which was used in some form in each and every subject, especially sciences.”

Such comments illustrate how students perceived mathematics as useful and relevant in their life. Since these students understand the relevance of mathematics and feel that mathematics is valuable in their lives then it is possible that these students will feel motivated to learn new aspects of mathematics, and hence engage with the subject, as found by Meyer and Koehler (1990).

In comparison to the other attitudinal factors, ‘Value/Worth’ was identified as a smaller proportion of the students’ responses (28%), but all but one related to a positive attitude. A reasonable proportion of the less well-prepared students (36%) felt mathematics was valuable to their future whilst only 20% of the well-prepared students commented upon the value of mathematics. This could suggest that the value of mathematics was not perceived by the students as important as other factors in influencing their attitudes towards mathematics. However, it is also possible that these students took it for granted that mathematics is important.

<table>
<thead>
<tr>
<th></th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(39)</td>
<td></td>
</tr>
<tr>
<td>Value/Worth</td>
<td>5</td>
<td>+ve 5</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>- ve 0</td>
</tr>
<tr>
<td>WP</td>
<td>6</td>
<td>+ve 5</td>
</tr>
<tr>
<td>LWP</td>
<td></td>
<td>- ve 1</td>
</tr>
<tr>
<td>(14)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.12: Breakdown of responses with regards to Value/Worth (1st distribution).

In terms of the students’ experience of mathematics at university, it appears that the value of mathematics has become more important in influencing the students’
attitudes, notably amongst the well-prepared students. Indeed, 50% of the well-prepared students commented upon this in the second distribution of the questionnaire, compared to 20% in the first distribution. Analysis of the responses suggest that generally the well-prepared students feel that university mathematics is useful and relevant to their future. Consequently, this has contributed to a more positive attitude towards mathematics.

SS (WP): I enjoy learning new levels of maths and how to apply them to the physics course I am doing and every day problems.”

However, ‘Value/Worth’ was identified in only one of the responses from the less well-prepared students (relating to a positive attitude), although the students did not refer to university mathematics as being valuable or worthwhile for their future, nor did they feel it would be useless. This suggests that amongst the students who responded to the second distribution of the questionnaire, the value of mathematics is not as important in influencing the attitudes of the less well-prepared students in comparison to the well-prepared students. However, since half of the responses from the well-prepared students relate to this attitudinal factor, this suggests that if a student values mathematics then they are likely to engage with the subject.

<table>
<thead>
<tr>
<th>Value/Worth</th>
<th>No. of students (29)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP (20)</td>
<td></td>
<td>10</td>
<td>+ve 10</td>
</tr>
<tr>
<td>LWP (9)</td>
<td>1</td>
<td>- ve</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ve 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ve 0</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.13: Breakdown of responses with regards to Value/Worth (2nd distribution).

3.2.6 FURTHER COMPARISON OF FIRST AND SECOND DISTRIBUTIONS

It should be noted that in the discussion above, comparisons made between the first and second distribution of the questionnaire were taken from analysis of the full sample of responses from each, that is 39 responses from the first distribution and 29 responses from the second distribution. However, only 27 of these responses could be paired between the two distributions. The researcher chose to analyse the responses by using the full data set to ensure that no data was lost. Nevertheless, to make a fair comparison further analysis was conducted with only these 27 responses. This section
will provide a summary of those results (a detailed account of this analysis can be found in Appendix N).

Of the 27 students who completed both questionnaires, only one student (who was deemed as being less well-prepared) had failed the mathematics module. In terms of the well-prepared students, it is anticipated that such students were generally more engaged since they had attended the lecture when the second questionnaire was distributed (only 55% of the full cohort had attended this lecture). The same is also true for the less well-prepared students. Analysis of attendance data from the first semester indicates that these students were generally engaged (average attendance rate of 67%), compared to the ‘missing’ less well-prepared students (average attendance rate of 30%). Therefore, the following analysis was conducted to examine the attitudes of the students who were generally engaged (in terms of behaviour).

Analysis of the 27 responses by comparing over the two distributions indicates similar results to those presented above. However, the responses from the second distribution were much less detailed than those from the first distribution, and so comments tended to reflect only one or two of the attitudinal factors. Generally the physics students’ attitudes towards mathematics were more positive, in relation to their university experience, compared to their experience of mathematics prior to university. This may indicate that students who were engaged with the module had a more positive attitude towards mathematics compared to those who were not engaged.

In terms of the five attitudinal factors that were analysed, ‘Self-concept of ability’ and ‘Experience of Teaching’ have continued to be important with regards to the engaged students’ attitudes towards mathematics. In response to how they felt about mathematics (either at university or prior to university) a notable proportion of students commented upon their perceived ability in the subject or a teaching experience of mathematics (59% and 63% respectively in the first distribution and 41% and 41% respectively in the second distribution). Again, since the majority of these responses were positive (from the second distribution), the data suggests that students who are confident in their abilities and have a positive teaching experience will be motivated to engage with mathematics.
However, there appears to be a notable shift in the engaged students’ attitudes with regards to ‘Enjoyment’ of mathematics. This was commented upon by 20 (out of 27) students in the first distribution, compared to just four in the second distribution. This does not necessarily mean that students did not enjoy mathematics at university, but rather this was not as important in influencing their attitudes compared to their school experience. In addition, students’ attitudes with regards to the perceived value of mathematics have also changed. Four well-prepared students commented upon the value of mathematics in the first distribution compared to nine students in the second distribution. Therefore, it is likely that an engaged student will value mathematics, which in turn may motivate them to engage with the module.

Generally, the initial findings presented in the previous section are further supported when considering solely the responses of the 27 students common to both distributions. Since the 27 students were likely to be engaged with mathematics, it appears that a positive attitude has contributed to their engagement, particularly in terms of their confidence, their attitude to the teaching of the module and their perceived value of mathematics.

3.3 CONCLUSIONS

This section has further investigated the construct of students’ attitudes, in relation to student engagement, as highlighted by preliminary research findings. In particular, a qualitative questionnaire (different from that in Section 2) was distributed to the 2006/7 cohort of students on two occasion, namely, on the commencement of their degree course and again on the completion of the first mathematics module (beginning of Semester 2). Comparisons were made between the two distributions to examine how students’ attitudes had changed since being at university. Comparisons were also made between the well-prepared and less well-prepared students.

A detailed analysis of the data revealed that in addition to the factors of confidence (later renamed by the researcher as ‘Self-concept of ability’) and ‘Enjoyment’, as identified from the preliminary research, the students’ attitudes also related to factors of ‘Motivation’, ‘Experience of teaching’ and ‘Value/worth’ of mathematics. Figure 7.4 provides a summary of the students’ attitudes with regards to these factors and
compares the well-prepared and less well-prepared students' attitudes over the two distributions.

Analysis of the data indicated that the factors of 'Self concept of ability' and 'Experience of teaching' were most influential upon the students' attitudes towards mathematics, since when asked to recall their feeling towards the subject (both at university and prior to this) the majority of students' attitudes related to these factors.

In terms of the well-prepared students, generally they had felt confident in their abilities prior to university and their experience of university had reinforced their confidence in mathematics. In comparison, the less well-prepared students generally lacked confidence in their abilities and such feelings were reinforced since being at university. Although it is perhaps unsurprising that the well-prepared students felt more confident in comparison to the less well-prepared students, it was hoped that the support initiative would help the less well-prepared students to feel prepared for the mathematics on the remainder of their course and hence feelings of confidence would emerge from this. However, this was not the case. Consequently, it appears that this was a key issue in relation to the subsequent lack of engagement.

With regards to students' attitudes to their experience of the teaching of mathematics, this attitudinal factor also emerged as a key issue. A large proportion of students chose to comment upon the teaching of mathematics in relation to how they felt about the subject. Indeed, there was an increase in the number of responses from the less well-prepared students (all relating to a positive attitude) with regards to this factor, in relation to their university experience. This indicates that the role of a teacher is of particular importance to their university experience of mathematics, perhaps more so than in relation to their prior experiences. Undoubtedly, within a school setting, the role of a teacher is perhaps key in relation to a student's attitude towards mathematics. Indeed, studies related to instructional practices (within schools) and academic achievement have suggested that the quality of teachers' instructional messages affects a student's task involvement and subsequent learning in mathematics, Cornell (1999); Dossey, Mullis, Lindquist, & Chambers (1988); Kober (1993). This is perhaps because much mathematics instruction remains teacher-centred and students depend upon a teacher to help guide and support their learning. However, there has been
limited research conducted with regards to the effect of the teaching experience at university on students’ attitudes towards mathematics. Moreover, since mathematics at university is generally student-centred with an emphasis on independent learning, the way in which mathematics is delivered is perhaps not considered as significant (with regards to the students’ learning experience) in comparison to their school experience.

Arguably, it is perhaps not the responsibility of the lecturer to provide a qualitatively positive teaching experience. However, in terms of the students in this study, it appears that the way in which the mathematics is delivered is related to their attitudes towards the subject and, perhaps, it is the way in which students perceive and approach their learning of mathematics which is the real root of a lack of engagement.

The attitudinal factor of ‘Value/Worth’ also provided interesting results. Prior to university, generally the less well-prepared students regarded mathematics as valuable to their future. In comparison, fewer of the well-prepared students chose to comment upon this. However, since studying the subject at university, there was a substantial increase in the number of well-prepared students who commented upon the value of mathematics, indicating that this has become more important in relation to the students’ attitudes. This may be an additional factor that has contributed to the students’ attitudes and, consequently, their engagement with mathematics.

However, in terms of student engagement, these findings can only be used to a limited extent. In particular, data from the second distribution of the questionnaire generally relates to students who were successful in mathematics at university and who were engaged with mathematics (in terms of attendance). These findings suggest that students who hold positive attitudes, particularly with regards to their Self-concept of ability, Experience of Teaching and Value of mathematics will be more likely to engage with the subject. This indicates that to ensure engagement with proactive support, action should be taken considering students’ attitudes and how they can be improved. It is acknowledged that further research is needed to examine the extent of these factors and how they specifically contribute to a lack of student engagement amongst students who had failed mathematics at university and who had failed to engage with the mathematics module. In terms of the research for this thesis,
gathering such data proved difficult. This will be discussed further in Chapter 8 in addition to an analysis of further data (by means of interviews) in an attempt to extend upon these findings.

However, it is worth noting that there is perhaps an additional factor with regards to student engagement that has not been considered here, namely the ability of the student. It is possible that active engagement may not necessarily result in success if the student lacks inherent mathematical skills. Consequently, this could result in disengagement, since students become disheartened by their performance despite the effort they have exerted.

Nevertheless, the findings from this research suggest that from the outset the less well-prepared students were vulnerable to disengagement, particularly due to their prior experience of mathematics (often associated to a lack of confidence). The proactive support was implemented with the intention to nurture a positive attitude amongst these students and to help build their confidence to encourage engagement. However, it appears that the exam assessment demoralised the students resulting in a lack of confidence and disengagement with the support.

This chapter has addressed the issue of students’ attitudes towards mathematics, as indicated from a questionnaire conducted with the 2005/6 cohort of physics students, in relation to student engagement. However, as highlighted by this analysis and from preliminary research (as presented in Section 2), it appears that the way in which students approach their learning of mathematics may contribute to the extent to which they engage with mathematics. The next chapter will discuss the construct of learning approaches to mathematics by examining the responses to the second question from the questionnaire.
Figure 7.4: Summary of the attitudes of the 2006/7 cohort of physics students prior to and whilst at university.
CHAPTER 8 – STUDENTS’ LEARNING APPROACHES TO MATHEMATICS AND FURTHER ISSUES

1. INTRODUCTION

In Chapter 7 it was found that two key issues may have contributed to a lack of engagement with mathematics amongst the physics students, particularly amongst the less well-prepared cohort. These were students’ attitudes towards mathematics and their learning approaches to mathematics. Chapter 7 specifically addressed the construct of students’ attitudes in relation to the 2006/7 cohort of physics students and their engagement with the proactive mathematics support initiative. In particular, it was found that the less well-prepared students’ attitudes differed to those of the well-prepared students, in that they lacked confidence in their abilities, did not relate mathematics as being valuable for their future and relied on the role of a ‘teacher’ to support and guide them. It was also found that students who were engaged with mathematics at university had a positive attitude towards the subject. This chapter will present the second issue of students’ learning approaches and will examine the differences between the two cohorts.

In particular this chapter will analyse further data taken from the questionnaire administered with the 2006/7 cohort of physics students, as described in the previous chapter (Section 3). It will extend the analysis presented in the previous chapter by examining how students approached their learning of mathematics prior to and at university. Preliminary findings indicated that the less well-prepared students had failed to monitor and direct their own learning appropriately to ensure success in mathematics. There were also some issues with regards to a lack of motivation and engagement with their learning. In particular, students had failed to take responsibility for their learning of mathematics, which may have been exacerbated by a lack of pressure at university and a reliance of support from their friends (who also lacked motivation). Therefore, it is particularly important to understand how students approach their learning of mathematics, including their intentions and strategies, in order to further examine student engagement (in terms of cognition). This will be done by examining pre-identified learning approaches (intended for any discipline),
informed by the literature review in Chapter 2, and how these relate to the students' learning of mathematics. The first section will use data from the questionnaire to investigate the way in which Physics students approached their learning of mathematics and will compare the strategies adopted by well-prepared students with the strategies adopted by less well-prepared students. It will also investigate whether the first semester experience has influenced students to change their learning approaches.

In the following section, this chapter will analyse data taken from a number of follow-up interviews to further examine the students' learning approaches. Analysis of the interviews is used to highlight key aspects of the students' individual learning approaches and how these relate to student engagement with mathematics. In particular, it will examine the methods of Procedural and Deep approaches in further detail, to determine the extent to which these categories can be clearly used in the context of learning of mathematics. It will also examine how students approached their learning of mathematics in terms of engagement, particularly whether they were cognitively or superficially engaged. In addition, this section will discuss a number of further issues, with regards to student engagement, as highlighted by the students' comments. These issues relate to the students' attitudes towards and their learning of mathematics. The issue of motivation will provide a basis of this discussion. This discussion will also highlight issues with regards to the 'Pass-culture' amongst students and the effect of 'University-culture' upon their engagement.

The chapter will then conclude with a summary of the findings and will discuss the implications of these findings.

2. LEARNING APPROACHES OF THE 2006/7 PHYSICS STUDENTS

This section will discuss the learning approaches of the 2006/7 cohort of physics students to examine how this construct relates to student engagement with mathematics and with a proactive mathematics support initiative. Details of the methodology, which involved an open-ended questionnaire, will be given before providing a detailed discussion of the results. The results will be presented by considering the construct of learning approaches with reference to four pre-identified
categories; namely, Surface, Procedural, Deep and Strategic learning approaches. The section will discuss how these approaches relate to the learning of mathematics and will also examine the issue of cognitive engagement in relation to these approaches.

2.1 METHODOLOGY AND ANALYSIS

As described in Chapter 7, Section 3, a qualitative questionnaire (which required an open-ended response) was administered to the 2006/7 cohort of physics students. The questionnaire was distributed on two occasions; on commencement of their degree courses and on completion of the first mathematics module (beginning of Semester 2). This section will analyse the responses to a second question from the questionnaire, which sought to examine students learning approaches to mathematics (see Appendix B for details of the questionnaire).

Chapter 7 also described how the methodology used in this study differs from that of traditional research examining students' attitudes and learning approaches. In terms of students' learning approaches, a review of the literature (as presented in Chapter 2) revealed that much of the research in this area has used a survey methodology, for example Biggs' "Study Process Questionnaire" (SPQ), Biggs (1978). As such, students are asked to agree or disagree (based on a Likert scale) with individual statements, which are steered towards certain pre-identified learning approaches. However, for the present research study, the researcher opted to take an open-ended approach to data collection. Initially this approach was taken since the process of administering a questionnaire such as the SPQ can be difficult and time-consuming and was not practical in terms of this research. Using such scales would mean the participants would be required to complete two separate questionnaires consisting of in excess of one hundred questions. However, the methodology that was taken required the participants to answer two open-ended questions, which took considerably less time to complete. Furthermore, this approach was purposely taken since the researcher did not want to pre-empt the participants' responses. Moreover, since there is limited research regarding students' learning approaches towards the discipline of mathematics, the use of the SPQ (or similar) would restrict the results, hence any subtle differences with regards to how students approach their learning of mathematics would not be apparent during analysis. Therefore, the participants were
asked to give a completely open response to ensure that they were not directed towards one particular learning approach and, hence, a rich data set would result.

The students were asked to respond to the following question in the first distribution:

*What strategies do you adopt when learning some mathematics? (approx 50-words)*

And the following question in the second distribution:

*What strategies have you adopted when learning some mathematics at university? (approx 50-words)*

The data were then analysed on two levels. The first entailed identifying characteristics that were related to pre-identified learning approaches intended for any discipline, namely Deep, Surface, Strategic and Procedural. These were informed by the literature review, as presented in Chapter 2. The Deep/Surface model has been taken from Marton and Saljo’s work, characteristics of the Strategic approach have been taken from Biggs’ work and characteristics of the Procedural approach have been taken from Case and Marshall’s work. In particular, the researcher examined the extent to which students could be classified within these categories for students’ learning of mathematics. These can be seen in Figure 8.1.

However, for the second level of analysis, the researcher analysed specific characteristics that were distinctive to students’ learning of mathematics and also compared the learning approaches of students who were deemed as being well-prepared with those who were less well-prepared. These findings will be discussed, with particular reference to the relationship between student engagement and learning approaches to mathematics.

