Evidence for Excellence in Education

Final report

Research into the impact of Project Maths on student achievement, learning and motivation

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• independent • insights • breadth • connections • outcomes

The views expressed in this report are those of the authors and do not necessarily reflect the views or policy of the Department of Education and Skills or the National Council for Curriculum and Assessment.

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Executive summary

About the research

The National Foundation for Educational Research (NFER) has been commissioned by the Department of Education and Skills, Ireland, and the National Council for Curriculum and Assessment (NCCA), to undertake research into the impact of Project Maths on student achievement, learning and motivation.

Project Maths is a major national reform of post-primary mathematics curriculum and assessment in the Republic of Ireland for both junior and senior cycles. The syllabuses are divided into five strands, as follows:

- Strand 1: Statistics and Probability
- Strand 2: Geometry and Trigonometry
- Strand 3: Number
- Strand 4: Algebra
- Strand 5: Functions.

Aims of the research

The overarching aim of the research is to explore the impact of Project Maths on students' achievement, learning and motivation in mathematics in:

- the initial schools (phase one schools), which introduced the revised mathematics syllabuses in September 2008
- all other post-primary schools (non-phase one schools), which introduced the revised mathematics syllabuses in September 2010.

Methodology

The methodology for this research comprises four parts:

- **assessment of student achievement** in all strands of the revised mathematics syllabuses in spring and autumn 2012, with two separate cohorts of Junior Certificate and Leaving Certificate students
- **attitude surveys** exploring students' experiences of the revised mathematics syllabuses, administered to the same cohorts of students above
- **case studies** in eight phase one schools, and eight non-phase one schools, exploring in more depth students' and teachers' experiences of the revised mathematics syllabuses
- **qualitative analysis of students' work**, exploring trends in the processes being promoted in the revised mathematics syllabuses.

Students' experiences of the revised mathematics syllabuses

Students' experiences of learning mathematics

Students report that they are frequently undertaking activities commonly associated with the revised syllabuses (for example, making connections between mathematics topics, and applying mathematics to real-life situations). However, more traditional approaches (for example, using textbooks and copying from the board) also continue to be widespread.

Students' perspectives on their progression in mathematics

While Leaving Certificate students appreciate the value of gaining a rich understanding of mathematics, they have found the change in learning approach between Junior Certificate and Leaving Certificate challenging.

In general, Junior Certificate students are more positive about their transition from primary school than Leaving Certificate students are about their transition from Junior Certificate. In part, this may be because Junior Certificate students have experienced greater continuity of learning styles across their transition from primary school.

Students' overall learning and motivation

Students are largely positive about their experience and confidence in learning mathematics, tending to agree that they enjoy it, do well in it and learn quickly in it. Junior Certificate students are more positive and more confident in their ability than Leaving Certificate students.

International comparison suggests that students following the revised syllabuses are slightly *less positive about mathematics, but more confident in their mathematics ability* than those who participated in TIMSS 2007. This implies that, in this research, enjoyment of, and confidence in, mathematics do not necessarily go hand in hand.

Evidence of the extent to which students are using the approaches promoted in the revised mathematics syllabuses

Based on the small sample of students' work included in this study there is emerging evidence that the revised syllabuses are impacting on students' learning in the key process areas. However, the processes promoted through the revised syllabuses are not yet embedded in the written output from mathematics lessons (although they may be evident in other aspects of lessons). This may be expected due to the early stage of the implementation of the revised syllabuses.

Whilst some processes of the revised mathematics syllabuses are visible in some of the student material reviewed, there does not appear to have been a substantial shift in what teachers are asking students to do, and few differences between the phase one and non-phase one students.

It is possible that teachers are currently emphasising the content of the revised syllabuses rather than the processes promoted within it. This reflects earlier findings from the interim report[1] that traditional approaches to mathematics teaching and learning continue to be widespread.

The evidence strongly suggests that students have a good mastery of

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

mathematical procedures and, to a slightly lesser extent, problem solving and making mathematical representations. There is very little evidence in the work reviewed that students are demonstrating reasoning and proof and communication, or making connections between mathematics topics.

The findings suggest that students need to be regularly given high quality tasks that require them to engage with the processes promoted by the revised syllabuses, including: problem solving; drawing out connections between mathematics topics; communicating more effectively in written form; and justifying and providing evidence for their answers.

Students' achievement and attitudes towards mathematics

The variables that affect students' attitudes and achievement

Students' confidence and achievement in mathematics is significantly associated with examination entry level and gender. Of note, girls are less confident about mathematics than boys and perform less well at Junior Certificate.

Overall, following a greater number of strands, or schools having greater experience of teaching the revised syllabuses, does not appear to be associated with any improvement in students' achievement and confidence.

Students' achievement and confidence across the five strands

Whilst achievement is highest in Strand 1 (Statistics and Probability) and lowest in Strand 5 (Functions), confidence is actually highest in both of these strands and lowest in Strand 3 (Number) and Strand 4 (Algebra).

The relationship between confidence and achievement

In this research study, confidence in mathematics does not always correspond to achievement. Although students who are further through their studies perform better than those who are at an earlier stage, higher levels of confidence are not associated with students who have almost completed their studies.

Furthermore, results show that students are confident in relation to Strand 5 (Functions), but do not perform highly when assessed in this area. While girls are less confident in their mathematical ability across all strands explored, at Leaving Certificate level, they perform as highly as boys.

Students' aspirations for further study and careers involving mathematics

Students' perceptions of the wider relevance and application of mathematics

Students tend to recognise the broader application of mathematics, particularly in helping them to secure a place at the university of their choice and in their daily life. Reflecting the broader difference in the attitudes of Junior and Leaving Certificate students, Junior Certificate students are generally more positive about the broader application of their mathematics study than students studying for the Leaving Certificate.

Students' aspirations to further study of mathematics

Almost all Leaving Certificate students plan to go on to further study when they finish their Leaving Certificate, and around half of all students intend to pursue further study involving mathematics.

Almost all Junior Certificate students plan to stay on at school after their Junior Certificate, and the majority plan to take the Higher Level Leaving Certificate examination. The aspirations of students for Higher Level examination in phase one schools are higher than students from non-phase one schools. This may be a result of the revised syllabuses beginning to embed in phase one schools, and therefore instilling a greater enjoyment of, and confidence in mathematics amongst their students.

Students' appreciation of careers involving mathematics

Around two-thirds of Leaving Certificate students stated that they do not intend to go into a job that involves mathematics.

It appears that students are developing a general awareness of the importance of mathematics in further study and of its broader application, but in some cases, the specifics of this, such as a sound understanding of what careers will draw on their mathematical skills and knowledge, appears to be lacking.

Concluding comments

The research highlights that considerable progress has been made in implementing the revised mathematics syllabuses since the inception of the Project Maths initiative in 2008. There are numerous examples of promising practice in the way that mathematics is being delivered in the classroom, and emerging evidence of positive impacts on students' experiences of, and attitudes towards, mathematics.

However, there is also evidence that more traditional approaches to teaching mathematics remain widespread and, in many cases, the approaches described by teachers and students are not yet being evidenced in students' written work. Moreover, at this stage of the curriculum's implementation, the revised mathematics syllabuses taken as a whole do not appear to be associated with any overall deterioration or improvements in students' achievement.

1. Introduction

The National Foundation for Educational Research (NFER) has been commissioned by the Department of Education and Skills, Ireland, and the National Council for Curriculum and Assessment (NCCA), to undertake research into the impact of Project Maths on student achievement, learning and motivation.

Project Maths is a major national reform of post-primary mathematics curriculum and assessment in the Republic of Ireland for both junior and senior cycles. Introduced in 24 phase one schools in September 2008, and rolled out to all post-primary schools in September 2010, Project Maths was designed to change not just *what* students learn about mathematics, but *how* they learn and are assessed. Project Maths represents a philosophical shift in Irish post-primary education towards an investigative, problem-focused approach to learning mathematics, emphasising its application in real-life settings. Both the Junior Certificate (students aged 12 to 15 years) and Leaving Certificate (students aged 15 to 18 years) syllabuses are divided into five strands, as follows:

- Strand 1: Statistics and Probability
- Strand 2: Geometry and Trigonometry
- Strand 3: Number
- Strand 4: Algebra
- Strand 5: Functions.

Students may follow a syllabus at a number of levels. Junior Certificate students can follow a syllabus at Ordinary or Higher Level, while Leaving Certificate students can follow a syllabus at Foundation, Ordinary or Higher Level. Both Junior and Leaving Certificate students may sit their examinations at Foundation, Ordinary or Higher Level. Across all strands and levels, students are encouraged to test out and apply their knowledge to meaningful contexts, and to take responsibility for their own learning through, for example, setting goals and developing action plans. The revised syllabuses are designed to offer a continuous learning experience for students throughout junior and senior cycles, building upon the foundations of mathematical knowledge acquired at primary school.

The research explores students' achievement, learning and motivation in:

- the initial schools (phase one schools), which introduced the revised mathematics syllabuses in September 2008
- all other post-primary schools (non-phase one schools), which introduced the revised mathematics syllabuses in September 2010.