It should be noted that when analysing the responses to the second distribution of the questionnaire, it is assumed that the responses relate to students who were generally engaged with the module, since these students account for the 55% of the cohort who had attended the lecture slot when the questionnaire was distributed. In addition, attendance data from Semester 1 provides further evidence that these students were engaged on a behavioural level (see Chapter 7, Section 3.1.2.2 for details).
Strategic
Intention to obtain highest possible grades
Organise time and distribute effort to greatest effect
Ensure conditions and materials for studying appropriate
Use previous exam papers to predict questions
Be alert to cues about marking schemes

Deep
Intention to understand
Vigorous interaction with content
Relate new ideas to previous knowledge
Relate concepts to everyday experience
Relate evidence to conclusions
Examine the logic of the argument

Procedural
Gain understanding through familiarity
Practice numerous problems to learn methods
Relate formulae to each other
No relation to underlying concepts or theories

Surface
Intention to complete task requirements
Memorize information needed for assessments
Failure to distinguish principles from examples
Treat task as an external imposition
Focus on discrete elements without integration
Unreflectiveness about purpose or strategies

Figure 8.1: Learning approaches and their defining characteristics (taken from Marton & Saljo (1976), Biggs (1978) and Case & Marshall (2004))

2.1.1 PRACTICAL PROBLEMS

It should be noted that the analysis of the students’ responses proved immensely difficult (as discussed in Chapter 7 with regards to students’ attitudes). Three researchers individually categorised the responses using the characteristics in Figure 8.1. However, since students were required to given an open-response without any prompt of how to answer the question, it is possible that the responses do not provide a full picture of how students approached their learning. In particular, students may only recall specific parts of information from their memory, such as this student:

WP (S2): “It helps to go through the notes after the lectures. I find the tutorials very helpful.”

Whilst this response provides vital information with regards to the way in which the student approaches their learning, it does not provide a deeper insight. For example, the student expresses that he uses the tutorials to help with his learning. However, he does not indicate how often he attended the tutorials or what he accomplished during the tutorial sessions. A Surface learner may attend the session to complete a task
without any reflectiveness. A Deep learner may attend the session to gain a deeper understanding of a problem or topic by examining concepts more closely. Without this information, this student could not be categorised as taking a specific approach.

In addition, some students could be classified as using more than one approach. For example this student could be classified as a Deep or Surface learner:

WP (S26): “Repetition of practice questions until the action becomes autonomous. Memorise formula by visualising their position among notes. Discussing concepts with others to understand from their perspective.”

The first part of this response indicates that the student is a Surface learner, since they use methods such as memorisation and repetition with an intention to reproduce rather than understand. However, the latter part of the response indicates a Deep learner, since the student has some intention to understand and conveys interaction with the content.

Moreover, some characteristics of Surface learning can be imperative when learning mathematics. For example rote learning can be an integral part of learning mathematics and could be used by a Deep learner. Many mathematics academics value a ‘drill and practice’ routine and this approach can be deployed intelligently to further higher-level educational aims. However, these methods must be used holistically in order to achieve long-term understanding, as opposed to achieving a short-term goal. This suggests that the Surface/Deep model of learning approaches, commonly used within the literature, is not completely generic for mathematics and possibly other disciplines. This will be discussed in more detail within Section 2.2.

Whilst the data collected provides a good basis for preliminary analysis, it is possible that not all students have been correctly identified as using one of the four learning approaches: Deep, Surface, Procedural or Strategic. The data does, however, provide a relevant insight into how the students approach their learning of mathematics and whether they adapt to a different way of learning at university.

It is anticipated that there will be differences in the way in which the well-prepared and less well-prepared students have approached their learning of mathematics, as highlighted by preliminary research (presented in Chapter 7). The next section will
examine data from both distributions of the questionnaire to investigate how the two cohorts have adapted to learning mathematics at university in order to ensure success. Since results from the questionnaire administered to the 2005/6 cohort (see Chapter 7) suggested that the less well-prepared had found it difficult to adapt to learning at university, it was anticipated that the 2006/7 less well-prepared students may have failed to adopt successful strategies and this may lead to a poor performance in their mathematics module.

2.2 RESULTS - STUDENTS’ LEARNING APPROACHES TO MATHEMATICS

This section will discuss the results of both distributions of the questionnaire. It will first discuss the characteristics of Surface, Procedural, Deep and Strategic learning approaches and the extent to which these characteristics were identified amongst the Physics students. It will also discuss the extent to which these learning approaches can be used to describe ways in which students approach their learning of mathematics. Further analysis will be presented to examine whether students had changed their strategies to learning mathematics since being at university by comparing these against the strategies they had adopted prior to university. The subsequent sections will describe the four learning approaches, which will be supported by illustrative quotes from the well-prepared students (WP), less well-prepared students (LWP) and unidentified students (U).

2.2.1 SURFACE APPROACH

As discussed in Section 2.1, there are a number of defining characteristics that can be recognised amongst students in order to identify a Surface learning approach. The most frequent feature of this approach that was identified amongst the physics cohort was that students would practise methods by completing numerous problems.

WP (S20): "I read a few examples before attempting numerous questions myself. I believe moving through many questions at your own speed is the most beneficial way to study as when you reach a problem in an exam the answer comes as second nature."

LWP (S38): "Practice questions from either a workbook or past exam papers. When an exercise is complete I check my answers, take note of the problems I got wrong and then try them again. Repeating this until all questions are correct."
Students emphasised the need to practice methods in order to learn the mathematics. Although this approach can be considered as fundamental to the learning of mathematics (and this is a key characteristic of a Procedural learner, as discussed later), students who take a Surface approach to this method will have an intention to reproduce the knowledge and procedures rather than an intention to learn the procedures for meaning and understanding. Unlike a Procedural learner, a Surface learner will not attempt to relate formulas to each other. In the case of WP (S20) and LWP (S38), since these students indicate no intention to gain understanding from practice and appear to be completing short-term goals, then these students were classified as taking a Surface learning approach (it should be noted that WP(S20) was also classified as using Strategic methods in terms of learning material with an emphasis on the exam assessment).

Another popular Surface strategy amongst the physics students was the memorization of facts or formulae. For example;

WP (S26): "I memorise formulae by visualizing their position amongst the notes."

U (S32): "I find that rather than trying to learn and understand the methods, it was easier to memorise formulas."

Using this strategy allows the student to memorise key information with an intention to reproduce. However, as a result, the student will have little understanding of its purpose or meaning. Arguably, when learning mathematics, some element of memorisation is fundamental, for example remembering trigonometric identities such as \( \sin^2(x) + \cos^2(x) = 1 \). However, if a student is merely using memorisation in order to reproduce, with little regard of how this relates to other aspects of mathematics, then this indicates a Surface learner, as in the case of U (S32).

In addition, students who were unreflective in their mathematical thinking were identified as using Surface learning techniques. Such students did not appear to integrate other mathematical concepts or prior knowledge when learning new material. Nor did they take time to understand the purpose of mathematical concepts or strategies.

WP (15): "[I] Don’t find lots of notes useful because I don’t ever tend to go back to them."
LWP (S37): "I can't honestly say I adopt a strategy. I attend lectures and will do well in exams. Or if it is a module I do not enjoy then I may turn up and just write notes without trying to understand."

It should be noted that the method of rote learning and repetition is not synonymous with Surface learning, however, the intention behind these methods is important. If a student learns by rote in order to have facts at hand to be slotted into an argument, if they are looking at their learning holistically, then this is not Surface learning. If a student is merely rote learning in order to reproduce without any reflection then this indicates Surface learning. However, repetition alone will not provide a deep understanding of the purpose of the material. Without this understanding, students will find it difficult to apply their knowledge to real problems outside of the learning environment. Furthermore, students are likely to forget procedures they have learned without understanding.

### 2.2.2 Procedural Approach

Analysis of the responses indicated that a number of students adopted some Surface methods to their learning of mathematics but they could not be clearly categorised as a Surface learner. These students adopted more substantial learning methods than memorising facts and formulae but they did not attempt to relate mathematical concepts to underlying theories. These students were classified as using a 'Procedural' learning approach since they lie between the classic 'Surface/Deep' learning continuum. Similar to the Surface learners, students using these strategies were willing to accept mathematical concepts without any initial understanding and nor did they relate new ideas to previous knowledge. However, they do possess an intention to understand the mathematics at some future point, usually after working on many questions.

For example, the following less well-prepared student described his learning approach to mathematics:

LWP (S36): "The main strategy I adopt to learn maths, was after learning something new, I would apply the methods learnt straightaway and do as many example questions as I could. This has always helped me to understand and memorise new processes and methods taught to me."
This student describes how he attempts to gain some understanding of new mathematical processes. However, since he does not relate the new theory to prior concepts and appears to focus on the application of the theory to problem solving, then this student can be classified as a Procedural learner.

Conversely, the following well-prepared student was also categorised as a Procedural learner:

WP (S18). "I tend not to understand the maths until I have done lots of questions on it. This means I don't usually understand until just before the start of an exam."

Similar to the less well-prepared student, this student indicates that although his learning approach did not centrally focus on understanding, his expectation is that he would gain the understanding through the use of practice and repetition.

2.2.3 Deep Approach

Students who approached their learning of mathematics by attempting to understand mathematical concepts and theories were classified as taking a ‘Deep’ learning approach. One feature that was recognised as Deep learning, and exhibited amongst these students, was an intention to understand the subject knowledge.

WP (S4): "I find that reading examples of different types helps because it enables you to see how a specific rule/formulae works in different situations and not just in one situation. I have to understand how the formulas are useful in mathematics and when to use them, not just how to use them."

WP (S29): "I think you must first have all the theory explained and all the formulas derived so you can see how everything fits together. Once you understand where it came from and what it's used for then you can get stuck into applying the formulas.

These students also describe how the content becomes meaningful to them, which contributes to a better understanding of the subject.

Another feature of a Deep learner is that students will understand the need to make connections between new knowledge and their existing knowledge. The following students illustrate this:

U (S28): It helps to read over some basic principles so I can understand the derivation and how a particular solution works."
LWP (S42): "I have a general interest in logical systems, so if there is any strategy, it's to understand it from base principles."

It is widely believed amongst educationalists that a deep learning approach is preferential in order to succeed in mathematics at university. Gibbs (1994) has argued that adopting a Surface approach in Higher Education courses (not specifically mathematics) will lead to poor marks and degrees, since the assessment system rewards a Deep approach. However, it may be argued that assessment methods for mathematics, particularly service mathematics, rewards a Procedural approach, since students can achieve marks by reproducing and working through methods. Therefore, it is possible that students who have adopted this approach will also be successful in their mathematics module, perhaps more successful than a Deep learner.

Although it is recognised that some students from both the well-prepared and less well-prepared cohorts had adopted Deep learning strategies when learning mathematics prior to university, there are still several Physics students who may benefit from adopting a Deep approach to their learning of mathematics at university, in order to ensure long-term understanding and success at university.

### 2.2.4 STRATEGIC APPROACH

A final learning approach, which was identified amongst the Physics cohort of students and is described in Figure 8.1 (in Section 2.1), is the Strategic approach. Students who were deemed to be Strategic learners focused on achieving the highest grade possible by learning routine topics and mathematical procedures for examination purposes. For example, strategic learners will use previous exam papers to predict questions. Therefore, specific mathematical topics and methods are generally learned regardless of their importance. This is illustrated below:

LWP (S17): "I think how they are going to ask me a question about this [maths topic] in the exam and then make sure I understand how to answer the bad boy."

Another feature of a strategic learner is that the student will use his/her learning time economically, again with an emphasis on the exam assessment. This is illustrated by the following response:
WP (S19): “I understand as much theory (derivations etc.) in the time I have and make sure I know all the necessary techniques for the exam.”

Strategic learners will assess the level of effort they need to exert in order to achieve success. Thus, compared to the Surface approach, the strategic approach will often lead to a better educational outcome. However, students only engage on a superficial level and may still lack any real understanding of the mathematical concepts.

2.2.5 Students’ Learning Approaches Prior to University

Analysis of the responses to the first distribution to the questionnaire indicates that generally the 2006/7 cohort of students adopted a range of strategies when learning mathematics prior to university. Indeed, eight students were classified as using more than one approach to their learning. Five students were classified as ‘Procedural/Strategic’, two as ‘Surface/Strategic’ and one as ‘Surface/Procedural’. As such, Table 8.1 shows the percentage of students classified as using each of the four learning approaches. It should be noted that a student who was classified as using two approaches was categorised as a ‘half’ in each.

<table>
<thead>
<tr>
<th>Number of students (43)</th>
<th>Surface</th>
<th>Procedural</th>
<th>Strategic</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%)</td>
<td>11 (26%)</td>
<td>10½ (24%)</td>
<td>8 (19%)</td>
<td>13½  (31%)</td>
</tr>
</tbody>
</table>

Table 8.1: Breakdown of students into the four learning approaches (prior to university).

In their responses, the majority of students (33 out of 43) indicated that they had adopted some form of “drill and practice” routine. Twelve of these students were identified as using a Procedural strategy, in the expectation that an understanding of the mathematics would be achieved through familiarity of solving problems. However, fourteen of the students were identified as using a Surface approach, whereby they had implemented a rehearsal strategy with no intention to understand. On a cognitive level, this indicates superficial engagement with the learning of mathematics since students will exert minimal amount of effort with little understanding of the material.
Ten students had indicated the use of Strategic learning approaches, such as using past exam papers to predict questions. Similar to the Surface learners, such strategies indicate superficial engagement with mathematics since students will only apply as much effort as required to achieve their short-term goals.

However, 15 students conveyed characteristics of Deep learners. Their responses indicated elements of self-regulation, persistence and elaboration of material. This indicates that students were cognitively engaged with mathematics.

In terms of the well-prepared and less well-prepared students, their responses indicate that there are differences in the way in which the two cohorts approached their learning of mathematics (see Table 8.2). Indeed, the majority of less well-prepared students were characterised as taking a Surface or Procedural approach to their learning, suggesting that prior to university such students were more likely to approach their learning of mathematics with an intention to reproduce rather than to understand. Only three students from the less well-prepared students indicated using Deep strategies, all of whom had achieved an A-level grade D in Mathematics. On the other hand only four well-prepared students used Surface strategies whereas ten indicated using Deep strategies.

<table>
<thead>
<tr>
<th></th>
<th>Surface</th>
<th>Procedural</th>
<th>Strategic</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%), No. (%), No. (%), No. (%)</td>
<td>3½ (14%)</td>
<td>6 (24%)</td>
<td>6 (24%)</td>
<td>9½ (38%)</td>
</tr>
<tr>
<td>Number of WP* students (25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of LWP students (13)</td>
<td>4½ (35%)</td>
<td>4½ (35%)</td>
<td>1 (8%)</td>
<td>3 (23%)</td>
</tr>
</tbody>
</table>

*LWP - less well-prepared, WP - well-prepared

Table 8.2: Breakdown of the less well-prepared and well-prepared students into the four learning approaches (prior to university).

It appears that the well-prepared students were more likely to engage with mathematics prior to university on a deep cognitive level compared to the less well-prepared students who seemed to engage on a superficial level. Since the two cohorts
show signs of different levels of engagement with mathematics prior to university, it is possible that this may affect the way in which they engage at university. This will be investigated in the following section.

2.2.6 Students’ Learning Approaches at University

Analysis of the responses to the second distribution to the questionnaire indicates that some students have adapted their learning approaches since being at university. However, by considering only the 27 students who completed both distributions of the questionnaire, it should be noted that these results relate to students who generally performed well in the mathematics module, since only one student failed, and it is likely that these students were actively engaged (in terms of attendance), as discussed in Chapter 7, Section 3.

However, in terms of these students, their responses indicate that they had adopted Procedural and Deep strategies at university. Indeed, only one student was characterised as a Strategic learner (who was deemed as being well-prepared) and four as Surface learners (three of whom were deemed as being less well-prepared). Table 8.3 shows the proportion of students classified as using each of the four learning approaches.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Procedural</th>
<th>Strategic</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Number of students (27)</td>
<td>4 (26%)</td>
<td>12 (24%)</td>
<td>1 (19%)</td>
</tr>
</tbody>
</table>

Table 8.3: Breakdown of students into the four learning approaches (at university).

The data indicates that students have adapted their learning approaches to mathematics whilst at university. In particular, there has been an increase in the proportion of students adopting a Procedural approach. On the whole, the physics students have adapted well to university, since very few students indicated they had used Surface strategies and a notable proportion of students had adopted Deep strategies, which indicates cognitive engagement and empirically predicts success, Gibbs (1994). Indeed, these students had performed well in the mathematics module
(only one student had failed) and were actively engaged with the module (in terms of attendance). It appears that such students were engaged on both a behavioral and cognitive level. However, since data was not available for students who were generally disengaged (because they had not regularly attended timetabled sessions), we cannot determine whether this lack of engagement is related to their learning approach. It is possible that these students had not adopted successful strategies. However, further research is needed to investigate this further.

Analysis of the well-prepared and less well-prepared cohorts (see Table 8.4) shows that far fewer well-prepared students (from the second distribution) were characterised as using a Strategic learning approach at university (only one student). Prior to university eight students indicated using this approach to their learning of mathematics. The data does not indicate the reasons behind the drop in Strategic learners, however, it is possible that this is related to the way in which the mathematics is delivered at university. For example, the lecturer may not have used past exam papers during timetabled sessions. Nevertheless, it appears that since being at university these students have changed their strategies to a Deep or Procedural approach. This indicates a deeper level of cognitive engagement since students are exerting more effort through their persistence to learn and understand the subject.