Further background and contextual information about Project Maths can be found on the NCCA website at www.ncca.ie/projectmaths. In addition, earlier findings of the evaluation can be found in NFER's interim report to DES and NCCA[2].

The report is divided into the following sections:

- about the evaluation, covering the research aims and methodological considerations (section 2)
- students' experiences of the revised mathematics syllabuses (section 3)
- the extent to which the processes promoted in the revised mathematics syllabuses are evidenced in students' work (section 4)
- impacts of the revised mathematics syllabuses (section 5)
- students' aspirations for further study and careers involving mathematics (section 6)
- concluding comments (section 7).

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

2. About the evaluation

This section sets out the approach taken to this research into the impact of Project Maths on student achievement, learning and motivation including:

- the overarching aims and key research questions
- the research activities undertaken and methodological considerations.

2.1 Aims of the research

The overarching aim of the research is to explore the impact of Project Maths on students' achievement, learning and motivation in mathematics, in both phase one and non-phase one schools. Table 2.1 sets out the key research themes for this study, mapped against each element of the research (outlined in more detail in section 2.2).

Table 2.1: Key research themes

Research theme	Assessment of student performance	Student attitude surveys	Analysis of students' work	Case studies
Students' achievement in mathematics, across each individual strand of the revised mathematics syllabuses	✓			
Comparison of students' performance in mathematics with international standards	✓			
Students' motivations and attitudes to mathematics, in general and in relation to the revised mathematics syllabuses		✓		✓
Students' perceptions of the effectiveness of different strands and approaches used in the revised mathematics syllabuses		✓		✓
Students' perceptions of their knowledge, understanding, confidence and achievement in mathematics		✓		✓
Students' aspirations for further study of mathematics		✓		✓
Students' views on the relevance and application of mathematics more generally		✓		✓
Students' understanding of the processes being promoted in the revised mathematics syllabuses			✓	✓
The impact of the revised mathematics syllabuses on individual students' progress and standards			✓	
Trends in students' approaches to, and performance in, the revised mathematics syllabuses	✓		✓	

2.2 Methodology

The methodology for this research comprises four parts, each described in detail later in this section:

- **assessment of student achievement in all strands of the revised mathematics syllabuses**. Data was collected at two time points, each time from four groups of students. In Spring 2012, this involved students in the Junior and Leaving Certificate classes of 2012 in both phase one and non-phase one schools. In Autumn 2012, this involved different Junior and Leaving Certificate students in the classes of 2013, again in phase one and non-phase one schools
- **attitude surveys exploring students' experiences** of the revised mathematics syllabuses, administered to the same year groups of students as described above
- **data-rich case studies** in eight phase one schools, and eight non-phase one schools, exploring in more depth students' and teachers' experiences of the revised mathematics syllabuses
- **qualitative analysis of students' work** exploring trends in the processes being promoted in the revised mathematics syllabuses.

Note that examination classes of 2012 and 2013 refer to the group of students reaching the end of their studies during each of these years. Throughout this report, the term examination class will be replaced simply with class (for example, class of 2013).

2.2.1 About the survey and assessment samples

The assessment of student achievement and attitude surveys involved students at both Junior Certificate and Leaving Certificate, in the classes of 2012 and 2013. The strands of the revised mathematics syllabuses followed by these year groups of students are set out in Table 2.2.

Table 2.2: Strands studied by students participating in the assessment of performance and attitude survey

	Year group	Years of study	Strands studied by phase one students	Strands studied by non-phase one students
Junior Certificate	**Students who completed the survey and tests in Spring 2012**	**2009-12**	Strands 1-4	No strands
	Students who completed the survey and tests in Autumn 2012	**2010-13**	Strands 1-5	Strands 1-2
Leaving Certificate	**Students who completed the survey and tests in Spring 2012**	**2010-12**	Strands 1-5	Strands 1-2
	Students who completed the survey and tests in Autumn 2012	**2011-13**	Strands 1-5	Strands 1-4

All phase one schools were invited to participate in the research, and a sample of non-phase one schools was drawn to be representative of school type and size, as well as those included in the Delivering Equality of Opportunity in Schools (DEIS) programme, which aims to address educational disadvantage.

The sample was also drawn to be representative of gender of students and provide coverage of geographical location: all 26 counties in the Republic of Ireland were included. Students were selected so that, across the sample, the distribution of predicted examination levels was broadly based on previous State Examination Commission (SEC) entry patterns.

Timing differences in data collection within the classes of 2012 and 2013

Surveys and assessments for the class of 2012 took place in Spring 2012, as students were reaching the end of their studies. By contrast, these took place in Autumn 2012 for class of 2013, as students were entering their final year of study. As a result, the class of 2013 had experienced fewer months of teaching than those in the class of 2012 at the time they participated in the research. This approach was governed by the research period and maximised data collection in the time available. Where appropriate, variations in students' attitudes and performance as a result of these timing differences are addressed.

Table 2.3 provides a breakdown of the number of schools and students who participated in these parts of the research, by phase and level of study.

Table 2.3: Number of students who participated in the assessment and survey phases of the research

			Phase one				Non-phase one			
			Assessment		Attitude survey		Assessment		Attitude survey	
	Assess-ment date	Exam year	Number of students	Number of schools[3]	Number of students	Number of schools	Number of students	Number of schools	Number of students	Number of schools
Junior Certificate	Spring 2012	2012	303	19	375	19	910	52	2,375	124
Junior Certificate	Autumn 2012	2013	421	17	417	17	795	43	2,248	128
Leaving Certificate	Spring 2012	2012	370	19	299	19	722	52	2,004	124
Leaving Certificate	Autumn 2012	2013	413	17	413	17	788	43	2,161	128

[3] Some phase one schools were unable to participate in the research due to other commitments (e.g. participation in PISA 2012, other school priorities).

The use of comparative data, to measure the impact of the revised mathematics syllabuses relative to the previous ones, is central to the research design. However, as this research commenced in January 2012, the revised syllabuses had been rolled out nationally to most cohorts of students. Therefore, involvement of non-phase one Junior Certificate students in the class of 2012 represents the only comparison group included in this research. Multi-level modelling has enabled further associations to be investigated between extent of involvement in the revised syllabuses and achievement, learning and motivation in mathematics. Multi-level modelling is a development of a statistical technique called 'regression analysis'. This is a technique for finding relationships between variables (for further detail, see Appendix A).

2.2.2 Assessment of student performance

Assessment of student achievement aims to gather quantitative data, focusing on:

- students' achievement in mathematics, across each individual strand of the revised mathematics syllabuses
- trends in students' approaches to, and performance in, the revised mathematics syllabuses.

Assessment of student performance at Junior Certificate level

Assessment booklets were created in order to assess students' performance in individual items pertaining to each strand of the revised mathematics syllabuses, thereby giving an indication of their overall performance across each strand. The phase one classes of 2012 and 2013 were both assessed in Strands 1-4. Additionally, students in the class of 2013 were assessed in two items relating to Strand 5 (Functions). This reflects the strands studied by these year groups[4].

For reference, the booklets are labelled according to the strands covered. Table 2.4 shows the syllabus strands covered by each booklet, and the number of items in each booklet[5]. Two Junior Certificate booklets were produced, which were randomly allocated to students at each school so that phase one students each completed one booklet. Students from non-phase one schools in the class of 2013 only completed questions relating to Strands 1 and 2. They were not assessed on Strands 3-5, which they had not yet been taught.

[4] Assessment booklets were made available in the Irish medium. However, participating Irish language schools included in the sample opted to administer the assessment in English.

[5] The Autumn 2012 booklet JC1/2/5 contains all the items presented in the Spring 2012 booklet JC1/2. The Autumn booklet LC3/4/5 contains all the items presented in the Spring 2012 booklet JC3/4.

Table 2.4: Booklets for the Junior Certificate

Booklet	Syllabus strand	Syllabus area	Number of items	Number of students completing booklet in the class of 2013[6]
JC1/2/5	Statistics and Probability	• concepts of probability • outcomes of random processes • statistical reasoning with an aim to becoming a statistically aware consumer • representing data graphically and numerically • analysing, interpreting and drawing conclusions from data	11	1006
	Geometry and Trigonometry	• synthetic geometry • transformation geometry • co-ordinate geometry • trigonometry	10	
	Functions	• graphing functions	2	
JC3/4/5	Number	• number systems • indices • applied arithmetic • applied measure	11	210
	Algebra	• representing situations with tables, diagrams and graphs • finding formulae • examining algebraic relationships • relations without formulae • expressions • equations and inequalities	10	
	Functions	• graphing functions	2	

[6] Class of 2012 figures are provided in the first interim report (November 2012).

The booklets were made up of items from two international surveys: 'released' items[7] from TIMSS 2007 (Trends in International Mathematics and Science Study, a survey of 13-14 year olds) and sample items[8] from PISA 2000, 2003 and 2006 (Programme for International Student Assessment, a survey of 15 year olds). The use of the TIMSS items allowed a direct comparison to be made between international results and the results of the phase one (and comparison group) students. Details of the origin of each item in the booklets, along with further explanation of the suitability of the international surveys for this research, are given in the interim report (November 2012).[9]

Assessment of student performance at Leaving Certificate level

Again, assessment booklets were created in order to assess students' performance in individual items pertaining to each strand of the revised mathematics syllabuses, thereby giving an indication of their overall performance across each strand[10]. Table 2.5 shows the syllabus strands covered by each booklet, and the number of items in each booklet.

Both phase one and non-phase one students completed one of two booklets, which were randomly allocated to students at each school. However, students from non-phase one schools did not complete the last set of items in the booklets assessing Strand 5 (Functions). Due to the phased introduction of the revised syllabuses, this strand had not yet been taught to the non-phase one students[11].

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[7] Released items are those that have been made public following administration of the survey, in contrast to secure items, which are kept secure for use in evaluating trends in performance in later cycles of TIMSS.

[8] Sample items exemplify the type of material included in a PISA assessment, but have not been used in a live test and so have no comparative data available.

[9] It should be noted that the number of students, at both Junior Certificate and Leaving Certificate, completing each of the booklets varies. Facilities based on relatively small numbers of students taking each item are not estimated to a high level of precision so should be treated with a degree of caution. To estimate facility with a reasonable degree of precision we would usually need to sample around 400 students in each group to be reported.

[10] Booklet LC1/2/5 contains all the items previously presented in SPLC1, GTLC2 and FLC5. Likewise booklet LC3/4/5 contains all the items previously presented in NLC3, ALC4 and FLC5. All items were unchanged and new items were not added.

[11] Assessment booklets were made available in the Irish language. However, participating Irish language schools opted to administer the assessment in English.

Table 2.5: Booklets for the Leaving Certificate

Booklet	Syllabus strand	Syllabus area	Number of items	Number of students completing booklet in the class of 2013[12]
LC1/2/5	Statistics and Probability	• concepts of probability • outcomes of random processes • statistical reasoning with an aim to becoming a statistically aware consumer • representing data graphically and numerically	9	596
	Geometry and Trigonometry	• synthetic geometry • co-ordinate geometry • trigonometry	10	
	Functions	• functions • calculus	9	
LC3/4/5	Number	• number systems • length, area and volume • problem solving and synthesis skills	10	605
	Algebra	• expressions • solving equations • inequalities • complex numbers	7	
	Functions	• functions • calculus	9	

The booklets were made up of items from three international surveys: released items[13] from the Trends in International Mathematics and Science Study (TIMSS 2007, 8th grade) and

[12] Class of 2012 figures are provided in the first interim report (November 2012).
[13] Released items are those that have been made public following administration of the survey, in contrast to secure items, which are kept secure for use in evaluating trends in performance in later cycles of TIMSS.

TIMSS Advanced (2008), and sample items[14] from the Programme for International Student Assessment (PISA) surveys of 2000, 2003, and 2006. Leaving Certificate items were specifically selected to match the revised mathematics syllabus and to assess a variety of mathematical skills. Some items are common across both Junior and Leaving Certificate booklets allowing for some comparison to be made across years. Again, further details are given in the interim report (November 2012).

Administration and marking of the assessment booklets

The booklets were administered to students by their teachers and returned to NFER before being marked using the NFER's own on-line system. Multiple-choice items were double marked by the NFER's data capture staff. The remainder of the items were marked by the NFER team. Teachers in the participating schools were not involved in marking the booklets. All participating schools were offered individual online feedback on their students' results. Fifty-one schools (out of a possible 80) downloaded their assessment results, and 115 (out of a possible 176) downloaded the survey results.

Versions of the revised mathematics syllabus referenced in this report

All references to the syllabus in the assessment sections of this report have been taken from the Junior Certificate Mathematics syllabus for examination in June 2015 and the Leaving Certificate Mathematics syllabus for examination in 2014 only. Where referring to a sub-section of a strand, numbering from the syllabus is provided in brackets. For example, 'representing data graphically and numerically' is labelled as sub-section 1.6 of Strand 1 (Statistics and Probability).

2.2.3 Student attitude surveys

The student attitude survey gathered quantitative data, focusing on:

- students' motivations and attitudes to mathematics, in general and in relation to the revised mathematics syllabus
- students' opinions on the revised mathematics syllabus, including the effectiveness of different strands and approaches
- students' perceptions of their knowledge, understanding, confidence and achievement in mathematics
- students' aspirations for further study of mathematics
- students' views of the relevance and application of mathematics more generally.

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[14] Sample items exemplify the type of material included in a PISA assessment, but have not been used in a live test and so have no comparative data available.

Surveys were administered to two separate year groups of students by their teachers. Students in the class of 2012 completed surveys in Spring 2012, and students in the class of 2013 completed surveys in Autumn 2012[15]. This report primarily focuses on the findings for the class of 2013, drawing comparisons to the class of 2012 as appropriate[16]. Further detailed findings relating to the class of 2012 are provided in the interim report[17].

2.2.4 Case studies

To explore in further depth students' attitudes and experiences of the revised mathematics syllabuses, 16 school case studies were conducted. These included:

- eight phase one schools, which were selected to include schools from different geographical areas and with varying characteristics (for example, school type, level of deprivation), in consultation with NCCA
- eight non-phase one schools, again including schools in different geographical areas and with varying characteristics, chosen from a self-selecting sample of 29 schools who had volunteered to take part in the first survey and assessment phase, and indicated an interest in participating as a case-study school.

The visits took place in Autumn 2012, following early telephone consultations with mathematics coordinators in several schools during the spring and summer terms. Focus groups were conducted with Junior and Leaving Certificate students, as well as face-to-face and telephone interviews with teachers and mathematics coordinators to understand how the revised syllabuses are being implemented. Senior leaders were also invited to participate in an optional interview. The number of participants involved in the case-study phase is presented in Table 2.6.

[15] Attitude surveys were made available in the Irish language. However, participating Irish language schools opted to administer the surveys in English.
[16] Significant differences in the descriptive statistics between phase are presented where appropriate. Comparisons between cohorts are also provided, based on an indicative exploration of the raw data rather than statistical analysis. As this is a cross-sectional study, caution should be applied when interpreting these results as they do not control for any factors which might differ between the two time points. Detailed findings taking account of these factors are explored in the multi-level modelling and presented in section 5.
[17] Jeffes *et al.*, 2012

Table 2.6: Number of participants involved in the case studies

Role	Number of participants	
	Phase one	Non-phase one
Principal/Senior leader	8	4
Mathematics coordinator	8	7
Teacher	15	10
Junior Certificate student	46	43
Leaving Certificate student	46	40

2.2.5 Analysis of students' work

This element of the research focuses on analysing students' written work to identify common features of students' mathematical approaches, as well as information about the mathematical skills that characterise particular groups of students. The sample material was produced by students during their mathematics lessons whilst following the revised syllabuses. Material has been collected from both phase one and non-phase one schools, some of whom were also involved in the case studies. The data collected falls into two categories:

- samples of student work that is the product of a mathematics lesson
- information provided by teachers detailing: the context of the lesson; the learning outcomes expected; and the teaching and learning approaches used.18

As the focus of this part of the study is solely on the analysis of students' written work, contextual details of the lesson have not been included in the analysis. It is important to note that this element of the research focuses on the processes promoted through the revised syllabuses and their presence in students' written work, and it is not intended as an analysis of student performance.

A total of 154 samples of students' written work (37 samples from phase one schools and 117 from non-phase one schools) were collected from 58 lessons (17 lessons from phase one schools and 41 from non-phase one schools). These are in several formats, including copy books, worksheets and class tests. Details of strands covered in these work samples, across the range of levels within the education system (e.g. Foundation, Ordinary and Higher Level), are set out in Appendix B.

[18] At the time of reporting not all teachers had provided this information, though some provided additional commentary on the success of the lesson and the next steps proposed.

In interpreting the data it is important to note that this is a small-scale exercise and the samples collected provide only an indicative picture of how the processes promoted through the revised syllabuses are being evidenced in students' work. Also, written student materials submitted for analysis are not the only product of the mathematics lessons where they were produced (for example, in some cases, students also engaged in discussions, worked in groups and participated in hands-on activity learning). Such approaches generate ephemeral evidence, which would require audio or video to record and was not conducted as part of this research.

3. Students' experiences of the revised mathematics syllabuses

Key findings

Students' experiences of learning mathematics

- Students report that they are frequently undertaking activities commonly associated with the revised syllabuses (for example, making connections between mathematics topics, and applying mathematics to real-life situations). However, more traditional approaches (for example, using textbooks and copying from the board) also continue to be widespread.

Students' perspectives on their progression in mathematics

- While Leaving Certificate students appreciate the value of gaining a rich understanding of mathematics, they have found the change in learning approach between Junior Certificate and Leaving Certificate challenging.
- In general, Junior Certificate students are more positive about their transition from primary school than Leaving Certificate students are about their transition from Junior Certificate. In part, this may be because Junior Certificate students have experienced greater continuity of learning styles in their transition from primary school.