<table>
<thead>
<tr>
<th></th>
<th>Surface</th>
<th>Procedural</th>
<th>Strategic</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Number of WP* students (18)</td>
<td>1 (6%)</td>
<td>8 (44%)</td>
<td>1 (6%)</td>
<td>8 (44%)</td>
</tr>
<tr>
<td>Number of LWP students (9)</td>
<td>3 (33%)</td>
<td>4 (44%)</td>
<td>0 (0%)</td>
<td>2 (22%)</td>
</tr>
</tbody>
</table>

*LWP = less well-prepared, WP = well-prepared

Table 8.4: Breakdown of the less well-prepared and well-prepared students into the four learning approaches (at university).

In terms of the less well-prepared students (from the second distribution), the proportion of students using Surface strategies has remained the same. Moreover, no students indicated using a Strategic learning approach. However, there has been an increase in the proportion of students using Deep strategies. It should be noted that
due to the small sample size (9 less well-prepared students), this difference only relates to one student. Therefore, such results cannot be used to generalise for the whole group. A more detailed examination of how the students' individual learning approaches have changed will be discussed in Section 2.2.6.

Nevertheless, in terms of the whole cohort of students, the majority of the responses to the second distribution of the questionnaire were categorised as Deep or Procedural strategies. With regards to the present study, valuable data with regards to the students' learning intentions was often missing, due to the open responses from students. Such information may have helped to clarify which strategies these students were in fact using. However, it is also possible that the characteristics of Deep and Procedural learning approaches need to be redefined for the learning of mathematics, to account for their similarities.

Such difficulty with distinguishing specific learning approaches within the discipline of mathematics has been highlighted by other researchers. Indeed both Biggs et al (2001) and Ramsden (1997), who individually determined specific learning approaches and measurement devices, have since acknowledged the need to revise their work. In particular, they highlight the difference between learning in the arts and learning in the sciences, and suggest the need to redefine learning approaches depending upon these areas. Indeed Biggs states:

"A generic way of describing 'what the student does' is precisely in terms of their ongoing approaches to learning...A student who typically picks out likely items for assessment and rote learns them, finds that strategy won't work under portfolio assessment, so goes deep...It is therefore quite inappropriate to categorise students as 'surface' or 'deep' learners on the basis of SPQ responses, as if an approach score measured a stable trait of the individual." Biggs et al (2001 p.136)

Ramsden highlights this issue further;

"...a deep approach to learning tasks in science departments often demands an initial concentration on details which is empirically hard to separate from a surface approach. This means that the descriptive category needs to be redefined somewhat in order to include this prior stage." Ramsden (1997, p.210)

Both Biggs and Ramsden (as well as other researchers such as Marton and Entwistle) have acknowledged the complexity of students' approaches to learning and the
disparity of these approaches between disciplines. In particular, they speculate that learning within science requires an emphasis on procedure and memorisation, which may not be inferior to deep approaches. Consequently, the way in which students approach their learning in science subjects may not be easily defined.

2.2.6 Learning Approach and Performance in Mathematics

Due to the small sample size, comparisons made between students’ learning approaches to mathematics prior to university and at university are very difficult to generalise from the data. Therefore, further analysis was conducted by examining how individual students’ learning approaches had changed and whether these correlated to their performance in the mathematics module. Figure 8.2 (see Appendix O) illustrates how the Physics students (comparing the 27 students who had completed both questionnaires) had adapted their learning of mathematics whilst being at university. Due to the complexity of the data, this section will only give a brief overview of the findings. However, a full analysis of this diagram is given within Appendix O.

The diagram illustrates that when learning mathematics at university the majority of the Physics students adapted their learning approaches, since 18 out of 27 (67%) students adopted a different learning approach at university compared to the approach they had adopted previously. However, those with better qualifications in the same category tend to perform better in the mathematics module. For example, within the Procedural category, A-level grade B students achieved module marks of 71% and 69% respectively compared to A-level grade C students who achieved module marks of 42%, 45%, 50%, 58%, and 60% respectively.

In terms of Surface learners, students who had adopted this strategy prior to university, but had changed their approach since, performed better in the mathematics module compared to students who had adopted a Surface approach since being at university. Interestingly the student who had failed the mathematics module had taken a Surface approach to his learning of mathematics at university, indicating superficial cognitive engagement.
Students adopting Deep learning strategies tended to perform better in the mathematics module compared to students who had adopted one of the other approaches, since they attained an average mark of 66%. Procedural learners also achieved a reasonably good average of 60%. This suggests that it is likely that students who adopt Deep or Procedural strategies and hence, are cognitively engaged, will be successful in mathematics at university. However, since the data relates to a very small sample size, there is not enough evidence to support a general hypothesis that Deep or Procedural learners will outperform other learners in mathematics at university.

The findings from this data suggest that the sample of students were generally engaged on a cognitive level as well as a behavioural level. It appears these students were aware of the need to adapt their learning of mathematics to ensure success at university and, as such, the majority of students elected to use Deep or Procedural strategies.

2.3 CONCLUSIONS

This section has analysed questionnaire data to examine the issue of student engagement with regards to how the physics students approached their learning of mathematics. In terms of the well-prepared and less well-prepared students, prior to university, the two cohorts generally adopted different approaches to their learning of mathematics. In particular, the well-prepared students were more likely to engage with their learning on a more cognitive level compared to the less well-prepared students who seemed to engage on a superficial level. Since the two cohorts conveyed different levels of engagement with mathematics prior to university, it is possible that this may relate to their engagement with mathematics at university.

Since the data regarding the students' learning approaches at university relates to students who were generally engaged (in terms of attendance) and had passed the mathematics module, it is impossible to determine a relationship between learning approach and a lack of engagement. However, it appears that students who were engaged on a behavioral level (i.e. regularly attending their timetabled sessions) were
also engaged on a cognitive level, since the majority of students adopted Procedural or Deep strategies to their learning of mathematics.

Whilst most students could easily be categorised as using just one of these approaches, a number of students conveyed characteristics of more than one of the approaches. In addition, categorising the responses with regards to the Deep and Procedural categories proved particularly difficult, since a student’s intention is necessary when describing their learning approach. In some cases this meant that students could not be easily categorised as using one of the approaches. Such problems highlight the limitations of the methodology of this research. Furthermore, they also suggest that the Surface/Deep model of learning approaches, which is most commonly used within educational research, may have limited applicability to mathematics.

From the literature, it is suggested that in order to ensure success at university students would need to adopt a Deep learning approach. However, since the nature of mathematics, in particular service mathematics, is to test competency of procedures rather than understanding it was anticipated that some successful students would have adopted a Procedural approach. The data has shown that some students did adapt their learning approaches to university mathematics. In particular, an increase of Procedural learners was evident amongst both cohorts. However, the proportion of students adopting Deep strategies remained approximately the same. Since a Deep approach indicates cognitive engagement and is likely to lead to a better understanding of subject knowledge, we would hope students would adopt this approach. However, the increase in students adopting Procedural strategies suggests that students are engaging on some form of cognitive level since they are learning by regular practice of procedures in order to acquire the necessary skills and, hoping, some understanding will emerge from this. However, since a large proportion of students changed their learning approach to Procedural or Deep mathematics at university it is concluded that further investigation of these two approaches is needed to clarify a distinction within the discipline of mathematics.

It is suggested that a more rigorous approach is needed to confirm the findings presented in this section and to further investigate how learning approaches to
mathematics relate to a lack of engagement. Although this was not possible in the scope of the present research, a number of follow-up interviews were conducted with some students to gather additional data with regards to attitudes and learning approaches. These data will be presented in the next section to examine student engagement within this construct.

3. FOLLOW-UP INTERVIEWS

Details of the follow-up interviews and the findings from these will now be discussed. In particular, this section will examine issues regarding student motivation, the 'pass culture', 'university culture', and learning at university.

3.1 METHODOLOGY

All physics students from the 2006/7 cohort were contacted via e-mail or were approached during a timetabled session and were invited to take part in a short interview. The interview aimed to gather additional data with regards to the students' learning strategies at university and also their attitudes towards mathematics and the support initiative. In particular, students who were deemed as being 'disengaged' (in that they had failed to regularly attend their timetabled sessions) were targeted, since limited data had been gathered previously with regards to those students.

Ten students agreed to participate in an interview, six of whom were deemed as being less well-prepared and four were well-prepared. As in previous attempts to recruit students for the research in this thesis, recruitment of participants for interviews proved immensely difficult, particularly since disengaged students were targeted. This may indicate that students, who failed to engage with the mathematics module and the support initiative, were generally disengaged with their courses, and possibly university, as a whole. As a result the students who were interviewed were either regular attendees or exhibited moderate attendance (it should be noted that attendance was only recorded amongst the less well-prepared group). The average attendance for the cohort was 40%. However, the students interviewed had attended 41% of the time, or more. A breakdown of the students, in terms of preparedness, attendance and module results, can be seen in Table 8.5. The table also shows the students' learning approaches to mathematics, as determined by their questionnaire responses.
Table 8.5: Breakdown of students in terms of preparedness, attendance and module result and learning approach.

<table>
<thead>
<tr>
<th>Student</th>
<th>Preparedness</th>
<th>Preparedness</th>
<th>Attendance</th>
<th>Mark</th>
<th>Learning approach (prior uni)</th>
<th>Learning approach (at uni)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LWP</td>
<td></td>
<td>41%</td>
<td>24%</td>
<td>Surface</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>LWP</td>
<td></td>
<td>47%</td>
<td>69%</td>
<td>Surface</td>
<td>Procedural</td>
</tr>
<tr>
<td>3</td>
<td>LWP</td>
<td></td>
<td>47%</td>
<td>73%</td>
<td>n/a</td>
<td>Procedural</td>
</tr>
<tr>
<td>4</td>
<td>LWP</td>
<td></td>
<td>53%</td>
<td>44%</td>
<td>Procedural/Deep</td>
<td>Surface</td>
</tr>
<tr>
<td>5</td>
<td>LWP</td>
<td></td>
<td>56%</td>
<td>35%</td>
<td>Surface</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>LWP</td>
<td></td>
<td>94%</td>
<td>56%</td>
<td>Deep</td>
<td>Procedural</td>
</tr>
<tr>
<td>7</td>
<td>WP</td>
<td></td>
<td>n/a</td>
<td>49%</td>
<td>Deep</td>
<td>Strategic</td>
</tr>
<tr>
<td>8</td>
<td>WP</td>
<td></td>
<td>n/a</td>
<td>51%</td>
<td>Strategic/Surface</td>
<td>Deep</td>
</tr>
<tr>
<td>9</td>
<td>WP</td>
<td></td>
<td>n/a</td>
<td>58%</td>
<td>Deep</td>
<td>Deep</td>
</tr>
<tr>
<td>10</td>
<td>WP</td>
<td></td>
<td>n/a</td>
<td>70%</td>
<td>Deep</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Each student was interviewed individually prior to the first mathematics module exam. Therefore, students were not yet aware of their success (or failure) in mathematics at university, by means of module marks.

A semi-structured interview approach was used, whereby the researcher used an interview guide as a basis for the interview. However, the questions could be modified or omitted based on the direction of the interview, Robson (2002). Each interview lasted for approximately 30 minutes. All sessions were audio recorded and transcribed by the researcher (a selective transcription approach was taken owing to time limitations). Analysis of the transcripts revealed a number of common themes that can be associated with a lack of student engagement with mathematics and mathematics support, which will now be discussed. The first will further investigate students’ learning approaches towards mathematics, particularly by comparing the students’ interview comments with their questionnaire responses. The second will examine further issues with regards to the students’ learning of mathematics and their attitudes toward mathematics as highlighted by the students within the interviews.
3.2 Results - Learning Approaches

This section will discuss further findings with regards to students’ learning approaches to mathematics, by presenting data from four of the ten interviews. Although all ten interviews were analysed, the students presented below were chosen by the researcher as a means to highlight key aspects of the students’ learning approaches (although analysis of all ten students can be found in Appendix P). In particular, the researcher chose to examine specific students whose strategies reflected the four different learning approaches.

Generally, the analysis indicates that the qualitative method used to collect data with regards to students’ learning approaches (see Section 2) was, on the whole, reasonably accurate, particularly with regards to those who were classified as Surface or Strategic learners. However, the analysis also reiterates the difficulty in distinguishing between Deep and Procedural learners in mathematics. Whilst some students could clearly be identified as using Deep approaches (such as Student 9, see Appendix P) others were not so apparent (such as Student 6). This will be discussed below.

3.2.1 Student 1

Student 1 was classified as using Surface strategies prior to university. However, he did not complete the second questionnaire and so his approach to learning university mathematics could not be identified. This student also appeared to be disengaged (in terms of behaviour) since he attended sessions only 41% of the time.

Analysis of the interview data indicates that Student 1’s comments were in harmony with his orientation towards Surface methods, particularly that of rote learning.

"I read through the written notes I made myself and perhaps a bit of the workbook...I’ll just try questions from the workbook or maybe from a handout in the lecture. I take an easy one a moderate one and a hard one usually. So if there is nine, I’d do the first one, the middle one and an end one...with the few problems I continue to get wrong do some more until I get them right”

It is clear that this student has no intention of gaining an understanding of the mathematics but rather concentrates on duplicating methods to get a correct answer. It
appears that Student 1 lacked cognitive engagement in addition to lacking behavioural engagement.

However, the student also showed some tendencies towards Strategic approaches, which he may have developed since coming to university.

"I'll practice them [past exam questions] more because most past papers have the rough same kind of set up don't they, because you can practise answering the same kind of questions because they're roughly the same but with different figures really...it's about getting the marks really"

Generally, it appears that Student 1 had adopted learning techniques that would achieve short-term goals, indicating superficial engagement with mathematics.

3.2.1 Student 6

Initially Student 6 was classified as using Deep approaches to learning mathematics at school. However his response to the second distribution of the questionnaire suggested that he had adopted Procedural strategies at university. In his interview, Student 6 conveyed characteristics of both of these approaches. His initial strategy was to complete numerous problems to practice methods. However, he would continue with this method until he felt confident that some understanding had emerged from this.

"I do questions, go through questions and make sure I get them right...I'll look at the process and the answer and I would go through the question and copy it down and eventually I would look at it less and less and just repeat the question until I could do it without looking and then try other questions that were similar until I was getting right answers... if I still find it hard to do stuff then I'll go back and try doing more on my own. I'll just work on my own until I understand it."

The above comment clearly illustrates persistence and effort, which indicates that the student is cognitively engaged (as well as behaviourally engaged as indicated by his attendance). Indeed, Student 6 indicated that he would also use other metacognitive strategies (which can be classified as Deep strategies), such as examining the logic of an argument by discussing problems with friends:

"Lecturers know exactly what they are talking about whereas friends you can discuss it with. So if I go to a lecturer they will say "right you've got to do it this way" but if
I go to my friends they sort of stop and make me think about it. And because of that thought process going through my head I actually learn it and it sinks in.”

It appears that Student 6 was actively engaged with mathematics. In particular, he was clearly dedicated and persistent and applied a significant amount of effort into his studies. However, since it is still not clear from his interview if the student had adopted one specific learning approach (Deep or Procedural), this provides further evidence of the difficulty in distinguishing between the two approaches in terms of learning mathematics.

3.2.3 STUDENT 7

Student 7 was identified as using Strategic approaches to learning mathematics at university. His interview confirmed that this student would make use of a variety of methods to gain short-term goals. Although not all of these emphasised the exam assessment, Student 7’s approaches were indicative of distributing time economically by applying the least amount of effort to achieve success. In terms of Student 7, this involved learning specific questions that would fundamentally lead to marks.

“First thing I do is read through my notes again...then I’ll try and go through as many questions as I can. And then when it comes to revision I’ll do problems, problems, problems. The more problems I can do the better...until I get bored of it. But then you’ll always find there are some problems you can’t do, so you leave them out because if it comes up in the exam it comes up in the exam. If it doesn’t then it’s good.”

Strategic methods are indicative of superficial engagement since a Strategic learner, such as Student 7, will distribute his effort in order to achieve success. Indeed, when describing his learning of mathematics, Student 7 emphasised that the majority of his ‘learning’ occurred before the exam;

“I’ll read through my notes and then do questions for a full day. And probably an all-nighter...Exams are all about confidence. You can blag them if you try.”

However, Student 7 was aware that his strategies would not necessarily lead to an understanding of the topic. However, this did not seem to be of concern.

“Some of them [questions] you can understand...but you sort of maybe don’t use all the sort of steps you’re suppose to and you sort of mingle your way around it and it
sort of works in a weird way...You know a check point list of the steps that need to be done, but why you're doing it...what's in the middle, is a blur."

However, although Student 7's strategies were largely related to the coursework and exam assessments, he did show some inclination of using metacognitive strategies. This involved reflecting upon the content by teaching it to a friend.

"We have a tendency to get together as a group. Sort of talking through coursework or with problems we've got like catching up on notes we've missed... for the maths for instance we'll work through the tutorial sheet or other questions from exam papers...even if you're the person helping, it helps you, because you’re actually breaking it down in steps rather than just doing it off the cuff and really having to think about it, to teach it."

Generally Student 7's comments suggest that the majority of his engagement was largely superficial in order to achieve short-term goals. However, it appears that he has made use of a variety of strategies and there is a potential that these could develop into more metacognitive strategies.

3.2.4 STUDENT 10

Student 10 was classified as using Deep learning strategies prior to university (from analysis of the questionnaire data). However, Student 10 did not complete the second distribution of the questionnaire and so it was unclear as to what strategies he chose whilst learning university mathematics. The interview data suggest that Student 10 continued to use Deep strategies. In particular, it appears that Student 10 has reflected upon his learning by interpreting knowledge, rather than accepting concepts at face-value.

"I like to do things my own way and I do things in a weird order to everybody else. Like, people are taught a way to do it and they do it like that, but I like to develop my own way."

Although no attendance data was available for Student 10, his interview indicated that he was actively engaged with the module, both behaviourally and cognitively. Student 10 would make use of all timetabled sessions to ‘practise’ what he had learnt.

"The lectures are good for getting the knowledge into your head and the tutorials are good for applying it...I use them for things I'm not really that good at, I don’t really practice for showing things I can do. Because a good thing about maths is that new
things build on things you’ve already done, so by practising the new things you’re also practising the old things.”

It is clear that Student 10 is cognitively aware of his learning on some level. However, Student 10’s comments suggest that he may have also been using Procedural strategies. Although he rigorously interacted with the content (indication of using Deep strategies) and would relate formulae to each other, Student 10 does not indicate that he would further his knowledge by relating problems to underlying concepts or theories. His comments suggest that his initial intention was not necessarily to understand the material.

“I’ll do some questions and then I’ll do some similar questions later on and if I can do them I’ll leave that section.”

This further evidences the difficulty in distinguishing between Deep and Procedural strategies in the context of learning mathematics.

3.2.5 DISCUSSION

The interview data were used to confirm students’ learning approaches to mathematics at university, as indicated by their questionnaire responses. However, the data were also used to extend upon the initial findings by identifying specific methods used by individual students. Four students in particular were examined.

The results suggest that students can be classified as using methods of Surface, Deep, Strategic and Procedural learning and, moreover, that the questionnaire data was reasonable accurate in determining those approaches. However, it appears that there are still some issues with regards to identifying between Procedural and Deep learning strategies, with regards to mathematics. Since Procedural strategies, such as practising questions, are largely fundamental to the learning of mathematics, most students will adopt this strategy. Whilst some students clearly practise questions on a Surface level, by merely reproducing methods, others will use this strategy more holistically. However, since this relates to acquiring an understanding of the material, it is difficult to distinguish if a student is using this strategy as means of gaining an eventual understanding or if they are actually using this strategy on a ‘deeper’ level to further their knowledge and understanding.
In addition, the interviews suggest that it is likely that students will use a variety of methods to learn mathematics and that this may involve using superficial strategies with metacognitive strategies, such as Student 7. However, the mixture of strategies adopted by the students in this study reflected the learning approaches that they had adopted prior to university. Therefore, it is possible that the students had not yet fully adapted to learning mathematics at university and, consequently, were still using some strategies that they had used at school.

Analysis of the students' learning approaches has also provided further information with regards to their engagement with mathematics. Generally, students who were engaged on a behavioral level (in terms of attendance) were also engaged on a cognitive level. Such students conveyed dedication, self-regulation and persistence, which are all indicative of a metacognitive awareness of their learning.

3.3 RESULTS - FURTHER ISSUES

A number of additional issues emerged during the follow-up interviews. These related to students' learning of mathematics and also their attitudes towards the subject. In particular, these issues revealed further information with regards to why students failed to engage with the proactive support initiative. These issues will now be discussed below. The first will be that of 'Motivation', particularly the influence of intrinsic and extrinsic motivation and how this related to student engagement. There will also be a discussion with regards to the 'Pass-culture' amongst students and the affect of 'University-culture' upon their engagement. The final issue will draw upon some general findings with regards to students' learning at university.

3.3.1 MOTIVATION

When questioned about their engagement with mathematics support, Student 1, Student 4 and Student 5 (who had also achieved the lowest module marks of the ten participants) were eager to label themselves as 'lazy'. Indeed, two of these students had failed the mathematics module. Their responses indicate that there is an inherent lack of motivation amongst some students which may prevent students from fully engaging with the support and with mathematics in general, as illustrated below;
Student 4: “I know deep down I should spend more time on it [maths] but I think I’m just lazy.”

Student 5: “I’ve not spent as much time on it [maths] as I’d hoped. It’s just my attitude really. I should be a bit more committed. I should be doing an hour a day or something but…you know, laziness.”

If a student is not engaging with mathematics then it is almost inevitable that they will not engage with mathematics support. This issue was investigated further by probing the students for reasons that may have contributed to their lack of motivation. Student 1 and Student 5, who had both failed the module, felt that the mathematics on their courses was either too difficult, lacked enjoyment or was perceived as irrelevant. This indicates that a lack of stimulation can cause some students to disengage with mathematics at university.

Student 5: “I didn’t tend to use the tutorials… It was straight after a lecture wasn’t it so I was probably fed up. If I hadn’t found anything particularly hard or interesting in the lesson then I was probably less inclined to spend an extra hour going back over it.”

The above quote illustrates the importance of intrinsic and extrinsic motivation. For some students there is a lack of internal desire to study mathematics that affects the amount of time and effort they put into their studies. In terms of the student above, since his mathematics tutorials do not provide enough stimulation the student is not extrinsically motivated to engage. Indeed, Student 1 referred to a lack of ‘fun’ associated with mathematics;

Student 1: “It’s [mathematics] sort of ‘samey’. Having done it before, it’s not that fun doing it all over again.”

Again there seems to be an absence of both intrinsic and extrinsic motivation. A lack of engagement is caused either because mathematics is not presented in a ‘fun’ way to the students or that the students perceive other subjects/activities as more ‘fun’ in comparison.

However, Student 6, who was a regular attendee and so was engaged with the module on a behavioural level, did not particularly enjoy mathematics. Although there was a lack of intrinsic motivation, this student was driven by external motivators. In particular, he was aware of the value of mathematics for the rest of his course and his
awareness of his weaknesses in the subject spurred him on to exert more effort into his studies.

Student 6: "It's [mathematics] like a necessity I guess. It's something you have to do, because I don't enjoy maths that much and I know how hard I find it, I just try and plough my way through it, so I attended all of my maths lectures because I already knew I wasn't so good at maths... I spend more time on this module than any of the other because of the trouble I have with it."

These findings reiterate the analysis of students' attitudes in Chapter 7, in that the perceived value of mathematics was an important factor in relation to student engagement. In particular, the data indicated that students who valued mathematics would be more likely to engage with the subject.

Other students are affected by a lack of confidence in their mathematics abilities, which in turn can affect their intrinsic motivation. Although support is offered to students to help build their confidence it appears that their negative feelings towards mathematics self-efficacy and self-concept actually prevents them engaging with it.

Student 1: "I have to work hard to get average results, so I don't like it [mathematics] that much... I prefer my sport science modules over the others. I just find them a lot easier so I work at them.

On the other hand, students who feel confident in their abilities were motivated to engage with the module, both on behavioural and cognitive level.

Student 9: "I've actually worked harder at maths because it the easiest [module] and because when I learn things I like to know precisely what I know and what I don't know. So I've been doing those HELM [Helping Engineers Learn Mathematics] worksheets and they are absolutely amazing."

Indeed, Student 9 shows the extent of his engagement with mathematics. Since this student is eager to take control of his learning he has engaged on a cognitive level. Again this is further evidence of the importance of a student's attitude as determined by their confidence and engagement with mathematics, as highlighted in Chapter 7.
3.3.2 ‘PASS-CULTURE’ AMONGST STUDENTS

De-motivation amongst students was also linked to a culture of passing the first year of their degree courses. Students will usually be extrinsically motivated by external incentives such as a motivation to perform well. However, at Loughborough University students can progress to their second year by achieving a ‘pass’ (i.e. achieving more than 40%) in ten out of their twelve modules. This means that students can fail the mathematics component of their degree (but with a mark of no less than 30%) but still pass the year. Furthermore, a student’s first year mark does not contribute to their final degree mark. For students whose motivation is already low, this can have a notable effect on their engagement with mathematics.

Student 1: “I think the problem with the first year not counting is that I haven’t really worked at it... I think I’ll work a lot harder next year.”

Conversely, students who were motivated and engaged with mathematics viewed the first year in a very different way. Indeed, such students aspired to achieve the best grade possible, in terms of their ability, since they felt that this was particularly important for achieving success in their degree courses. It was felt that aspiring for merely a ‘pass’ would undoubtedly cause repercussions in other modules and in further years of study.

Student 6: “I don’t like to be one of those people who only sets their target as getting 40%. I’m seeing this as a year that really matters, because this year doesn’t count towards my final degree, but I’m acting as though it does because that will put me in better stead for next year.”

This student’s cognitive awareness of his learning has undoubtedly contributed to his engagement with mathematics.

3.3.3 UNIVERSITY CULTURE

For many students the first year of university can be a difficult one, in particular students are faced with the task of making adjustments to university life. In some cases this can take priority over their university studies.

Student 1: “I’ve sort of seen this year as a settling in year. I could’ve definitely worked a lot harder. It’s just with the whole experience of being at university and
being away from home and meeting new people. That takes a higher priority than the actual work. I always try and make my [mathematics] lectures, just so I have a finger in what’s happening, but sometimes I don’t listen when I’m there.”

From other responses made by the students in this study it was found that the social setting at university prevents many students from engaging with their courses, as illustrated by the following quote:

Student 4: “I’ve missed a few of the tutorial bits...I wasn’t up for working through stuff, this was a purely social thing from the night before type thing. So I went to the lecture struggled through that, just in case we learnt something new, and then the tutorial rather than going over something we had just learnt I thought “I’ll go to bed”...If the tutorial was on a Monday in the middle of the day then I’d have gone to every one I think, because I don’t do anything on Sunday nights.”

It appears that engagement with mathematics is perceived as a low priority by some students. Since their interests lie elsewhere, mathematics and obtaining support with mathematics is neglected.

3.3.4 LEARNING AT UNIVERSITY

From the analysis, it appears that the students have notably different beliefs about learning mathematics at university. A notable feature of the responses from students who were particularly engaged in terms of attendance (and specifically the well-prepared students) was a concept of ‘independent learning’. These students indicated an awareness to take responsibility for their own learning, indicating that they were adapting to university. For example:

Student 10: “I will read through my lecture notes and examples and try private study and complete examples off example sheets on my own. If problems occur I will ask the lecturer and probably go to the maths support to use HELM booklets to assist my learning.”

Generally students who were actively engaged with the module were also engaged with their learning of the subject. They will do more than just attending timetabled lectures and will take responsibility for their own learning by completing work outside of the timetabled hours and making use of other resources available to them to aid their learning.
In comparison, students who failed to regularly engage with the module had also failed to take responsibility for their own learning, particularly those who indicated that they would take a Surface approach to their learning of mathematics.

   Student 5: “Not attending tutorials was a problem as this would have given me practice at performing questions and memorising strategies. I generally collated notes and relied heavily upon a few notes and mainly HELM booklets to revise material. I did a practice paper, however, this was not good enough preparation.”

The above quote illustrates a lack of cognitive engagement, since the student did not attempt any work outside of timetabled sessions (until exam time) and failed to make use of any other resources available to him. Students who fail to monitor and direct their own learning throughout the term are, therefore, unaware of their weaknesses until it is too late. Indeed, for some students, ‘learning’ does not occur until the revision period where students are motivated due to their impending exam. However, this strategy often fails, in the case of same student:

   Student 5: “My knowledge is a bit limited to what I’m expected to know for a test, rather than knowing everything and more. I think I understand it and I feel really confident with it but then it comes to the test and I haven’t done as well as I know I am. Well it’s happened to me all the way through the past two years, all the way through A-level...I don’t know my preparation is obviously well out.”

This further supports the notion that students who are disengaged in terms of behaviour are likely to be disengaged in terms of cognition.

3.4 CONCLUSIONS

Results from the follow-up interviews suggest that students who failed to engage with the mathematics module were failing to engage on many different levels. Such students not only failed to engage on a behavioural level (in terms of attendance) but also on a cognitive level (in terms of taking control over their learning). It is possible that the students who do attend their mathematics lectures regularly, and hence benefit from the support, are students who would actively seek help with mathematics regardless of the support initiative, since they are actively engaged in terms of behaviour and cognition. Consequently, students are engaged with the learning process by adopting learning strategies that convey persistence, effort and self-regulation on behalf of the student.
Analysis of the students' comments suggests that students who engage with mathematics will be motivated by an intrinsic desire to perform well in their mathematics module and, moreover, a desire to learn. Therefore, they will actively engage with the mathematics.

In terms of the students who fail to engage with mathematics support, it appears that such students lack some form of intrinsic motivation. Some students do not perceive mathematics as 'fun' or as interesting as other modules on their courses or other aspects of their university life. It was also found that many students fail to engage on a cognitive level, with some failing to 'learn' the mathematics material until the exam period. For some students, this lack of engagement extends further than their mathematics module, since they are also failing to engage with their course as a whole.

If a student is not intrinsically motivated then it may be possible to provide extrinsic motivation. Provision of an outside influence or reward may encourage students to apply effort and encourage them to engage with mathematics support. For example, at school, it is likely that students were provided with a source of extrinsic motivation through their teacher. However, due to a lack of pressure at university, this source of extrinsic motivation is missing. Conversely, for some students the exam provides a source of extrinsic motivation, since there is a fear of failure, (although the desire to pass the exam is intrinsic). One possibility of providing additional sources of extrinsic motivation could involve changing the general teaching approach of mathematics, for example by introducing Problem-based learning, Pedersen (2003) and Bragg (2005), or an Inquiry-based approach, Crabtree (2004), which are claimed to significantly enhance motivation and engagement. Such methods can make use of cooperative learning methods (students working together) and technological devices in order to present mathematics as a stimulating and interesting topic. Consequently, students are motivated since they are active participants in learning and, hence, may feel a sense of inclusion.

However, the analysis presented above suggests that the reasons behind a lack of engagement are complex and deep-rooted and perhaps extend further than the students' attitudes and learning approaches. Therefore, implementing relatively simple
measures may still result in a failure to engage. It appears that students who had failed to engage with the mathematics module had a very different mind set to those who were actively engaged and, therefore, it is likely that students’ perceptions may need to be changed. However, this is perhaps an unfeasible task and as such would require further research to investigate possible effective action.

4. SUMMARY AND DISCUSSION

Results from Chapter 5 indicated that students may fail to engage with mathematics support since students are required to take the initiative to use it. Therefore, a proactive support initiative was implemented with a group of first year physics students. However, an issue with regards to a lack of engagement (particularly amongst the less well-prepared students) was evident, despite the support initiative. In an attempt to understand the reasons behind this lack of engagement, a qualitative research approach was undertaken. Preliminary results with regards to the 2005/6 cohort of physics students suggested that some students (in particular the less well-prepared) lacked mathematics confidence and did not adapt their learning of mathematics at university to ensure success (see Chapter 7). Hence, this may have contributed to a lack of engagement with the proactive support and the effectiveness of this support.

To investigate these issues further a questionnaire requiring an open-ended response from participants was distributed on two occasions to the 2006/7 cohort of physics students. The questionnaire sought to examine students’ attitudes and their approaches to learning. A number of follow-up interviews were also conducted in an attempt to gather additional data, particularly with regards to a lack of engagement.

Analysis of the data suggests that students who were likely to be disengaged held qualitatively different perceptions about mathematics, compared to students who were actively engaged. Due to a lack of data regarding students who had failed to engage with the module, the analysis presented in Chapter 7 and Chapter 8 can not be used to determine how the attitudes and learning approaches adopted by disengaged students have changed since coming to university. However, the analysis can be used to describe the behaviour of engaged students.
In particular, students who actively engage with the module will generally have a positive attitude to mathematics. Such students are aware of the perceived value and worth of mathematics and they will often have a positive self-concept. It is likely, that the prior experience of the student will contribute to their engagement with mathematics. Therefore, if a student lacked confidence in their abilities and did not particularly enjoy mathematics prior to university, then they will be less likely to engage with mathematics at university.

However, engaged students will also be actively engaged with their own learning of mathematics. They will show persistence and effort when learning concepts and procedures and will monitor and direct their learning so that they are aware of any problems. Indeed, students will engage on a deep cognitive level by adopting Deep or Procedural strategies to their learning at university. It is likely that such students will have a desire to perform well and moreover, a desire to learn. They have adapted accordingly to ensure success in mathematics at university and as such, students are engaged on a cognitive and behavioural level. It is likely that students who lack some form of cognitive engagement or who are only engaging on a superficial level, and hence fail to adapt successful learning approaches at university, will fail to engage with the module.

In terms of the students in this study, the data suggests that students who had failed to engage with the mathematics module failed to engage on a cognitive level. It is likely that these students lacked motivation, intrinsically or extrinsically; hence they failed to engage with their own learning. Indeed, it appears that disengaged students held no high aspirations, in terms of their performance in mathematics. Consequently, their engagement with the module was limited to superficial involvement, leading to the use of Surface or Strategic learning techniques in order to achieve short-term goals. It is possible that for some students, a negative mathematics attitude prior to university may have contributed to their lack of engagement at university. Moreover, it appears that for many students (although not all) a failure to engage with the module was a result of general disengagement at university.