Students' overall learning and motivation

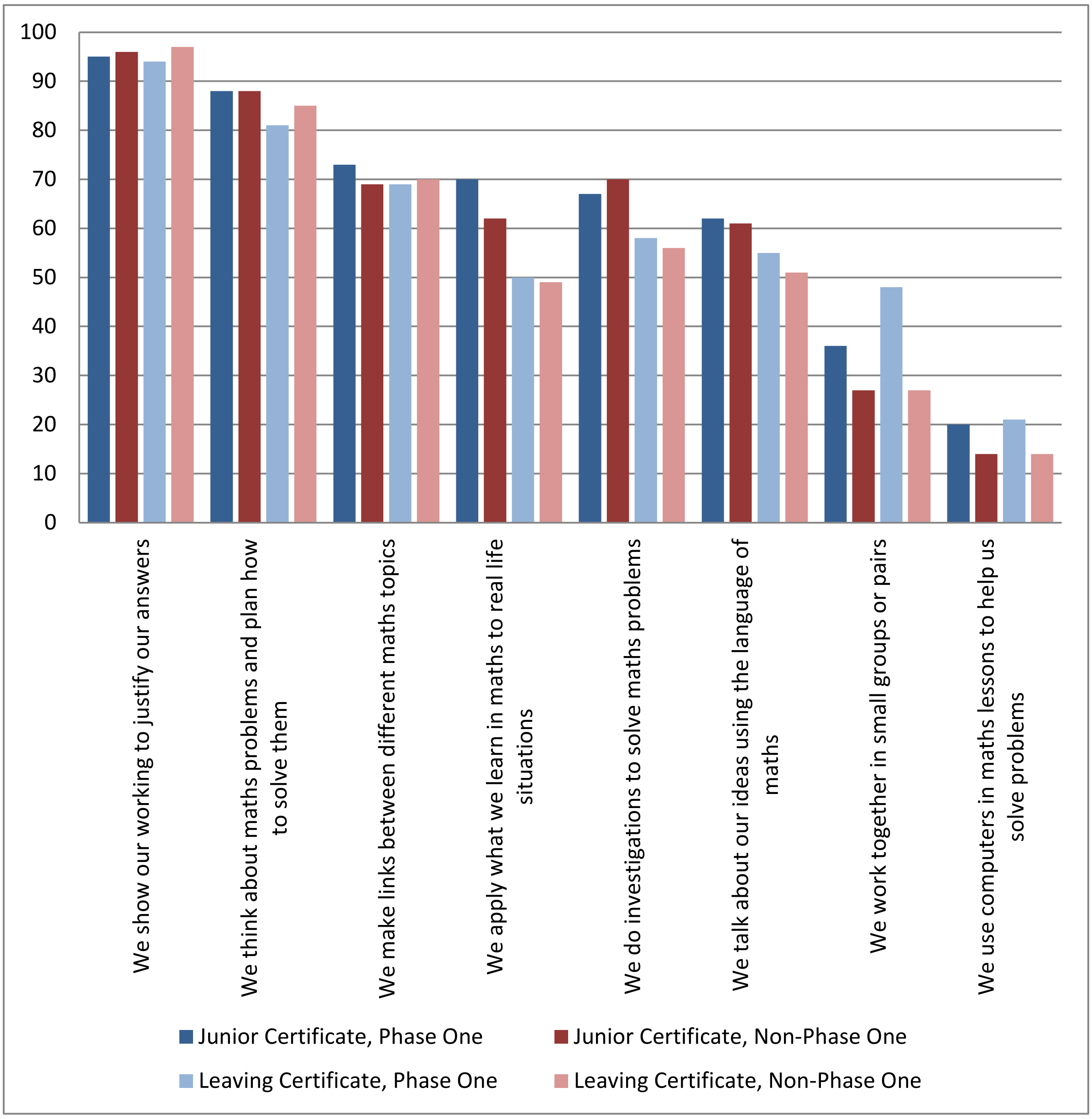
- Students are largely positive about their experience and confidence in learning mathematics, tending to agree that they enjoy it, do well in it and learn quickly in it. Junior Certificate students are more positive and more confident in their ability than Leaving Certificate students.
- International comparison suggests that students following the revised syllabuses are slightly less positive about mathematics, but more confident in their mathematics ability than those who participated in TIMSS 2007. This implies that, in this research, enjoyment of, and confidence in, mathematics do not necessarily go hand in hand.

This section explores students' experiences of learning mathematics and their perceptions about mathematics teaching. It draws on survey and case-study data collected from Junior Certificate and Leaving Certificate students in both phase one and non-phase one schools. Survey findings presented here primarily focus on the class of 2013, making comparison to the class of 2012 as appropriate. Further detailed findings from the class of 2012 are presented in the interim report (November 2012).

3.1 Students' experiences of the revised syllabuses

Students were asked about the frequency with which they participate in a range of activities which feature in the revised mathematics syllabuses. An overview of the answers given by students in the class of 2013 is presented in Figure 3.1 (for full data tables, see Appendix C, Tables 1-8).

Figure 3.1: Percentage of students who report that they ‘often’ or ‘sometimes’ participate in each of the following activities in mathematics lessons



Source: NFER student survey, Autumn 2012

Figure 3.1 shows that many students in the class of 2013 ‘often’ or ‘sometimes’ undertake activities commonly associated with the revised syllabuses. Students most commonly report that they participate in activities to develop their understanding of the processes underpinning mathematics (for example, showing their working to justify their answers, and thinking about mathematics problems and planning how to solve them). By contrast, students do not commonly report that they regularly work together in small groups or pairs, or use computers in class to solve mathematics problems. This mirrors the findings of the analysis of students’ work set out in section 4.

Further analysis reveals that there are statistically significant differences between the views of phase one students - who are in schools where teachers have been engaged in Project Maths for longer - and non-phase one students. Phase one students report that they 'often' or 'sometimes' participate in the following activities more frequently than their non-phase one peers:

- we make links between different maths topics
- we apply what we learn in maths to real-life situations
- we work together in small groups or pairs
- we use computers in maths lessons to help us solve problems.

This suggests that the approaches promoted through the revised syllabuses are becoming more widespread in the classroom as schools' familiarity and depth of involvement increases. Although use of computers in lessons, and working in small groups and pairs, appear to be the least frequent approaches used in lessons, observed comparison of the classes of 2012 and 2013 suggests that these are more frequent in the later year group. By contrast, application of learning to real-life situations appears to have become less common.

3.1.1 Findings from the case studies

Teachers' increased attention on raising students' depth of understanding of mathematical processes and the connections between mathematics topics

Teachers explain that they have increased the attention they give to **developing students' knowledge of the processes underpinning mathematics**, placing a greater emphasis on teaching for understanding, and introducing students to a range of different methods to solve mathematical problems. Many teachers report that they spend more time when introducing students to new topics, to ensure their basic understanding before moving on to more advanced concepts.[19]

> *We spend more time explaining* [mathematical concepts] *at the beginning of a topic rather than moving straight onto calculations, which is necessary to help their understanding as pupils are out of their comfort zone…*
>
> Mathematics teacher, phase one school

[19] While teachers involved in this research do not report that time spent introducing topics is particularly problematic, it is interesting to note that teacher feedback collated by the Irish Maths Teachers Association (IMTA) suggests that the amount of time required to cover many of the topics within the revised syllabuses is too great. (Irish Maths Teachers Association (2012). *Project Maths and the Irish Maths Teachers Association*. Cork: IMTA.)

Many students (including those studying at Higher Level) express difficulties with providing written explanations for their solutions to mathematical problems. Some report that they find the use of word-based problems challenging and difficult to interpret. Teachers and students alike report that students (particularly younger students) tend to be uncomfortable if there is room for interpretation and not just one 'correct' answer. There is a general consensus among students and teachers that across examination entry levels these are particularly challenging aspects of the revised syllabuses.

> *It's hard to be specific... is my interpretation different from yours? That never happened in maths before. You know you had your solution and you got it right or wrong.*
>
> Mathematics subject coordinator, non-phase one school

Teachers feel that it is beneficial for students to engage in group and pair work in mathematics lessons, and feel that this helps students learn to communicate using mathematics terminology and by contributing knowledge from different strands. The majority of students report that they are **starting to make connections between different mathematics topics**. For example, students and teachers commonly describe making links between geometry and algebra, and between business studies and number systems ('financial mathematics'). It is interesting to note, however, that such connections are not yet apparent in students' written work (see section 4).

> *Your mind has to be very various in its abilities for Project Maths, to bring together all the different strands.*
>
> Leaving Certificate student, phase one school

Applying mathematics to real-life situations

The majority of students report that teachers use real-life contexts to explain mathematical concepts, for example measuring missile trajectories and activities based around modern technology. Students report that they enjoy applying mathematics to real-life contexts and find this beneficial for their learning.

> *Real-life applications are interesting, even if it* [the context] *is outside your subject. We've used lots of contexts from modern life, financial life and personal life.*
>
> Leaving Certificate student, non-phase one school

While students find learning through real-life contexts to be stimulating and motivating, they also describe the challenges of applying their learning to unfamiliar contexts. Phase one students comment on these challenges more frequently than non-phase one students, reflecting their broader experience of the style of questions used in the revised syllabuses. Many find the unpredictability of questions challenging, even at Higher Level.

In general, students prefer to apply their learning to actual real-life situations (for example, going outdoors to measure angles in nature) than contrived real-life situations (for example, measuring the volume of a grain silo). Junior Certificate students appear to have a broader experience of conducting investigations and undertaking practical activities than Leaving Certificate students and express a view that a more hands-on approach makes mathematical concepts more 'fun' and easier to understand.

Teachers observe that the deeper understanding of mathematics acquired by students as a result of the revised syllabuses will yield longer-term benefits for students. For example, one non-phase one teacher gave the example of two bridges, one built by an engineer who studied the previous mathematics curriculum and one built by an engineer who had studied the revised syllabus.

> [Given the choice], *I would rather cross the bridge that the Project Maths engineer built.*
> Mathematics teacher, non-phase one school

Use of ICT in the classroom

Use of information and communication technologies (ICT) in the classroom appears to be highly variable amongst the case-study schools, although some teachers report having introduced a range of approaches including, for example, digital media and mathematics software such as GeoGebra. This suggests that, in general, schools recognise the benefit of using computers to support mathematical learning. However, it should be reiterated that, as shown in Figure 3.1, students participating the attitude survey appear to use computers in their mathematics lessons relatively infrequently. Additionally, samples of students' work analysed as part of this study also provide limited evidence of the use of ICT (see section 4 for further details). Although all post-primary schools in Ireland were in receipt of an ICT infrastructure grant in 2012, some case-study schools remain concerned that they have insufficient resources to fully exploit this aspect of the curriculum and that this will disadvantage their students.

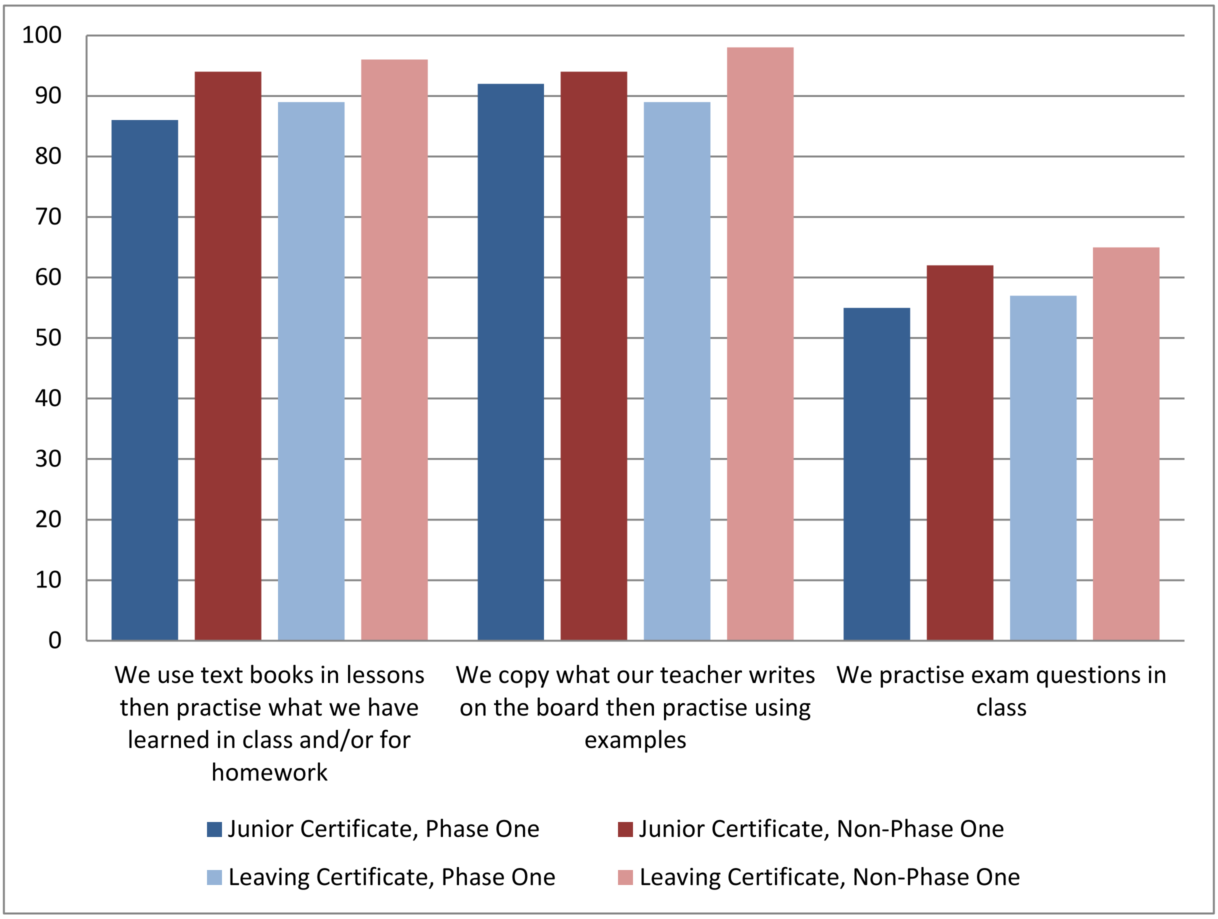
3.2 Students' experiences of more traditional approaches in the revised curriculum

Students were also asked about the frequency with which they participate in certain activities more typically associated with a traditional approach to teaching and learning mathematics. They were asked how often they:

- use textbooks in lessons then later practise what they have learned
- copy what their teacher writes on the board then practise using examples
- practise examination questions in class.

Although worthwhile as part of a balanced teaching of mathematics, it is hoped that, as the revised syllabuses become more embedded, students will report engaging with these activities less regularly as approaches promoted through the revised syllabuses take up a greater proportion of the available teaching time. Again, an overview of students' responses in each of these areas is presented in Figure 3.2 (see Appendix C, Tables 9-11 for more detail).

Figure 3.2: Percentage of students who report that they 'often' or 'sometimes' undertake each of the following activities in mathematics lessons



Source: NFER student survey, Autumn 2012

Figure 3.2 shows that more traditional approaches to mathematics teaching and learning continue to be widespread. This is also evident in students' written work (see section 4). All three approaches appear to be more widely used in non-phase one schools, which is expected given that they are at an earlier stage of implementing the revised syllabuses. The proportion of students who report that they 'sometimes' or 'often' use textbooks in lessons, and copy what their teacher writes on the board, suggests that these approaches become less common with increased exposure to the revised syllabuses.

3.2.1 Findings from the case studies

Traditional approaches to learning mathematics are evident and appear to be in use regularly, particularly in non-phase one schools. In non-phase one schools especially, there is some confusion about the availability of resources to support the teaching and learning of mathematics. For example, teachers report that they have adapted materials from existing textbooks and workbooks, some of which do not completely match the revised curriculum. By contrast, phase one teachers appear to have been more proactive in developing their own resources and materials for use in the classroom, perhaps because they have received a greater level of support as a result of their early involvement in delivering the revised syllabuses. In general, phase one students appear to have greater enjoyment of, and confidence, in mathematics than their non-phase one peers. One conclusion is that this is due to phase one teachers' own increased confidence in implementing the revised syllabuses.

Of note, case-study participants identify considerable concerns about 'exam readiness'. It is common for students to be using grinds[20] to support revision for their mathematics examinations. Students in over half of schools involved in the case studies, report that this is the case, which they feel is indicative of generally low confidence levels and concerns over examination preparation. This is experienced by both Junior Certificate and Leaving Certificate students in phase one and non-phase one schools alike. However, it should be noted that the use of grinds has historically been more common in mathematics than other subjects[21].