It has been found within this research, and suggested by other researchers such as Biggs and Ramsden, that there are perhaps qualitative differences between learning
approaches in the arts and learning approaches in the sciences. This indicates the need to redefine learning approaches depending upon these areas. In particular, this research has highlighted the difficulties in classifying Deep and Procedural strategies in learning mathematics. Indeed, critics of ‘deep’ and ‘surface’ learning note the limitations of this classification, particularly that insufficient account is taken of the learner’s social and cultural context. For example Malcolm & Zukas (2001) argue that the learner frequently appears as an anonymous decontextualised “learning style”. In addition, using classifications, such as the Deep/Surface model, does not provide further explanation as to why certain students struggle with particular concepts that others grasp with ease. As such, educational researchers have developed a new theoretical construct with regards to learning approaches, known as the ‘Threshold Concept’. This construct assumes that certain concepts can be ‘troublesome’ to learn, but that once they are acquired, new openings to the understanding of a topic that were not possible before are exposed, Hay (2007). Unless students can grasp these threshold concepts, their understanding will remain partial and superficial. The notion of threshold concepts can be linked with the deep and surface learning distinction. Indeed Professional Development for Academics Involved in Teaching (ProDAIT) (2006) suggests that researchers may find it is useful to perceive the acquisition of a threshold concept as a paradigm case of ‘deep learning’ since threshold concepts need to be ‘deep learned’ and internalised by learners. However, the concept of disciplinary thresholds has a number of advantages, perceived by some researchers, over the deep/surface distinction. For example, Williams (2007) favours the Threshold Concept since it suggests that impediment to the learner’s advancement may be due to an intrinsic difficulty of the object of study, rather than the result of a deficit in the learner’s approach. Conversely, Davies (2003) believes in the construct of thresholds since it provides further information to understand deep and surface learning approaches. In particular, that “it provides a link between approaches (deep or surface) to learning and the outcomes of learning”. Davies suggests that students who fail to understand a threshold concept are more likely to resort to Surface methods in the hope that they can pass this off as real understanding. Therefore, a student may use procedural methods, for example, to learn a topic. However if they fail to grasp a certain Threshold Concept with regards to that topic then they may opt to take a Surface approach.
However, the construct of Threshold Concepts is a relatively new area of research and there are some quandaries associated with the construct. In particular, it implies that learning is likely to proceed by increment (not continuous progression) as different ‘threshold concepts’ are acquired. In addition, it is often viewed as ‘troublesome’, Perkins (1999), meaning that as students progress through their journey of learning they will be forced to think differently in terms of their identity and their beliefs in learning. Indeed, students will often find this difficult and as such this may mean that students will graduate without ever grasping some threshold concepts on their course.

It is acknowledged that further research is needed to investigate this construct with regards to learning mathematics, particularly if this has some relation to distinguishing how students use procedural strategies (i.e. cognitively or superficially). Furthermore the implications that this may have with regards to student engagement is perhaps complex. Indeed, the present research has shown that there are a number of issues that may cause implications for the way in which students engage with mathematics and the methods that they choose when learning mathematics. However, there are perhaps also additional factors, that have not been discussed here, which may have contributed to a lack of engagement. Consequently, it is unclear as to what effective action could be taken to significantly improve student engagement. Possible action has been suggested, such as introducing Problem-based learning or an Inquiry-based approach, which are claimed to significantly enhance motivation and engagement. Indeed, many institutions have reported on action that has been taken to promote student engagement at university, for example the European First Year Experience conference (2008) provided an opportunity for institutions across Europe to share ideas. However, further research is needed to investigate if such action would be successful in motivating students, particularly those at risk of failing mathematics, to engage with the subject. It is suggested that a more rigorous investigation of the students’ attitudes and learning approaches would be useful in determining the difference between engaged and disengaged students, and how these constructs relate to their levels of engagement. This may involve the use of attitude and learning approach inventories in conjunction with student interviews.

The findings presented in this thesis suggest that for students who need mathematics support (since they are mathematically unprepared), a lack of engagement usually
relates to a lack of engagement with mathematics in general. Students with such characteristics are not intrinsically motivated to learn and hence do not engage with the mathematics module. Moreover, even though mathematics support is supplied proactively, such students will still fail to engage.
CHAPTER 9 – CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK

This research has sought to evaluate the effectiveness of mathematics support, with particular reference to the issue of student engagement and how this impacts upon the effectiveness of the support. The research study was located within broader and ongoing concerns about the mathematical preparedness of undergraduates and the theoretical framework associated with this was presented in Chapter 2. This was followed by a discussion of the research methodologies, in Chapter 3, as a prelude to their use in the present research. Chapters 4, 5, 6, 7 and 8 will now be summarised and the findings will be discussed in the context of the whole research study. This chapter will use these findings to discuss the implications of the research and will also provide recommendations and possibilities for future work in this area.

1. SUMMARY OF FINDINGS

To evaluate the effectiveness of mathematics support, this research has discussed the research findings with regards to two particular support mechanisms, namely a reactive support initiative and a proactive support initiative. The issue of student engagement was considered throughout these chapters and was presented in two strands by considering quantitative and qualitative data. These were presented as follows:

- **Reactive** support initiative: Mathematics Support Centre

  Student engagement was considered as a *behavioral* component by analysing quantitative data such as attendance and usage figures. (Chapter 4)

  Student engagement was considered as a *cognitive* component by analysing qualitative data taken from student interviews and focus groups. (Chapter 5)

- **Proactive** support initiative: Small group teaching
Student engagement was considered as a *behavioral* component by analysing quantitative data such as attendance and usage figures. (Chapter 6)

Student engagement was considered as a *cognitive* component by analysing qualitative data taken from student interviews and focus groups. (Chapter 7 and Chapter 8)

The first part of this research evaluated a *reactive* support initiative, by way of Loughborough University's Mathematics Learning Support Centre (MLSC). Since students must take the initiative to use the support, student engagement is vital to its success. Therefore, a detailed examination of the usage of this support initiative was carried out within Chapter 4, to investigate the extent to which the MLSC was effectively used by students who required it.

Analysis of usage statistics indicated that usage of the support amongst students had changed over time (between 2004/5 to 2006/7). In particular, it was found that students were failing to make repeated visits to the centre, with nearly half (45%) of all users in 2006-7 having made just one visit. Clearly, one visit is not of sufficient benefit since it is likely that regular support is needed for students who are inadequately prepared for mathematics at university. Further analysis of usage amongst Science, Technology, Engineering and Mathematics (STEM) students indicated that the average number of visits made by such students had dropped in 2006-7 from 2004-5. On average, STEM students had made 0.8 fewer visits. It is possible that these students did not require the same level of mathematics help as was needed in previous years or that students were sufficiently helped in just one or two visits and did not require any further help. However, analysis of performance data did not support this.

Indeed, 86% of first year STEM students who had failed a mathematics module had never used the MLSC. Clearly such students were in need of mathematics support but for unknown reasons these students had failed to engage with it. In addition, students who had regularly engaged with the support were generally high achieving students seeking success (rather than students avoiding failure) and perhaps were generally motivated and engaged and would seek support regardless of the MLSC.
Chapter 5 investigated this issue further by analysing qualitative data from student interviews and focus groups. It was found that students who had never used the support and who had also failed a mathematics module had failed to engage with the support for a number of reasons. Some of these reasons were relatively simple, such as a lack of awareness of the location and of the facilities available in the MLSC. However, others were more complex. In particular, students had failed to monitor and direct their own learning and consequently they were unaware of any mathematical difficulties. Further analysis of interview data with regular users of the support suggested that students who had failed to engage with the support (and who had also failed a mathematics module) lacked some form of intrinsic motivation. The regular users had generally enjoyed mathematics at university and, hence, were motivated to engage with mathematics support and their courses. Indeed, the MLSC was used as a ‘learning space’ by the regular users, since the ‘working environment’ encouraged motivation and engagement amongst such students. Consequently, the regular users were active participants in their own learning. Since students had regularly completed the work they were able to identify their weaknesses and had obtained the support immediately. This in turn developed feelings of confidence and encouraged the students to engage further with mathematics and the support.

These findings imply that students who fail to engage with mathematics support lack the study skills and cognitive skills needed to engage successfully with the learning of mathematics at university. Unlike the regular users of the support, students who failed to engage with the support were not motivated or engaged with much of their degree. Therefore, it appears that action needs to be taken to raise students’ general engagement levels (not just engagement with mathematics support).

Since such a large number of students who had failed mathematics had also failed to engage with mathematics support provided by the MLSC (because they did not take the initiative of using it) this research also examined the effectiveness of a proactive method of providing mathematics support. It was anticipated that the introduction of such support would help students who lacked the motivation to seek out ‘drop-in’ support. Chapter 6 discussed findings from a proactive support initiative that had been implemented at two institutions (Loughborough and Coventry Universities). The support, which had involved identifying mathematically less well-prepared students...
and teaching them separately to the main group and using alternative teaching methods, was found to have had mixed success at both institutions.

Initial findings indicated that proactive support can be successful in supporting mathematically less well-prepared students. At Loughborough University, the pass rate amongst the supported students in 2005/6 increased to 67% in the first semester compared with 48% in 2004/5. Similarly at Coventry University, the pass rate also improved although by a much smaller increase (from 33% in 2004/5 to 36% in 2005/6). The support was also successful in engaging students, since the supported group at Loughborough University had attended their timetabled sessions (in the first semester of 2005/6) on average 75% of the time, compared to an average attendance of 51% amongst the main group. Furthermore, no supported students withdrew from the module in 2005-6 at Coventry University and Semester 1 of 2005-6 at Loughborough University. This is compared with three withdrawals at Loughborough University and one at Coventry University (all less well-prepared) in 2004-5.

The supported students' coursework marks had also noticeably improved (at both institutions). At Loughborough University, the supported students in Semester 1 of 2005/6 outperformed the less well-prepared students in 2004/5 by 11 percentage points in the coursework assessment and also performed better (by 5 percentage points) than the main group. Similarly, at Coventry University, the supported students in 2005/6 out performed the less well-prepared students in 2004/5 by 11 percentage points in the coursework assessment. However, the supported students, both at Loughborough and Coventry, performed poorly in the exam compared to the well-prepared students. For example, at Loughborough University, the well-prepared students in 2005/6 outperformed the supported less well-prepared students (from the same cohort) by 19 percentage points. Unfortunately, it appears that this caused a lack of engagement in Semester 2 of 2005/6 amongst the less well-prepared students. Whereas students were attending their first semester timetabled sessions on average 75% of the time, in the second semester this had dropped to just 41%. Without regular attendance many students struggled to cope with the mathematical material and, consequently, the pass rate amongst the less well-prepared students dropped to 32% in the second semester in 2005-6.
The support was implemented with a new cohort of students in 2006-7 (both at Loughborough and Coventry Universities). However, again student engagement particularly impacted upon the effectiveness of the support (although it should be noted that the implementation of the support differed slightly in 2006/7, including different teaching staff and different timetabling). At Loughborough University, the less well-prepared students within the supported group attended, on average, 40% of the time and only 47% of this cohort passed the module. Since 48% of students in 2004/5 passed the module but did not receive support, it appears that the support initiative had no effect on the 2006/7 cohort. At Coventry University, only 15% of the less well-prepared students passed the module in 2006-7 and three students had withdrawn from the course. Similarly to the results at Loughborough University, this means that less well-prepared students who did not receive support in 2004/5 outperformed students who did receive support in 2006/7.

It was anticipated that by introducing a proactive support initiative, students who do not avail themselves of the available mathematics support (such as that offered by the MLSC) but who are at risk of failing, would receive the necessary mathematics help. However, this was not the case since the majority of students failed to attend their timetabled sessions and hence could not benefit from the support. Results from the 2005/6 and 2006/7 cohorts indicate that the support can be effective in improving pass rates and promoting retention and progression in mathematics. However, in order to be successful students must be encouraged to engage with the mathematics module.

To understand why students had failed to engage with the support, Chapters 7 and 8 analysed qualitative data taken from questionnaires, student interviews and focus groups. Preliminary results from a questionnaire, distributed to students from the 2005/6 cohort at Loughborough University, indicated that students’ attitudes and learning approaches towards mathematics had impacted upon their engagement with the module. A number of attitudinal factors were analysed, which revealed that a student’s self-concept of their ability was particularly influential. Prior to university the less well-prepared students had generally lacked confidence in their abilities and such feelings were reinforced since being at university, primarily associated with their poor exam performance. In comparison, the well-prepared students generally had felt
confident in their abilities prior to university and their experience of university had reinforced their confidence in mathematics. Although it is perhaps unsurprising that the well-prepared students felt more confident in comparison to the less well-prepared students, it was hoped that the support initiative would help the less well-prepared students to feel prepared for the mathematics on the remainder of their course and hence feelings of confidence would emerge from this.

Findings from this research have also indicated that the students’ attitudes with regards to their teaching experience of mathematics may have impacted upon their engagement with the subject. The role of a teacher was of particular importance to their university experience of mathematics and this was more so than in relation to their prior experiences. The less well-prepared students needed the guide and support of a ‘teacher’ to provide extrinsic motivation. However, due to a lack of pressure at university, this source of motivation was missing. Consequently, their attitudes towards the teaching of the subject were largely negative.

These results suggest that the less well-prepared students were vulnerable to disengagement from the outset, particularly due to their prior experience of mathematics (often associated with a lack of confidence). The proactive support was implemented with the intention of nurturing a positive attitude amongst these students to help build their confidence and to encourage engagement. However, it appears that the exam assessment had demoralised the students resulting in a negative attitude, a lack of confidence and, consequently, disengagement with the support.

In comparison, students who had engaged with the mathematics module had held a positive attitude in relation to the subject. Since studying mathematics at university, their confidence in their abilities was reinforced and a large proportion of students now felt that mathematics was valuable to their future. Undoubtedly, these factors had motivated the students to engage further with the module.

Findings from this research have also shown that students had failed to engage on a cognitive level, as well as failing to engage on a behavioural level (i.e. attendance), particularly in terms of how they approached their learning of mathematics. Analysis of qualitative data indicated that students could be classified as using methods of
Surface, Deep, Strategic and Procedural learning in mathematics. In terms of engagement, a Deep or Procedural approach was deemed as preferential, since this meant that students were likely to be engaging with their learning of mathematics on a deep cognitive level. Such students conveyed dedication, self-regulation and persistence, which are all indicative of a metacognitive awareness of their learning. However, students who conveyed superficial cognitive engagement were likely to use Surface or Strategic learning techniques in order to achieve short-term goals. Prior to university, there was a greater proportion of less well-prepared students using Surface methods in their learning of mathematics, whereas there was a greater proportion of well-prepared students using Deep strategies. Therefore, the well-prepared students were more likely to engage with mathematics prior to university on a deep cognitive level compared to the less well-prepared students who seemed to engage on a superficial level. Since a large proportion of the less-well prepared students had failed to engage cognitively prior to university, it is possible that this had also contributed to their lack of engagement with the mathematics module.

In terms of the strategies students had adopted to learning mathematics at university, the data indicated that the majority of students had changed their learning approaches. In terms of the sample of students who represented the whole cohort, the majority were classified as using Deep or Procedural strategies. Hence, students who had engaged with the proactive support, in terms of their behavior, had also engaged cognitively by taking control of their learning and adapting metacognitive learning strategies.

However, the research methods used to collate data with regards to students’ learning approaches was limited in that students could not always be clearly defined as using a specific learning approach. In particular, a large proportion of students were classified as using Procedural and Deep strategies and analysis of the data proved difficult in distinguishing between the two. Whilst on one level, this indicted that the method of data collection was insufficiently rigorous, it also suggests that there are perhaps qualitative differences between learning approaches in mathematics and learning approaches in other subjects (specifically art-based subjects). This indicates the need to redefine learning approaches depending upon these areas.
Finally, Chapter 8 revealed that motivation was a key issue in students’ level of engagement with the support (as also suggested in Chapter 5). In particular, these findings suggest that students who engage with mathematics will be motivated by an intrinsic desire to perform well in their mathematics module and, moreover, a desire to learn. Therefore, they will actively engage with the mathematics. However, in terms of the students who fail to engage with mathematics support, it appears that such students lack some form of intrinsic motivation. Some students do not perceive mathematics as ‘fun’ or as interesting as other modules on their courses or other aspects of their university life. In addition, it is likely that disengaged students will have no high aspirations, in terms of their performance in mathematics. Consequently, students are not motivated to engage, either intrinsically or extrinsically, and so their engagement with mathematics is often limited to superficial involvement. It is possible that for some students, a negative mathematics attitude prior to university will contribute to their lack of engagement at university. Moreover, it appears that for many students (although not all) a failure to engage with the module was a result of general disengagement at university.

2. IMPLICATIONS AND RECOMMENDATIONS

The main aim of this research was to evaluate the effectiveness of different methods of mathematics support for ‘at risk’ students. Findings from the research suggest that both proactive and reactive method of support can be effective in aiding such students. In particular, ‘at risk’ students that engage regularly with the support are more likely to perform better than ‘at risk’ students who do not engage with the support. This thesis has also shown that proactive methods, such as small group teaching, can be particularly successful in aiding ‘at risk’ students. Since students do not need to take the initiative to seek out the support, such methods help to support students who may otherwise have struggled without it. This method of support also helped to build a sense of community amongst the students and helped to promote a positive attitude towards mathematics.

However, such methods could only be deemed as successful if students engaged with the support. Unfortunately, the lack of student engagement with mathematics support at university, as indicated within this thesis, is an obvious concern. It is now widely
accepted that a vast number of students embarking on STEM courses (and other course which contain mathematics) lack the necessary skills needed for the mathematical component of their degree. Implementing some form of a mathematics support initiative is an obvious method of tackling this problem. However, if students fail to engage with the support then they cannot benefit from it. Whilst some manner of disengagement may be expected with regards to reactive support (such as ‘drop-in’ support), it is perhaps surprising that there is also an issue of disengagement with proactive methods.

Worryingly students who are failing to engage with mathematics support are students who most need it, since they are at risk of failing the mathematical component of their degree courses. Such students have qualitatively different attitudes towards mathematics, compared to engaged students, and fail to adapt successfully at university. Indeed, it is likely that students who are in need of the support have had a history of low achievement or repeated failure. This often leads to negative attitudes and a lack of confidence, meaning that many students (although not all) will have no high aspirations, in terms of their performance in mathematics. Hence, students lack motivation and will only apply enough effort as needed to achieve their short term learning goals, often engaging on a superficial level. This means students cannot benefit from proactive support and will fail to avail themselves of reactive support. Unfortunately, this often results in failure and, hence, students further disengage with mathematics.