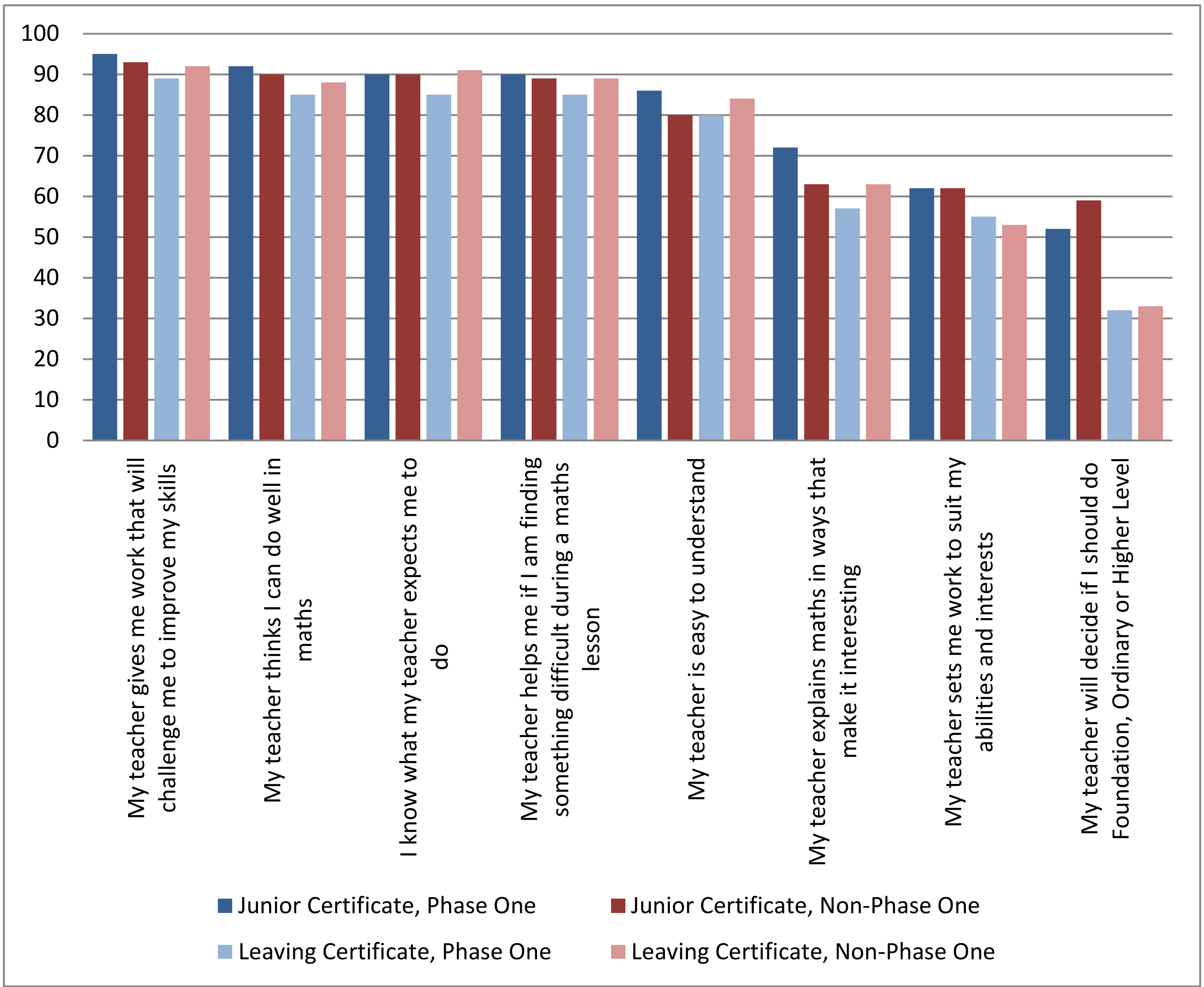
> *I know the whole reason behind Project Maths is to get rid of the whole structure* [of the examination]… *but you just felt that bit more confident* [with the previous curriculum] *because there was a structure to it. We have no idea what our exam is going to be like in June.*
>
> Leaving Certificate student, non-phase one school

3.3 Perceptions of mathematics teaching within the revised syllabus

To gain a deeper understanding of students' experiences of the revised mathematics syllabuses, teachers and students were asked about their perceptions of mathematics teaching. Students were asked to what extent they agreed with a range of statements about the mathematics teaching they had experienced, as presented in Figure 3.3 (see Appendix C, Tables 12-19 for more detail).

[20] Private tuition.
[21] NCCA. (2007). *ESRI research into the experiences of students in the third year of junior cycle and in transition to senior cycle: summary and commentary*. Available online: http://www.ncca.ie/uploadedfiles/publications/ESRI_3rdYr.pdf [Accessed 30th July 2013]

Figure 3.3: Percentage of students who report that they 'strongly agree' or 'agree' with the following statements about their mathematics teaching and learning



Source: NFER student survey, Autumn 2012

Figure 3.3 shows that Junior and Leaving Certificate students in both phase one and non-phase one schools have highly positive perceptions of their mathematics teaching. Statistically significant differences occur between phase one and non-phase one schools in relation to the following statements:

- my teacher helps me to understand if I am finding something difficult during a mathematics lesson
- my teacher is easy to understand
- my teacher explains mathematics in ways that make it interesting
- my teacher will decide if I should do Foundation Level, Ordinary Level or Higher Level.

Broadly, phase one students are more positive than their non-phase one peers in all of these areas. This suggests that students have increasingly positive perceptions as the revised syllabuses become more embedded in school. Additional analysis reveals that, of these four areas, there are statistically significant differences between Junior Certificate and Leaving Certificate students in relation to ‘my teacher explains mathematics in ways that make it interesting’ and ‘my teacher will decide if I should do Foundation Level, Ordinary Level or Higher Level’, with Junior Certificate students agreeing with this more strongly in both cases.

3.4 Students’ perspectives on their progression from primary and Junior Certificate mathematics

Students involved in the attitude surveys and case studies were asked to comment on their experiences of progression, in the case of Junior Certificate students, from primary level mathematics and, in the case of Leaving Certificate students, from Junior Certificate level. Students were asked to draw out key differences in their experiences of learning mathematics at different stages to ascertain how this had impacted upon their progress.

In general, Junior Certificate students are more positive about their transition from primary school than Leaving Certificate students are about their transition from Junior Certificate. Whilst Leaving Certificate students appreciate the value of gaining a rich understanding of mathematics, they have found the change in learning approach between Junior Certificate and Leaving Certificate challenging. Most Junior Certificate students report that the revised curriculum is ‘just maths’, and have experienced a more natural transition from primary to post-primary level.

A note on attitudes at Junior versus Leaving Certificate levels

As set out above, Junior Certificate students are more positive about their transition from primary school than Leaving Certificate students are about their transition from Junior Certificate. This finding reflects a general trend presented in Sections 3 to 6, as Junior Certificate students are generally more positive about mathematics, more confident in their ability and recognise the broader application of mathematics more than their older, Leaving Certificate counterparts.

As described above, Junior Certificate students have used approaches similar to those promoted in the revised syllabuses through their experience of mathematics at primary school. By comparison, some Leaving Certificate students experienced a shift in teaching and learning approaches in the transition from the previous curriculum at Junior Level. This may explain some of the difference in attitude.

Leaving Certificate students may be seeking additional university tariff points by studying mathematics at Higher Level. In some cases, highlighted through the case-study visits, students who would otherwise have followed the Ordinary Level syllabus are now working at Higher Level. As a result, some teachers and students feel that this affects the learning of the whole class.

3.5 Students' overall confidence, motivation and attitudes towards mathematics

While impacts on students' confidence are explored in depth in section 5, it is interesting to compare students' perceptions of their abilities and levels of engagement with mathematics with an international sample of students who participated in TIMSS 2007 (aged, on average, 14 years old). Comparison suggests that the students involved in this study are slightly less positive about mathematics, but slightly more confident in their mathematics ability than the average of those involved in the TIMSS study.

4. Evidence of the extent to which students are using the approaches promoted in the revised mathematics syllabuses

Key findings

- Based on the small sample of students' work included in this study there is emerging evidence that the revised syllabuses are impacting on students' learning in the key process areas. However, the processes promoted through the revised syllabuses are not yet embedded in the written output from mathematics lessons (although they may be evident in other aspects of lessons). This may be expected due to the early stage of the implementation of the revised syllabuses.
- Whilst some processes of the revised mathematics syllabuses are visible in some of the student material reviewed, there does not appear to have been a substantial shift in what teachers are asking students to do, and few differences between the phase one and non-phase one students.
- It is possible that teachers are currently emphasising the content of the revised syllabuses rather than the processes promoted within it. This reflects the earlier finding that traditional approaches to mathematics teaching and learning continue to be widespread.
- The evidence strongly suggests that students have a good mastery of mathematical procedures and, to a slightly lesser extent, problem solving and making mathematical representations. There is very little evidence in the work reviewed that students are demonstrating reasoning and proof and communication, or making connections between mathematics topics.
- The findings suggest that students need to be regularly given high quality tasks that require them to engage with the processes promoted by the revised syllabuses, including: problem solving; drawing out connections between mathematics topics; communicating more effectively in written form; and justifying and providing evidence for their answers.

This section sets out the findings from an analysis of a sample of students' written work. It aims to identify evidence of the processes introduced in the revised mathematics syllabuses in sample of students' written work, as well as information about the mathematical skills that characterise particular groups of students.

4.1 About the samples of students' work

4.1.1 Number of lesson samples

As set out in Table 4.1, a total of 154 samples of students' written work (37 samples from phase one schools and 117 from non-phase one schools) have been collected from 58 lessons (17 lessons from phase one schools and 41 from non-phase one schools). Further detail on the methodology for this research activity is provided in section 2.2.5.

Table 4.1: Number of lesson samples included in the analysis of students' work, by strand

		Leaving Certificate			Junior Certificate			Total
		Higher Level	Ordinary Level	Mixed	Higher Level	Ordinary Level	Mixed	
Strand 1	Phase one	0	1	0	1	0	0	**2**
	Non-phase one	0	4	0	5	1	3	**13**
	Total	0	5	0	6	1	3	**15**
Strand 2	Phase one	1	0	0	0	0	0	**1**
	Non-phase one	3	0	1	5	4	1	**14**
	Total	4	0	1	5	4	1	**15**
Strand 3	Phase one	1	1	0	0	0	1	**3**
	Non-phase one	1	3	0	0	1	0	**5**
	Total	2	4	0	0	1	1	**8**
Strand 4	Phase one	1	1	2	2	2	2	**10**
	Non-phase one	2	2	0	1	1	0	**6**
	Total	3	3	2	3	3	2	**16**
Strand 5	Phase one	0	0	1	0	0	0	**1**
	Non-phase one	2	0	1	0	0	0	**3**
	Total	2	0	2	0	0	0	**4**
Total	Phase one	3	3	3	3	2	3	**17**
	Non-phase one	8	9	2	11	7	4	**41**
	Total	**11**	**12**	**5**	**14**	**9**	**7**	**58**

4.1.2 Format of the samples

Table 4.2 outlines the formats for written work that were evident in the student material gathered. Students indicated the use of textbooks by reference to pages, exercises and questions.

Table 4.2: Number of lesson samples of student material by format

Format of students' work	Total number of samples received
Copy	32
Worksheets	
Tests	6
Mind map	3
Copy/worksheets	3
Total	**58 lessons**

A further breakdown of sample material format is set out in Table 4.3 where the specific types of worksheets used are identified and the copy-work based on textbook activity has been extracted.

Table 4.3: Details of the lesson samples of student material by format

Format of students' work	Total number of samples received
Copy	13
Copy and textbook	19
Test/sample examination paper	6
Worksheet only	5
Copy/Worksheet	3
Activity Maths worksheets	7
Project Maths worksheets	2
Mind maps	3
Total	**58 lessons**

Three mind maps were submitted as sample lesson materials[22]. These were of varying standards but indicated in every instance an attempt at synthesis of information, making connections and seeing patterns in the subject matter explored.

4.2 Interrogating students' written work

The samples collected were analysed to explore evidence of the following mathematical processes, which are promoted through the revised mathematics syllabuses, demonstrated in students' work:

- **problem solving**, including analytical consideration of different approaches and evidence of adjusting and self-correcting where appropriate
- **mastery of mathematical procedure**, including ability to solve a problem using accurate techniques to reach the correct solution

[22] Due to the complexity of some of these mind maps it is unlikely that they were the product of a single lesson.

- **reasoning and proof**, including the use of arguments, evidence and proof to support an answer to a mathematical problem
- **communication**, including effective explanation of arguments and appropriate use of mathematical language
- **connections between mathematics topics**, including observation of relationships between subjects and themes to solve mathematical problems
- **mathematics representations**, including construction of models and tools to analyse and interpret data.

A detailed description of these categories, and the criteria used to assess the type and extent of evidence present in students' written work, is presented in Table 4.4, adapted from process standards produced by the National Council of Teachers of Mathematics (NCTM)[23] and adapted by Exemplars[24].

---

[23] National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics.* Reston, VA: NCTM [online]. Available: http://www.nctm.org/standards/content.asp?id=322 [21 March, 2013].

[24] Exemplars (2013). *Exemplars: Standard Maths Rubric.* Underhill, VT: Exemplars [online]. Available: http://www.exemplars.com/resources/rubrics/assessment-rubrics [21 March, 2013].

Table 4.4: Framework for analysis of students' work

Process	No evidence	Novice level	Practitioner level	Expert level
Problem solving[25]	All examples show the same solution strategy. Where a single example is presented it is based solely on a worked example.	There is no strategy or the strategy chosen does not lead to a solution. Little or no engagement with the task presented.	A correct strategy is chosen based on the mathematical situation in the task. Planning or monitoring of the strategy is evident. Evidence is present of solidifying prior knowledge and applying it to the problem solving situation. Correct, or partially correct, answer is obtained.	An efficient strategy is chosen and progress towards a solution evaluated. If necessary, self-correction and adjustments are made along the way. Evidence is present of analysing the situation in mathematical terms and extending prior knowledge. Correct answer is obtained.
Mastery of mathematical procedures	No evidence of following any basic mathematical procedure.	Evidence of some familiarity with a basic mathematical procedure. Does not always lead to the correct answer.	Evidence of the application of a basic mathematical procedure. Some insecurity evident. Correct answer is not always obtained.	Mathematical procedures are accurately followed. Correct answer is obtained.
Reasoning and proof	No reason or proof provided.	Arguments made have no mathematical basis.	Arguments are constructed with adequate mathematical basis.	Deductive arguments are used to justify decisions and resulted in formal proofs.

[25] In general, it is challenging to effectively analyse problem solving within students' work. This is because sometimes the most able students simply select the simplest method and apply it in a straightforward way. By contrast, the less able may show more evidence of modifying their approach.

	The task/activity does not require a reason/proof.	No correct reasoning or justification for reasoning is present.	A systematic approach and/or justification of correct reasoning is present leading to the exploration of mathematical phenomena, noting pattern, structure and regularities.	Evidence is used to justify and support decisions made and conclusions reached. This may be indicated in self- corrections, the testing and rejection of hypotheses, explanation of phenomenon or generalising and extending the solution to other cases.
Communication	No communication evident. Task/activity does not require students to communicate in any way.	Everyday familiar language is used to communicate ideas.	Communication of an approach is evident through a methodical, organised, coherent, sequenced and labelled response. Formal mathematical language is used throughout the solution to clarify and express ideas.	Communication of argument is supported by mathematical properties. Precise mathematical language and symbolic notation are used to consolidate mathematical thinking and to communicate mathematical ideas precisely.
Connections between mathematics topics	No connections are made between maths topics.	Some attempt is made to relate the task to other maths topics.	Mathematical connections and observations are recognised and evident.	Mathematical connections and observations are used to extend the solution.
Mathematical representations	No attempt made to construct mathematical representations	An attempt is made to construct mathematical representation to record and communicate problem solving. Not always accurate.	Appropriate and accurate mathematical representations are constructed and refined to solve problems and portray solutions	Abstract or symbolic mathematical representations are constructed to order, record and analyse relationships, to extend thinking and clarify or interpret phenomena.

The analysis sought to explore the extent to which the processes emphasised in the revised syllabuses are evident in the student material. The analysis also explored the extent to which the evidence suggests that students are engaging with the approaches promoted through the revised syllabuses on a continuum of 'no evidence' to 'expert', as well as the proportion of examples which are based on students using structured worksheets or copies and text books (characteristic of the previous version of the curriculum), as an indicator of their prevalence in the classroom. At each level, the extent and nature of differences between the work of students in phase one and non-phase one students was explored.

Illustrations of students' work at both Junior and Leaving Certificate are provided in Figures 4.1 and 4.2. The students' work in Figure 4.1 demonstrates an **expert level mastery of the mathematical procedures** required to answer the problem posed. Mathematical procedures have been accurately followed and the correct answer has been obtained. The student also demonstrates **expert level use of mathematical representations**, evidenced in their illustration of their thought processes and as a means of providing proof and reasoning for their answer. The student demonstrates **practitioner level evidence of communication**, as whilst communication is logical, there is evidence of the student using language from earlier parts of the question to formulate their responses. There is no evidence of connections between mathematics topics evident in the student's work.

The students' work in Figure 4.2 demonstrates a **novice level evidence of making mathematical representations** due to the poor level of accuracy in the graph. The student's work demonstrates **novice level evidence of mastery of mathematical processes**, as many of the calculations in the table are inaccurate, even though the correct points are subsequently graphed. There is no evidence of reasoning and proof, communication, or making connections between mathematics topics.

Figure 4.1: Extract from a Junior Certificate student's work, studying towards Higher Level examination