However, students who are actively engaged with the support are often students seeking excellence, rather than avoiding failure. Generally students who are actively engaged with mathematics are also engaged with their learning of the subject. They will do more than just attend timetabled lectures and will take responsibility for their own learning by completing work outside of the timetabled hours and making use of other resources available to them to aid their learning. Hence, such students will regularly engage with reactive support, such as that provided by a Mathematics Support Centre. However, students will use this as a ‘learning space’ to scaffold their learning, as opposed to a place to only obtain support. These students are motivated and engaged with mathematics due to the ‘working environment’. Consequently, the students are active participants in their own learning. Since they regularly complete
their work they are able to identify any weaknesses and obtain the support immediately. This in turn builds confidence, which encourages students to engage further with the mathematics and the support.

In light of these findings it is perhaps difficult to ascertain what action can be taken to effectively engage students who lack motivation and confidence (but who clearly need the support). Whilst relatively simple measures could be taken, such as increasing advertising of the available support to encourage students to use it, or targeting “at risk” students immediately by proactively supplying the support, it is believed that addressing the problem on a deeper-level is required to significantly improve student engagement. In particular it appears that action should be taken to raise students’ general engagement levels (not just engagement with mathematics support). This may involve changing the way in which mathematics is delivered to the students to encourage them to engage with their courses, for example by introducing Problem-based or Inquiry-based learning which claim to significantly enhance motivation (as discussed in Chapter 5). Indeed, the issue of disengagement with university studies has been recognised by many institutions and, consequently, they have implemented various methods to promote student engagement.

However, it is acknowledged that further research is needed to investigate if such action would be successful in motivating students to engage with mathematics support. For many students the reasons for not engaging with the support are complex and deep-rooted. Hence, a more rigorous investigation of the students’ attitudes and learning approaches would be useful in determining the difference between engaged and disengaged students, and how these constructs relate to their levels of engagement with mathematics support, and in understanding how engagement can be improved.

3. FUTURE WORK

The underlying aim of this research was to examine the effectiveness of mathematics support and the impact of student engagement on its effectiveness. The research conducted has reported on two specific methods of mathematics support, reactive and proactive support. The discussion following from the outcomes of the qualitative and quantitative research conducted has given an insight into the measures that could be taken to improve student engagement and, hence, enhance the effectiveness of such
support mechanisms. However there is more work that could be undertaken to investigate what further action could be taken.

This thesis has, on numerous occasions, compared students’ behaviour and attitudes towards mathematics at university with their behaviour and attitudes at school. Thus, it is suggested that further work be carried out with regards to how students’ prior experiences may impact upon their engagement levels, both in terms of behaviour and cognition. In particular, there is much debate surrounding “teaching to the test” in mathematics. Since students are being taught how to pass exams rather than how to make sense of mathematics, the subject rarely excites students resulting in a “dislocation of the love of learning”, Covington (2005). It is likely that this has major repercussions in the way students interact with mathematics in the future, particularly those that are “at risk”. Further research could be carried out to examine the extent of this problem within Higher Education and its impact upon student engagement.

It has also been suggested that the way in which students approach their learning of mathematics is qualitatively different to the way in which students approach their learning of other subjects (particularly art-based subjects). The way in which students interact and relate with a task will be indicative of their level of engagement. In particular, this thesis has discussed Deep learning, indicative of active cognitive engagement and Surface learning indicative of superficial engagement. However, there is a need to redefine such learning approaches for the areas of mathematics. Further research in this area will provide further information with regards to how students engage with the mathematics and how this may differ from other disciplines.

Finally, it is recommended that further research is carried out to examine the effectiveness of other mathematics support initiatives. Chapter 2 drew upon work by Challis et al (2004), whereby it was recognised that evaluating the benefit of mathematics support would be a difficult and extremely large project. Indeed the research conducted in this thesis has revealed that when evaluating mathematics support there are a number of complex issues that could impact upon its effectiveness, specifically student engagement. This thesis has concentrated on two particular support mechanisms. However, it would be useful to investigate the effectiveness of
other support mechanisms, particularly within other institutions and to examine the extent to which student engagement may impact upon their effectiveness.

In summary there is scope for further research in the area of student engagement and mathematics support, particularly within Higher Education.
REFERENCES


Furner, J. M. and Berman, B. T. (2004). Confidence in their ability to do mathematics: the need to eradicate math anxiety so our future students can successfully compete in a high-tech globally competitive world. Philosophy of Mathematics Education Journal, 18, pp. 1–33.


Ireland, L. (2006). Maths support at the University of Hull: what we do and what we have learned. MSOR Connections, 6(3), pp 1-3


APPENDICES

APPENDIX A: QUESTIONNAIRE USED FOR PRELIMINARY RESEARCH FINDINGS

<table>
<thead>
<tr>
<th>MAA108 - Mathematics for Physics 1 Module Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>We would like to gather information with regards to the module MAA108. Your perceptions and opinions are important to us so that we can assess the successfulness of the support mechanism put into place this year. To assist us in this matter could you please provide your ID number for identification purposes only. Please be assured that all data is confidential and your anonymity will be preserved throughout.</td>
</tr>
</tbody>
</table>

1. Student ID: [ ] [ ] [ ] [ ] [ ]

2. What was your previous mathematics qualification?
   - A-level 'A'
   - A-level 'B'
   - A-level 'C'
   - AS level (any grade)
   - Foundation Year (Loughboro')
   - Foundation Year (Other Uni)
   - Access Course

3. Please tick all that apply with regards to your education prior to this course.
   - I enjoyed maths.
   - I was good at maths.
   - I viewed maths as important to Physics.

4. Which group were you placed in?
   - Group R
   - Group W

4. What were the advantages/disadvantages of this group? Tick all that apply.

   **Disadvantages**
   - Separated from friends.
   - Pressure to do well.
   - Felt stigmatized.
   - Availability/non-availability of extra hour.

   **Advantages**
   - In a cohort of students with similar ability.
   - Confidence to ask questions.

   Other __________________________

5. Please rate the following, in terms of what is useful to you when learning mathematics. (1 = extremely useful ... 5 = not useful at all.)

   - Clear explanation of basic theory. 1 2 3 4 5
   - Plenty of worked examples 1 2 3 4 5
   - Explicit linkage between mathematics and topics in Physics. 1 2 3 4 5
   - Opportunity, in class, to try examples myself. 1 2 3 4 5
   - Talking to fellow students about my problems. 1 2 3 4 5
   - Regular testing. 1 2 3 4 5
   - Written feedback on my work. 1 2 3 4 5
   - Taking one-to-one with a tutor. 1 2 3 4 5

   Are there any other activities that particularly help you to learn mathematics?

6. How regularly have you attended lectures on your course?
   - < 25%  [ ]
   - 25% - 50%  [ ]
   - 50% - 70%  [ ]
   - > 75%  [ ]
7. What were the **two** main reasons for missing lectures?
- Too early in the morning
- Couldn't be bothered.
- Don't get much from them.
- Another appointment at same time.
- Illness
- Disliked the lecturer.
- Transport problems.
- Other: [ ]

8. Please indicate how strongly you agree/disagree with the following statements: (1 = strongly disagree, 2 = disagree, 3 = neither agree or disagree, 4 = agree, 5 = strongly agree)

- "I enjoyed this module."
- "I felt confident in the topics covered by this module."
- "The teaching materials were appropriate to my needs."
- "The teaching style was appropriate to my needs."
- "I felt that the group I was in suited my mathematics ability."

9. Please think about how this module compared to other modules on your course. Now indicate how strongly you agree/disagree with the following statements: (1 = strongly agree... 5 = strongly disagree).

- "This module was useful for other modules on my course."
- "This module was easier than other modules on my course."
- "This module was more enjoyable than other modules on my course."

10. Please order these topics accordingly. (1 = the topic I found the easiest... 6 = the topic I found the most difficult.)

- Vectors
- Curve sketching and limits
- Differentiation
- Integration
- Series
- Complex Numbers

11. On average, how many hours per week did you spend on study, outside lecture/tutorial sessions. (Excluding revision for the exam).

- 0
- 1
- 2
- 3
- 4+

12. Please indicate how strongly you agree/disagree with these statements (1 = strongly disagree... 5 = strongly agree).

- "The coursework helped me to learn the material of the topics covered."
- "The feedback from the coursework was useful."
- "Two weeks was adequate time to complete the coursework."

13. Please indicate how strongly you agree/disagree with the following statements (1 = strongly agree... 5 = strongly disagree).

- "This module was useful for other modules on my course."
- "This module was easier than other modules on my course."
- "This module was more enjoyable than other modules on my course."

14. Please order these topics accordingly. (1 = the topic I found the easiest... 6 = the topic I found the most difficult.)

- Vectors
- Curve sketching and limits
- Differentiation
- Integration
- Series
- Complex Numbers
13. We are investigating the possibility of changing the format of the coursework for the academic year 2006-07. Please rate these suggestions in order of preference. (1 = least prefer, 5 = most prefer)

- [ ] One written coursework worth 20% (current format).
- [ ] Two written coursework’s worth 10% each.
- [ ] More than two written coursework’s, totaling 20%.
- [ ] Computer based tests to be taken on the completion of each topic (can be taken at own leisure from any lab worth 20% in total).
- [ ] Invigilated computer based tests, to be taken on completion of each topic. (Must be taken at a specific time with an invigilator present worth 20% in total).

Other:

14. Please indicate how strongly you agree/disagree with these statements: (1 = strongly agree ... 5 = strongly disagree).

- "I felt prepared for the exam." 1 2 3 4 5
- "I felt confident with my exam attempt." 1 2 3 4 5
- "It was fair to give both groups the same assessment." 1 2 3 4 5

15. How many hours did you spend on private revision (outside lectures/tutorials) for the exam?

- [ ] < 5
- [ ] 6 - 10
- [ ] 11 - 20
- [ ] > 20

16. On average, how many times did you visit the Math’s Learning Support Centre (MLSC) in Semester 1?

- [ ] 0
- [ ] 1-3
- [ ] 4-6
- [ ] 7-10
- [ ] > 10

If you have visited the MLSC, please indicate how strongly you agree/disagree with these statements: (1 = strongly agree ... 5 = strongly disagree).

- "I found the support helpful." 1 2 3 4 5
- "I would recommend the MLSC to friends" 1 2 3 4 5

17. Please tick all that apply with regards to your math education at university:

- [ ] I enjoy maths.
- [ ] I am confident at maths.
- [ ] I am good at maths.
- [ ] I view maths as important to Physics.

Please use this space for any other comments about the module:

Thank you for your participation.
APPENDIX B: ATTITUDES / LEARNING APPROACHES QUESTIONNAIRE
USING OPEN-ENDED QUESTIONS

MAA108 - Mathematics for
Physics 1 Questionnaire

1. Student ID: 

2. When you were at school, how did you feel about studying mathematics?
(Please discuss in detail. At least 50 words)

3. What strategy do you adopt when learning some mathematics?
(Please discuss in detail. At least 50 words)

4. How do you feel about studying mathematics at university?

Interesting comments may be investigated further. Please tick the following box if you are willing to take part in a focus group session and/or interview.
Please provide your telephone number so we can contact you.
Telephone number:
1. Student ID: [ ] [ ] [ ] [ ] [ ] [ ]

Previous Mathematics qualification:
- A-level 'A'
- A-level 'B'
- A-level 'C'
- A-level 'D'
- A-level 'E'

[ ] AS (any grade)
[ ] Access
[ ] Foundation Yr
[ ] Other (please specify)

2. At university, how do you now feel about studying mathematics? (Please discuss in detail. At least 50 words)

3. What strategies have you adopted when learning some mathematics at university? (Please discuss in detail. At least 50 words)

Thank you for your participation.
APPENDIX C: PILOT QUESTIONNAIRE

Pilot Questionnaire

Thank you for taking the time to pilot this questionnaire. You need only answer Questions 2, 3 and 4.

Please note that the information you give will not be shared or analysed. The answers you provide will only be used to ensure that the questionnaire is understandable and ready for distribution.

If any of the questions appear to be ambiguous or if you have any suggestions of how to improve the readability of the questionnaire, please comment below.

Thank you.

Comments:
<table>
<thead>
<tr>
<th>1. Student ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

2. What are your feelings towards studying mathematics at school?  
(Please discuss in detail. At least 50 words)

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

3. How do you usually go about learning some mathematics?  
(Please discuss in detail. At least 50 words)

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

4. How do you feel about mathematics at university?  

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Interesting comments may be investigated further. Please tick the following box if you are willing to take part in a focus group session and/or interview.  
Please provide your telephone number so we can contact you.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Telephone number:
**APPENDIX D: INTERVIEW GUIDE**

**Interview Guide - Regular MLSC user's**

1. What course are you taking at Loughborough University?

2. What is your current year of study?

3. How did you hear about the centre?
   - Advertising in lecture
   - Advertising from a leaflet/poster
   - Recommendation (lecturer/friend)

4. What was the reason for your first visit to the centre?
   - Came to collect a workbook
   - Curiosity
   - Had a specific problem which needed addressing

5. Why did you come back to use the centre again? What made you a 'regular' user?
   - Needed more help on the same problem/area
   - Needed help on a different problem/area
   - Liked the atmosphere
   - Convenient place to work
   - Generally engaged with everything on course? (tutorials etc.)

6. Do you view yourself as a 'good' mathematician?
   - Compared to friends / other students
   - Do they feel able / weak / talented / unprepared in the subject?

7. From my previous research I have found that there are a number of reasons as to why some students are not using the centre (see below);
   - Awareness of the centre's location
   - Awareness of the centre's facilities
   - Awareness of the need for help
   - Feeling embarrassed and/or intimidated
   - Perception that the centre is not relevant to the degree course (eg. Geography, Business students)

**Did you have to overcome any of these factors before you used the centre?**

- YES → Which one(s) and how did you overcome them?
- NO → Why were they not a factor?

8. Describe a typical visit to the centre from your personal experience. Include what made you come to use the centre, what you did/how you were helped, what you got out of the visit.
   - How were they engaging with the support?
     - just to get 'answers'  
     - to understand a method/area
     - SURFACE
     - DEEP

9. How has using the centre helped you in terms of learning maths at university?
   - Do they feel more confident?
   - Do they feel able to 'stand on own two feet'?
   - Do they feel the support had some kind of effect on their performance in mathematics?

10. How often do you think you will use the MLSC in the future?
    - Usage tail-off/increase towards end of degree?

11. What was a good aspect of the MLSC / what could be improved?
APPENDIX E: PARTICIPANT CONSENT FORM

INFORMED SUBJECT CONSENT FORM (STUDENT)
FOR STUDENT PROJECT IN THE DEPARTMENT OF MATHEMATICAL SCIENCES,
Coventry University

NAME OF STUDENT: Ria Symonds
NAME OF UNIVERSITY SUPERVISOR: Prof Duncan Lawson
COURSE TITLE:
TITLE OF RESEARCH PROJECT: How Effective are Mathematic Support Mechanisms?

THANK YOU FOR AGREEING TO CONSIDER BEING A SUBJECT IN MY RESEARCH.

BY ANSWERING MY QUESTIONS YOU ARE CONSENTING TO YOUR DATA BEING USED IN MY STUDY. YOUR NAME WILL ONLY BE RECORDED FOR MATCHING PURPOSES. ANY PAPERWORK WITH THIS RECORD WILL BE KEPT SECURE IN A LOCKED CABINET, AND ELECTRONIC DATA WILL BE STORED ON A PASSWORD PROTECTED PC. ONLY MY SUPERVISORS AND MYSELF WILL HAVE ACCESS TO THIS DATA. IN THE WRITE UP OF MY THESIS, YOUR NAME WILL NOT BE MENTIONED AND SO YOU WILL REMAIN ANONYMOUS.

(Note that a PARENT or GUARDIAN MUST give their consent if you are under the age of 18.)

PURPOSE OF THE RESEARCH

- IDENTIFY AND EVALUATE VARIOUS MEANS OF PROVIDING MATHEMATICS SUPPORT THROUGHOUT THE UK AND IN PARTICULAR COVENTRY AND LOUGHBOROUGH UNIVERSITIES.
- IDENTIFY STUDENTS WHO MAY BE AT RISK DUE TO PRIOR KNOWLEDGE OR SPECIAL NEEDS.
- TO UNDERSTAND WHY SOME AT RISK STUDENTS AVAIL THEMSELVES OF EXTRA SUPPORT AND OTHERS DO NOT.

PARTICIPATION IN THIS RESEARCH WILL INVOLVE
You will be asked a few questions with regards to your opinions about the mathematical content on your course and mathematical support systems. This session will be recorded for analysis purposes but all data will remain anonymous.

WHAT WILL HAPPEN TO YOUR DATA
Any data/results from your participation in the study will be used by Ria Symonds as part of her project work. The data will also be available to Prof. Duncan Lawson and Dr. Carol Robinson. It may also be published in scientific works, but your name or identity will not be revealed.
Data will not be available or seen by anyone except the Project Supervisors and Research Student (as named above). All paper-based data will be stored in a secure cabinet. Electronic data will be stored on a password protected PC.

If you have any questions or queries Ria Symonds will be happy to answer them. If they cannot help you, you can speak to Prof. Duncan Lawson or Dr. Carol Robinson.

If you have any questions about your rights as a participant or feel you have been placed at risk you can contact Tony Croft (Mathematics Education Centre, Loughborough University).

I confirm that I have read the above information. The nature, demands and risks of the project have been explained to me.

I have been informed that there will be a payment of £5 to me for participation.

I knowingly assume the risks involved and understand that I may withdraw my consent and discontinue participation at any time without penalty and without having to give any reason.

Subject’s signature ___________________________ Date ______________

Investigator’s signature ___________________________ Date ______________

The signed copy of this form is retained by the research student, and at the end of the project submitted to the supervisor.

A second copy of the consent form should be given to the subject for them to keep for their own reference.
APPENDIX F: SPSS OUTPUT COMPARING USAGE BY STEM/NON-STEM

Case Processing Summary

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Valid</td>
<td>Missing</td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students * Year</td>
<td>13402</td>
<td>100.0%</td>
<td>0</td>
<td>.0%</td>
<td>13402</td>
<td>100.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Students * Year Crosstabulation

Count

|            | Year                      |            |            |            |            |            |            |            |            |            |            |            |            |            |            |
|------------|---------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|            | 2004-5                    | 2005-6     | 2006-7     | Total      |            |            |            |            |            |            |            |            |            |            |            |
| Students   | STEM                      | 4429       | 3587       | 3827       | 11843      |            |            |            |            |            |            |            |            |            |
|            | Non STEM                  | 431        | 338        | 790        | 1559       |            |            |            |            |            |            |            |            |            |
| Total      |                           | 4860       | 3925       | 4617       | 13402      |            |            |            |            |            |            |            |            |            |

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>205.765a</td>
<td>2</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>196.723</td>
<td>2</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>154.011</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>13402</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 456.58.
APPENDIX G: SPSS OUTPUT COMPARING USAGE BY MODULE GRADE
AND FREQUENCY OF VISIT

Case Processing Summary

<table>
<thead>
<tr>
<th>Cases</th>
<th>Valid</th>
<th>Missing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent</td>
<td>N</td>
</tr>
<tr>
<td>Visits * Grade</td>
<td>744</td>
<td>100.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

Visits * Grade Crosstabulation

<table>
<thead>
<tr>
<th>Count</th>
<th>Grade</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;40%</td>
<td>&gt;40%</td>
</tr>
<tr>
<td>Visits 0 visits</td>
<td>67</td>
<td>338</td>
</tr>
<tr>
<td>1 visit</td>
<td>6</td>
<td>52</td>
</tr>
<tr>
<td>&gt; 1 visit</td>
<td>5</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>473</td>
</tr>
</tbody>
</table>

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>15.768a</td>
<td>4</td>
<td>.003</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>17.305</td>
<td>4</td>
<td>.002</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>15.046</td>
<td>1</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>744</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.49.
Schedule of questions for Focus Groups / Interviews

- How many times did you use the centre last year?

- What are your views towards mathematics during your first year at university?
  - Like/dislike? (Why?)
  - Compared to school?

- What were your feelings towards your performance in your first year mathematics module/s?
  - Why didn’t you perform very well? (Laziness, other commitments etc.)
  - Did they work hard?
  - Learning strategy? Did they have one, did it change?
  - Revise for the exam? When/How?

- Were/Are you aware of the MLSC and the facilities available in mathematics support?
  *If not, why?*
  - Were you told about it in lectures?
  - Do you know any friends who use it?

  *If yes, why didn’t you make use of these facilities?*
  - Did you seek support elsewhere?
  - Did you think it wouldn’t be helpful? Why?
  - Did you feel you didn’t need to use it?
  - Intimidating atmosphere?
  - Too busy?
  - Can get help with practice tests/coursework and HELM workbooks.

- What support would you have found useful / would you have used?

- Do you think you could have improved your mathematics performance with support from the MLSC?
  - Have you used the MLSC in your second year? If not, why not?
about the support centre and probably go into it. But you know because it's the first semester you weren't really that aware of the help as well and where things are and stuff. I'm more settled now, at uni, and I know what's what. So after experiencing one semester of uni and a feel of the exams and that and the level of maths, I know that I do need to come quite regularly.

Interviewer: Did you ever think to ask your lecturer or anybody else about where the support centre was? Was there anything else stopping you from finding out where it was?

Student D: I think probably just the embarrassment, because I feel like I'm that bad at maths. I scraped a C at GCSE the last time I did maths so I think coming to a support centre at a university it's a bit daunting as well. I suppose it was the embarrassment for me, I just felt, because I know myself that I'll sit in my lectures and I find it really hard what other people have probably done.

Interviewer: Do you think that has a played a big role or not?

Student D: Probably yeah.

Interviewer: Do you think that still might hinder you from using the centre?

Student D: No, at the moment I need to go now, embarrassment or not. After the mark I got I need to force myself to go.

Interviewer: So how are you feeling about actually coming and taking that first step?

Student D: I still feel a bit wary because I'm going to have to say to someone, like I've got this question or this topic that I'm stuck on and they'll probably say to me "well do you know how to do this and that?" and I'll say no. And that's what I'm a bit embarrassed about. But I suppose I've got to make the first step so then each time I come it will probably get easier. And it will help me as well.

Interviewer: Is there anything similar for you Student E?

Student E: Yeah I think the reason why I wouldn't ask the lecturer or anyone during term time was because I'd probably be behind on the work. And so I'd feel embarrassed about going up and saying or asking about work I did two weeks ago, saying I don't understand how to do that. Just because of the fact that, I mean I don't think you'd get shot down or they wouldn't say "why are you coming about that now?" but it's just in your mind you don't want to ask you still feel quite embarrassed. So essentially you don't really understand what's going on and two weeks following that.

Interviewer: Was that in your lectures and tutorials?

Student E: Lectures more so, yeah. It would probably be something I'd go to Mustoe and ask but it's quite daunting.

Student D: Yeah like, sometimes if there's something about two weeks, say when your looking back at your notes say something about two weeks earlier, and you think 'I don't understand it' I have sometimes thought you know maybe I should just go to Mustoe or something and say 'you know these lectures we had about two or three weeks ago I'm still not understanding them', but you feel a bit silly because you think they might think why didn't you come then or something. The time just goes so quick as well, and then you move onto the next topic and it's
**APPENDIX J: PHASE 2 QUESTIONNAIRE FOR ON THE SPOT INTERVIEWS WITH NON-USER**

<table>
<thead>
<tr>
<th>ID Number:</th>
<th>Year of Study:</th>
</tr>
</thead>
</table>

1. What course do you take?

2. Does this involve a mathematics-based module?
   (specify)

3. Are you aware of the MLSC?
   - **YES**
   - **NO**

4. If **YES**, Have you used the MLSC?
   - **YES**
   - **NO**
     - leaflets, posters, lecture recommendation, friends.
     - Any ideas of what it is?

5. If **YES**, If **NO**,
   i) How often?
   ii) Have you used it recently?
   iii) Did you find it useful?

   i) Why not?
   ii) Where do you usually learn/revise?
   iii) Where do you get help with your maths?

---

**Other comments:**
APPENDIX K: SAMPLE SIZE CALCULATIONS

The formula for sample size for a finite population size $N$ is

$$n = \frac{t^2PQ}{d^2} \cdot \frac{1}{1 + \frac{1}{N} \left(\frac{t^2PQ}{d^2} - 1\right)}$$

Where $t$ is a value from t-tables associated with the confidence required, $P$ is the presumed proportion of “successes”, $Q$ is the presumed proportion of “failures” and $d$ is the ± band for the proportion (i.e. I want to be X% confident of my estimate being within ± $d$). Cochran (1963).

For the sample of students who had never used the MLSC and had failed a mathematics module:

$N = 196$,  
$t \approx N = 2$ (95% confidence) or  $t \approx N = 1.65$ (90% confidence)

Assuming the worse case scenario, i.e. $P = Q = 50(\%)$

95% confidence

$$n = \frac{2^2(50)(50)}{0.95^2} \cdot \frac{1}{1 + \frac{1}{196} \left(\frac{2^2(50)(50)}{0.95^2} - 1\right)} = 192.6$$

A sample of 193 students would be needed to be 95% confident that the result represents the total population.

90% confidence

$$n = \frac{2^2(50)(50)}{0.90^2} \cdot \frac{1}{1 + \frac{1}{196} \left(\frac{2^2(50)(50)}{0.90^2} - 1\right)} = 192.4$$

A sample of 193 students would be needed to be 90% confident that the result represents the total population.
A sample of 29 students was obtained.

By rearranging

\[ d = t \sqrt{\frac{N - n}{N - 1}} \sqrt{\frac{PQ}{n}} \]

\[ n = 29, \quad N = 196, \]
\[ t = N = 2 \text{ (95\% confidence)} \quad \text{or} \quad t = N = 1.65 \text{ (90\% confidence)} \]

Assuming the worse case scenario, i.e. \( P = Q = 50(\%) \)

95\% confidence

\[ d = 2 \sqrt{\frac{196 - 29}{195}} \sqrt{\frac{(50)(50)}{29}} = 17.2 \]

This translates to a margin of error of 17.2\%.

90\% confidence

\[ d = 1.65 \sqrt{\frac{196 - 29}{195}} \sqrt{\frac{(50)(50)}{29}} = 14.2 \]

This translates to a margin of error of 14.2\%. 
APPENDIX L: LEARNING CONTRACT

Learning Contract: Mathematics

MODULE: MAA108 Mathematics for Physics 1
Module Lecturer Dr J P Ward (joe)

Name ID
Email address

I agree

• That it is very important for success in my chosen course that I will develop my mathematical skills to the best of my ability. I will need to put in considerable, sustained effort to achieve this.
• To do my utmost to attend every lecture and every tutorial in mathematics and I accept that poor attendance leads to poor results.
• To prepare properly for lectures and tutorials by reading handouts and completing exercises in good time.
• To concentrate and to listen carefully in lectures.
• To attempt every exercise presented and to construct solutions to all, either by myself or with assistance of the lecturer or tutor.
• To trial the computer tests.
• To prepare adequately and in good time for the end of module examination.
• To take additional actions as become necessary (e.g. attend regularly the drop-in sessions at the Mathematics Learning Support Centre) if despite all the above, I am still struggling with the material.

Signed Date

Name Dr Joe Ward
Email Address: j.p.ward@lboro.ac.uk

I agree

• To do my best to increase the skill level that this student has in mathematics.
• To be available to help at all reasonable times during the week and to be sympathetic to the difficulties this student experiences in learning mathematics.
MAA108 Follow up Interview Questions

1. How do you feel about maths compared to your school experience?
   - Same/different?
   - More/less enjoyable, more/less confident

2. How did you feel about your maths module mark?
   - Were you happy/disappointed/surprised?
   - How did you do in relation to other modules?
   - Did you expect to do any better/worse than other modules?

3. How much work/revision did you do for the module?
   - Could you have done more?
   - If you didn’t come to lectures, why?
   - If you didn’t revise, why?
   - If you did put in a lot of work, why do you think you didn’t get a higher mark?
   - Were there other factors that prevented you from working? i.e. social side of university, a part time job.

4. What are your feelings towards the assessment methods of the module?
   - Coursework, Exam.
   - Which was easier?
   - Which did you prefer? (Why do you prefer one to the other?)
   - Why do you feel you performed poorly/well in the coursework/exam assessment?

5. Did you struggle with any of the mathematics in the module?
   - Did you feel you needed more support?
   - Did you use the MLSC for extra support?
   - Could you have done more? If so, what?
   - Did you make full use of the support offered?
   - Could you have done more?

6. Did you enjoy the module?
   - Have your feelings towards mathematics changed as a result of this module?
   - If you didn’t, why? Could it have been made more enjoyable?
   - Did you view the module as important? If not, why?
APPENDIX N: ANALYSIS OF RESPONSES FROM 27 STUDENTS FROM BOTH DISTRIBUTIONS OF THE QUESTIONNAIRE

A notable proportion of the responses from the 27 students were related to the attitudinal factor of Self-concept of ability. The relatively large number of students who chose to comment upon this may indicate that this was particularly influential in terms of the students' attitudes towards mathematics. It appears that prior to university the well-prepared students were, unsurprisingly, more confident in their abilities compared to the less well-prepared students. However, after the first semester of university the students' attitudes are generally much more positive. Although two less well-prepared students still lack confidence in their ability, the remaining nine students indicated a positive attitude. This may indicate that students who were likely to be engaged (in terms so behaviour) with the mathematics module were more likely to hold a positive self-concept of their ability.
With regards to students' overall enjoyment of mathematics, it appears that this attitudinal factor was more influential upon the students' attitudes prior to university than afterwards. Indeed, in the first distribution, 20 out of the 27 students related their attitude to enjoyment (or dislike) of the subject compared to four students in the second distribution. It appears that the well-prepared students and the less well-prepared students had enjoyed mathematics at some point prior to university. However, a larger proportion of the less well-prepared students also indicated disliking mathematics at some point prior to university. Nevertheless, all comments made in the second distribution relate to a positive attitude, which could suggest that students who were engaged were more likely to hold a positive attitude towards mathematics.

<table>
<thead>
<tr>
<th>Prior to uni</th>
<th>No. of students (27)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>7</td>
<td>WP (20)</td>
<td>+ve 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (7)</td>
<td>-ve 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-ve 2</td>
</tr>
<tr>
<td>At uni</td>
<td>4</td>
<td>WP (20)</td>
<td>+ve 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (7)</td>
<td>-ve 0</td>
</tr>
</tbody>
</table>

In comparison to the other attitudinal factors, 'Motivation' did not appear to be as influential with regards to the students' attitudes towards mathematics, since only a small proportion of responses related to this factor. It also appears that there was very little difference between the well-prepared and less well-prepared students' attitudes with regards to 'Motivation'. However, this does not necessarily mean that motivation was not important with regards to these students' attitudes. Similarly to the other attitudinal factors, all students' responses with regards to 'Motivation' were positive, further indicating that students who are engaged will be more likely to hold a positive attitude.
A large proportion of students choose to comment upon the teaching of mathematics in relation to how they felt about the subject (in both distributions of the questionnaire). This may indicate the importance of a good teaching experience and how this relates to a student’s attitude. Although a few less students choose to comment upon this in the second distribution, compared to the first, the majority of these responses were positive. All but one student held a positive attitude with regards to the teaching of mathematics at university. It is likely that his has helped reinforce a general positive attitude towards mathematics and that a positive teaching experience has encouraged students to engage with the subject.

Finally, in terms of students’ attitudes with regards to the value of mathematics, there appears to be a notable change in their perceptions prior to university compared to their experience at university. Compared to the other attitudinal factors, the value of mathematics was commented upon by a smaller proportion of students within the first

<table>
<thead>
<tr>
<th>Prior to uni</th>
<th>No. of students (27)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience of Teaching</td>
<td>17</td>
<td>WP (20) 13</td>
<td>+ve 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (7) 4</td>
<td>-ve 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ve 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-ve 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At uni</th>
<th>No. of students (27)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience of Teaching</td>
<td>11</td>
<td>WP (20) 7</td>
<td>+ve 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (7) 4</td>
<td>-ve 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ve 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-ve 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prior to uni</th>
<th>No. of students (39)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value/Worth</td>
<td>6</td>
<td>WP (20) 4</td>
<td>+ve 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (7) 2</td>
<td>-ve 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ve 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-ve 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At uni</th>
<th>No. of students (39)</th>
<th>No. of students</th>
<th>No. of comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value/Worth</td>
<td>9</td>
<td>WP (20) 9</td>
<td>+ve 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LWP (7) 0</td>
<td>-ve 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ve 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-ve 0</td>
</tr>
</tbody>
</table>
distribution. Perhaps indicating that although students did not find mathematics useless, nor did they feel it was particularly worthwhile. However, within the second distribution, there was an increase in the number of responses relating to this factor, all of which relate to students who were deemed as mathematically well-prepared. Since all responses were positive, it appears that a positive attitude with regards to the value of mathematics may have helped students to engage with the subject at university.
For example: Prior to university, an A-level grade ‘B’ student was identified as a Surface learner. He adapted a Procedural approach whilst at university and achieved 69% in his mathematics module.

Figure 8.2: Comparison of students’ learning approaches to mathematics prior / whilst at university and the affect on educational outcome.
Figure 8.2 represents how the Physics students had adapted their learning of mathematics whilst being at university. It illustrates how the 27 students (who had completed both questionnaires) were distributed amongst the four learning approaches prior to university and also whilst at university. The diagram also shows each student’s mathematics module mark and their prior mathematics qualification. For example, prior to university, an A-level grade ‘B’ student was identified as a Surface learner. He adopted a Procedural approach whilst at university and achieved 69% in his mathematics module. It should be noted that due to the small sample size, the following analysis cannot be used to make general assumptions. However, the data does provide interesting preliminary findings in this area.

Prior to university, it appears that the approach that a student adopted to their learning of mathematics was not particularly related to their performance in the subject. This may suggests that the assessment system was equally likely to reward a Surface or Deep approach to learning mathematics. However, since the sample size is particularly small and that qualitative methods were used to collect this data, further data would be needed to examine this issue further. Interestingly, the six Strategic learners all achieved a good A-level grade (three C’s, two B’s and an A), which could suggest that the A-level assessment does reward a Strategic approach in mathematics. However, these students may not necessarily have a deep understanding of the subject.

Comparison of the average mathematics module grades of the four categories of learners shows that, for these students, there are notable differences in the average marks of the students’ final performance in mathematics in relation to their learning approaches. In particular, Deep learners were more successful than Surface learners at university. Figure 8.2 shows that students who were classified as Surface learners achieved a poorer grade than those classified as Procedural or Deep learners, since their average module mark was 49%. Students classified as Procedural learners performed notably better than the Surface learners (average of 60%) but were not as successful as the Deep learners (average of 66%). Although this data is not statistically significant, it could suggest that students who adopt a Deep approach to learning mathematics at university will be more successful. However, some students
can still perform well by adopting one of the other approaches and more data is needed to investigate this further.

The diagram shows that when learning mathematics at university the majority of the Physics students adapted their learning approaches, since 18 out of 27 (67%) students adopted a different learning approach at university compared to the approach they had adopted at school. Of the three students who took a Surface approach to learning mathematics prior to university, one student used this same approach when learning university mathematics, one student adopted a Procedural approach and the other student adopted a Deep approach. The students who changed their learning strategies performed better in the module than the continued Surface learner (69% and 54% compared to 49%). This could suggest that a Surface approach to learning mathematics at university will lead to a poorer educational outcome.

Of the seven Procedural learners three students adopted the same strategy at university and performed well (module marks of 50%, 58% and 60% respectively). Two students adopted a Surface approach, of which one performed well in the module (69%) and one student performed poorly (35%). It is worth noting that the student who performed well had achieved an A-level grade B in Mathematics whereas the student who performed poorly had achieved an A-level grade D in Mathematics. Finally, two students adopted a Deep approach and performed very well in the mathematics module (module marks of 76% and 77% respectively).

Of the ten Deep learners, four students adopted the same approach at university and performed reasonably well in the mathematics module (marks of 54%, 58%, 58% and 73%) respectively. Five students adopted a Procedural approach and this resulted in a variety of performances (range from 42% to 76%). Interestingly, the A-level grade B student and the International Baccalaureate student performed well in the mathematics module (71% and 76% respectively) whilst the two students with an A-level Grade C and one student with an A-level grade D performed comparatively poorly (42%, 45% and 56% respectively). Finally one student adopted a Strategic approach and achieved 49% in the mathematics module.
In the final category, Strategic learners, all six students adapted their learning approach at university. Two students adopted a Procedural approach, of these one performed well (58%) and one performed very well (76%). Again, it is worth noting that the latter student had achieved an A-level grade A in Mathematics whilst the former students had achieved an A-level grade C. The remaining three students adopted a Deep learning approach at university. One student achieved 51% (A-level grade B) in the mathematics module whilst the other three students performed very well with scores of 70%, 71% and 81% respectively (A-level grade B, C and B respectively).

Analysis of this data suggests that in terms of the Physics cohort, Deep learners were more successful in mathematics at university compared to Surface and Procedural learners. However, since the data relates to a very small sample size, there is not enough evidence to support a general hypothesis that Deep learners will outperform other learners in mathematics at university. Since so many students have appeared to change their learning approach to mathematics at university, the data may suggest that the learning approaches are difficult to distinguish within the discipline of mathematics. However, the classification method used meant it was particularly difficult to distinguish between Deep and Procedural learners within this context, especially since mathematics requires an element of skill and to acquire these skills some amount of practice is essential. Moreover, the nature of service maths is to assess competence at procedures rather than a focus on understanding. Therefore, students may be more likely to adopt a Procedural learning approach at university to achieve a good grade. However, since additional information was missing with regards to how students were using such methods and their intentions, this meant it was difficult to classify students as Procedural or Deep learners.
APPENDIX P: ANALYSIS OF INTERVIEW DATA WITH 2006/7 PHYSICS STUDENTS – FURTHER EXAMINATION OF LEARNING APPROACHES

Student 1

Analysis of Student 1’s interview indicates that he has failed to take responsibility for his own learning. Worryingly, Student 1 felt that he was coping fine at university, and as such did not feel as though he needed to attend his mathematics lectures or tutorials. However, this student failed the module with a module mark of 24%. When asked how often he had attended, Student 1 stated:

“...only a few times because I’ve not really been that stuck on much stuff. And if I ever was stuck I found out the answer by myself...I don’t come [to the sessions] when it’s a subject I’m quite familiar with”

Student 1 conveyed obvious characteristics of Surface learning (both in his interview and from the questionnaire), particularly that of rote learning.

“I read through the written notes I made myself and perhaps a bit of the workbook...I’ll just try questions from the workbook or maybe from a handout in the lecture. I take an easy one a moderate one and a hard one usually. So if there is nine, I’d do the first one, the middle one and an end one...with the few problems I continue to get wrong do some more until I get them right”

It is clear that this student has no intention of gaining an understanding of the mathematics but rather concentrates on duplicating methods to get a correct answer. It appears that Student 1 lacked cognitive engagement in addition to lacking behavioural engagement.

However, the student also showed some tendencies towards Strategic approaches, which he may have developed since coming to university.

“I’ll practice them [past exam questions] more because most past papers have the rough same kind of set up don’t they, because you can practice answering the same kind of questions because they’re roughly the same but with different figures really...it’s about getting the marks really”

Generally, it appears that Student 1 had adopted learning techniques that would achieve short-term goals, indicating superficial engagement with mathematics.
Student 2

Student 2 was classified (using data from the questionnaire) as using procedural strategies to learn mathematics at university. His interview confirmed this orientation:

"First I need to study all the things in the topic and then try some examples. If it is a completely new topic I like to look at all the examples and I will do all the problems from the workbook then that's it. I will look at notes and examples 50% [of my time] each. If I look at some questions and they become familiar to me then I will understand the material behind it."

Clearly, Student 2 would practise questions to learn mathematics. Although he has no initial intention to understand mathematical concepts or theories, Student 2 does indicate that some understanding will emerge through rigorous interaction with the subject. This indicates that the student is actively engaged with his learning of mathematics. However, he perhaps is not fully engaged on a cognitive level. Student 2 also indicated to using some Strategic methods, which were not indicative from the questionnaire data. This involved using past exam papers to help 'learn' questions.

"I will look at past question papers and if I can do all of them then that is fine, but if not I will look at my notes."

Strategic learners are likely to be superficially engaged. However, since Student 2 indicates that he will utilise his lecture notes in conjunction with the past exam papers to learn the material, it appears that his engagement is more profound.

Student 3

Analysis of the questionnaire data indicated that Student 3 also used Procedural strategies to learn mathematics at university. This was confirmed in his interview:

"Examples first. If they are any notes I will go through them. I will do them until I can do them [right], after the examples I will try and look for questions similar to that and then I will think 'yeah that's quite enough of that'. I will stop after I think I have learnt that stuff. First method, then what I normally do is I do it until it's in my mind. I try to understand it. I'll close that topic then when it is easy."

Since Student 3 is actively engaged with the material then this may indicate some form of cognitive engagement with mathematics.
Many of the students who were interviewed indicated that they would use past exam papers to help learn mathematical material. However, whilst some of these related to Strategic methods (since they used exam papers to alert them of cues or predict exam questions), the majority would use them merely as a way of practicing more questions, in a procedural way. This is illustrated by student 3:

“I use past papers and other examples, I go through the workbook first then try questions and then normally I go to the past papers. But I will only do one of those.

Clearly, Student 3 was engaged with mathematics in terms of behaviour, since he exerted effort in solving problems. However, this may not necessarily have been on a deep cognitive level.

Student 4

Student 4 conveyed characteristics of Surface learning both in the interview and from analysis of data from the second distribution of the questionnaire. In particular, Student 4 would learn by rote with an intention to replicate procedures (rather than to gain understanding).

“Basically [I learn by] doing questions, what other way can there be really? I tend to write things out again. That’s the only way I can learn by writing things out again, going back over it...I stop [doing questions] when I find it easy. Like, say differentiation, I’d probably do five [questions] but if I found the first three really easy then I’d probably stop then...I’ll probably do the easy ones to check I could but generally I won’t do all of them”

However, his strategies seemed to involve some elements of Deep learning. This may have been a legacy from his learning strategies adopted prior to university, since data from the first distribution of the questionnaire had indicated that Student 4 had used a mixture of Deep and Procedural strategies to learn mathematics at school.

“I think by the end of a book if I look back and think “well I don’t really know why I use chain rule” I’ll go back and read it again to check with my knowledge from the end of the chapter.”

It appears that Student 4 has made some effort to gain a deeper understanding by relating his knowledge to previous concepts. However, in his interview, Student 4 referred to this as an afterthought and, generally, emphasised the use of examples and questions to learn mathematics.
It appears that Student 4 will only apply as much effort as he feels is needed and, moreover, generally his engagement is largely superficial.

**Student 5**

Student 5 was classified as using Surface methods in his approach to learning mathematics. His questionnaire responses (both prior and at university) and his interview indicated that this student could be classified as a Surface learner. In particular, Student 5 would use strategies such as memorising and rote learning.

"I look at what I need to do then cover it up to see if I can remember it by redoing the question...working through exercises using the examples given as a template usually helps to lock it in memory"

Although Student 5 clearly uses a strategy that is similar to a Procedural approach, in that he will complete numerous questions, his methods can be classified as Surface since the student appears to have an intention to reproduce the knowledge and procedures rather than an intention to learn the procedures for meaning and understanding.

However, Student 5 has clearly not adapted his learning approaches to learning at university and as such, this student struggled with the mathematical material and, consequently, failed the module.

"I think after the lecture if I had gone back and reviewed the material it would have made maths a lot easier. The problem is I haven’t, so when I fall behind one week I don’t feel like studying it the next since I find it difficult to understand. I have to find out a way to work regularly."

His interview indicates that this student has not taken responsibility for his own learning and lacks some kind of motivation to help him engage with his learning of mathematics.

**Student 6**

Student 6 indicated that he liked to work with groups of friends. In particular, if he came across a problem in mathematics, he would always ask his friends first for help.
Student 6 indicated that he preferred to work in this way since this helped with his understanding of the problem. His rigorous interaction with the material is indicative of Deep learning.

"Lecturers know exactly what they are talking about whereas friends you can discuss it with. So if I go to a lecturer they will say "right you've got to do it this way" but if I go to my friends they sort of stop and make me think about it. And because of that thought process going through my head I actually learn it and it sinks in."

However, Student 6 also liked to work on his own. In particular, Student 6 was aware of his previous weaknesses in mathematics. Therefore, he applied additional effort to his learning of mathematics in order to overcome these weaknesses.

"...I’ll do work on my own extra because I know how hard I find it"

However, Student 6 indicated that he would also use Procedural methods to learn mathematics, by practicing numerous problems.

"I do questions, go through questions and make sure I get them right...I’ll look at the process and the answer and I would go through the question and copy it down and eventually I would look at it less and less and just repeat the question until I could do it without looking and then try other questions that were similar until I was getting right answers... and if I still find it hard to do stuff then I’ll go back and try doing it on my own. I’ll just work on my own until I understand it."

Student 6's dedication, self-regulation and persistence are all indicative of metacognitive awareness of his learning and, hence, Student 6 was clearly cognitively engaged with mathematics. However, since his interview still does not seem to indicate that the student had adopted one specific learning approach (Deep or Procedural), this provides further evidence of the difficulty in distinguishing between the two approaches in terms of learning mathematics.

Student 7

Student 7 was identified as using Strategic approaches to learning mathematics at university. His interview confirmed that this student would make use of a variety of methods to gain short-term goals. Although not all of these emphasised the exam assessment, Student 7’s approaches were indicative of distributing time economically
by applying the least amount of effort to achieve success. In terms of Student 7, this involved learning specific questions that would fundamentally lead to marks.

"First thing I do is read through my notes again...then I'll try and go through as many questions as I can. And then when it comes to revision I'll do problems, problems, problems. The more problems I can do the better...until I get bored of it. But then you'll always find there are some problems you can't do, so you leave them out because if it comes up in the exam it comes up in the exam. If it doesn't then it's good."

Strategic methods are indicative of superficial engagement since a Strategic learner, such as Student 7, will distribute his effort in order to achieve success. Indeed, when describing his learning of mathematics, Student 7 emphasised that the majority of his 'learning' occurred before the exam;

"I'll read through my notes and then do questions for a full day. And probably an all-nighter...Exams are all about confidence. You can blag them if you try."

However, student 7 was aware that his strategies would not necessarily lead to an understanding of the topic. However, this did not seem to be of concern.

"Some of them [questions] you can understand...but you sort of maybe don't use all the sort of steps you're suppose to and you sort of mingle your way around it and it sort of works in a weird way...You know a check point list of the steps that need to be done, but why you're doing it...what's in the middle, is a blur."

However, although Student 7 strategies were largely related to the coursework and exam assessments, he did show some inclination of using metacognitive strategies. This involved reflecting upon the content by teaching it to a friend.

"We have a tendency to get together as a group. Sort of talking through coursework's or with problems we've got like catching up on notes we've missed...for the maths for instance we'll work through the tutorial sheet or other questions from exam papers...even if you're the person helping, it help you, because you're actually breaking it down in steps rather than just doing it off the cuff and really having to think about it, to teach it."

Generally Student 7's comments suggest that the majority of his engagement was largely superficial in order to achieve short-term goals. However, at appears that he has made use of variety of strategies and there is a potential that these could develop into more metacognitive strategies.
Student 8

Analysis of Student 8’s interview indicates that his initial approach to learning mathematics was to use Procedural methods;

“I’ll get a list of exercises that we were given and work through them and I’ll look at my notes as I need the reminder of what needs doing, so if I get to a question and think “right how do I do that one?”, I’ll look at my notes to find the one that corresponds to the question, read it, and carry on doing the questions. I try and do as many examples to help me learn that maths because if you do enough of them it comes second nature, you know what you’re looking for and your able to do it.”

As indicated by all students in the interviews, practising questions was the most favoured method of learning mathematics since this helped to reinforce mathematical knowledge. In the case of Student 8, it appears that he was actively engaged with learning the material in this way. However, Student 8’s questionnaire response indicated that he had used Deep strategies to learn university mathematics. Indeed, his interview confirmed that when using Procedural strategies, Student 8 would engage on a deep cognitive level;

“I’ll use the internet in the sense to find more equations, more questions. Maybe a different way of wording them...more of an example of something where you have to draw the information from the question, just so I have a bit of a variety of different ways of questions being asked to see if I can still do the question in a different manner.”

However, although Student 9 had indicated using Deep approaches to understand the material, he also seemed to be using some Strategic approaches. This involved using past exam papers to predict questions;

“A lot of the problems I get are from past papers because I know it’s going to be a similar style, so even though I’ll find different ones [questions] so I can understand it, for the actual exam I just need to be able to recognise the style that it will be in.

But if it was different, because I’ve done other ways of doing it, I’d still feel confident because ok that’s different but I still know what I’m doing.”

Interestingly, Student 8 seems to learn mathematics with two separate intentions. The first is to understand the material but the second is to pass the exam. Nevertheless, Student 8’s comments indicate that he was cognitively engaged with mathematics at university.
Student 9

Analysis of the interview data with regards to Student 9 provides clear indication that this student was using Deep learning strategies. In particular, Student 9 vigorously interacted with mathematics and would do more than just attend timetabled sessions and complete worksheets.

"I do random research on the internet for maths and physics...I do mostly research on my own, I go on the computer and look up certain formulae and theories and stuff and try and work it out...more for curiosity really."

Student 9 was classified as using cognitive strategies both prior to and whilst at university (using data from the questionnaire data). Student 9’s comments during his interview support this analysis and confirm his orientation towards a Deep learning approach. In particular, he revealed highly metacognitive strategies.

"I don’t like to write things down. Well I’ll write things in the lesson and I might look over it but I do most of my maths in my head. Like I’ll rearrange things in my head and try and put them to theories and sometimes if I come up with something I’ll try and do it on a computer and might put it together and see if the theory works if it doesn’t then I think about it even more. I just remember things because I use them in my head more if I just write it down."

It has been discussed that some Procedural and Surface methods are not synonymous with that approach, such as rote learning, since these methods are essential for learning mathematics. However, the student’s intention behind these methods is important. Student 9’s comments illustrate this. Although he clearly practiced questions to learn the material (which would be classified as Procedural learning), he indicated a much deeper level of engagement with this method. In particular, linking material together.

"I’d usually go through the same kind of questions and do all those and as soon as I know I know that topic I’ll go onto the next subject and learn all those so you can link questions together."

It is clear that Student 9’s cognitive awareness of his learning had undoubtedly contributed to his engagement with mathematics.
Student 10

Student 10 was classified as using Deep learning strategies prior to university (from analysis of the questionnaire data). However, Student 10 did not complete the second distribution of the questionnaire and so it was unclear as to what strategies he chose whilst learning university mathematics. The interview data suggest that Student 10 continued to use Deep strategies. In particular, it appears that Student 10 has reflected upon his learning by interpreting knowledge, rather than accepting concepts at face-value.

"I like to do things my own way and I do things in a weird order to everybody else. Like, people are taught a way to do it and they do it like that, but I like to develop my own way."

Although no attendance data was available for Student 10, his interview indicated that he was actively engaged with the module, both behaviourally and cognitively. Student 10 would make use of all timetabled sessions to 'practice' what he had learnt.

"The lectures are good for getting the knowledge into your head and the tutorials are good for applying it...I use them for things I'm not really that good at, I don't really practice for showing things I can do. Because a good thing about maths is that new things build on things you've already done, so by practising the new things you're also practising the old things."

It is clear that Student 10 is cognitively aware of his learning on some level. However, Student 10's comments suggest that he may have also been using Procedural strategies. Although he rigorously interacted with the content (indication of using Deep strategies) and would relate formulae to each other, Student 10 does not indicate that he would further his knowledge by relating problems to underlying concepts or theories. His comments suggest that his initial intention was not necessarily to understand the material.

"I'll do some questions and then I'll do some similar questions later on and if I can do them I'll leave that section."

This further evidences the difficulty in distinguishing between Deep and Procedural strategies in the context of learning mathematics.