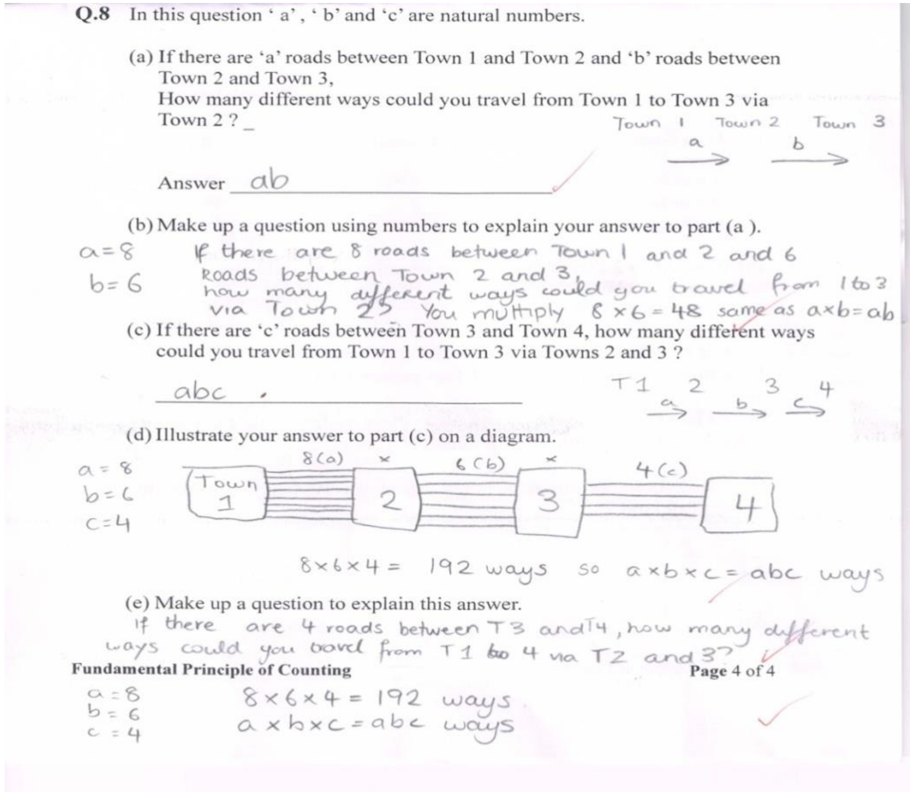
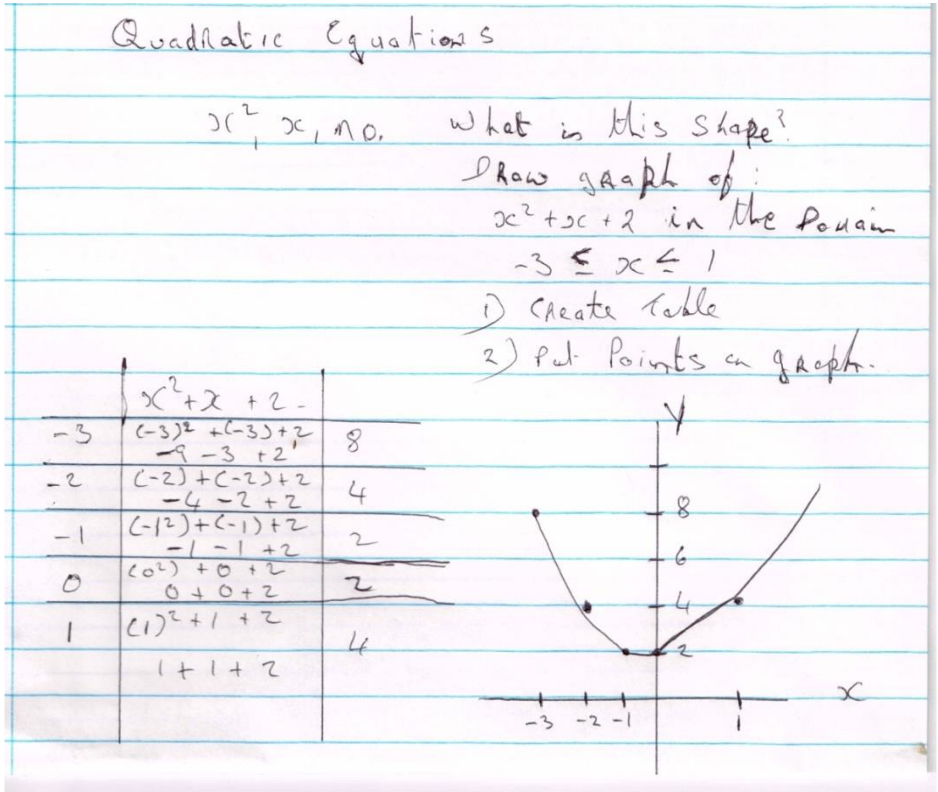


Figure 4.2: Extract from a Leaving Certificate student's work, studying towards Ordinary Level examination



4.3 Evidence of the mathematical processes present in students' work

There is variation in the extent to which the approaches promoted through the revised syllabuses are evidenced in students' work, which is as might be expected at this stage of the curriculum's implementation.

Evidence of mastery of mathematical procedures is visible in many examples of students' work from both phase one and non-phase one schools. To a slightly lesser degree, there is also evidence of problem-solving, communication and representations. There is very limited evidence of students demonstrating reasoning and proof, or making connections between mathematics topics, in their written work.

The following sections provide an overview and commentary on the analysis of students' work in relation to each of the mathematical processes described above. Further technical details are provided in Appendix B.

4.3.1 Problem solving

Six pieces of 6th year phase one students' work meet the 'expert' criteria. Of these, four are from a lesson where the standard of work was 'expert' overall. Of the eight students in 6th year whose work was at 'practitioner' level, six were the product of lessons by the same teacher.

Table 4.5: Evidence of problem solving in phase one and non-phase one schools

	Year group	No evidence	Novice	Practitioner	Expert
Phase one	2nd year	1	0	2	2
	3rd year	5	1	2	1
	5th year	6	0	1	0
	6th year	2	0	8	6
Non-phase one	1st Year	1	0	0	0
	2nd Year	0	3	3	0
	3rd year	15	5	9	1
	5th Year	3	9	4	1
	6th Year	0	3	25	0

In non-phase one schools, 'expert' level work in problem solving was not in evidence among the 1st and 2nd year samples. Most notably, among the sample material presented by 3rd year students there was often no evidence (19 cases out of 48) that an opportunity to engage in problem solving activity had been provided. The 'practitioner' level problem solving work was predominantly evidenced in 6th year material: this was the modal standard of problem solving at this level and was spread across a number of teachers, schools and strands.

4.3.2 Mastery of mathematical procedure

In the phase one schools, over half of students appear to be engaging in traditional mathematical procedures at 'expert' level. This standard of work is not always present in the other processes explored, suggesting that students are still engaging in processes more closely associated with the previous version of the curriculum, such as drill and practice. In some lessons, mastery of mathematical procedure was the only process evidenced in the sample material for these lessons. This suggests that these students are not required to engage in other mathematical processes and have not been given opportunities to do so; instead they present material that is based on worked examples.

Table 4.6: Evidence of mastery of mathematical procedure in phase one and non-phase one schools

	Year group	No evidence	Novice	Practitioner	Expert
Phase one	2nd year	0	0	3	2
	3rd year	0	1	4	4
	5th year	0	2	1	4
	6th year	0	2	5	9
Non-phase one	1st year	1	1	5	0
	2nd year	1	3	2	0
	3rd year	0	4	19	25
	5th year	0	3	10	4
	6th year	0	8	13	18

Similar to the phase one schools, high standards of mastery of mathematical procedures are evident in almost all sample material from the non-phase one schools. The material also indicates that students are being given opportunities to engage in mathematical procedure, often quite complex in nature, without engaging in the other processes that are integral to the revised mathematics syllabuses. A total of 128 samples of students' work (in both phase one and non-phase one schools) indicate that students are operating at 'practitioner' or 'expert' level when mastering the application of a method and practising a particular algorithm.

Where material is at 'novice' level, most of the students are deemed by their teacher to be 'struggling', at Foundation or Ordinary Level. At the standard of 'novice', fluency is sometimes insecure, mathematical engagement is shallow and many errors are evident.

4.3.3 Reasoning and proof

The sample material from phase one schools' lessons suggests that students are not engaging in any depth in reasoning and proof as a mathematical process within attempts at problem solving. Most sample material has no evidence of students giving any reasons or proofs.

Table 4.7: Evidence of reasoning and proof in phase one and non-phase one schools

	Year group	No evidence	Novice	Practitioner	Expert
Phase one	2nd year	2	2	1	0
	3rd year	4	3	1	1
	5th year	6	0	1	0
	6th year	2	7	3	4
Non-phase one	1st year	7	0	0	0
	2nd year	6	0	0	0
	3rd year	32	10	5	1
	5th year	4	11	1	1
	6th year	10	16	8	5

Similarly, in non-phase one schools, it could be conjectured that in most samples, students are not required to give reasons and proofs, and are therefore not doing so. At 'novice' level, some students who provide a proof presented incorrect, ineffective reasoning, or make arguments that have no mathematical basis. At the 'practitioner' and 'expert' level, students present adaptive, correct, effective reasoning when a proof is provided.

4.3.4 Communication

Although communication in mathematics has both oral and written elements[26]; this analysis considers only the written element. Where samples include an attempt at communication they range from familiar student language to more precise mathematical language and symbolic notation to consolidate mathematical thinking, to explain and communicate ideas.

In phase one schools, 26 samples have either no evidence or are at 'novice' level. Most students appear not have given explanations of their answers or to communicate their thinking in writing. Typically most 'novice' standard work makes use of everyday familiar language, although often not focussed and sometimes inaccurate. There is very little evidence of students exploring patterns or noting where patterns are evident in their work.

[26] Some teachers included comments on their use of oral communication/discussion in the lesson context information provided

Table 4.8: Evidence of communication in phase one and non-phase one schools

	Year group	No evidence	Novice	Practitioner	Expert
Phase one	2nd year	4	0	1	0
	3rd year	6	2	0	1
	5th year	3	3	1	0
	6th year	1	7	3	5
Non-phase one	1st year	6	1	0	0
	2nd year	5	1	0	0
	3rd year	21	15	9	3
	5th year	7	5	5	0
	6th year	13	20	2	4

Once again the pattern is replicated in the non-phase one schools, with the majority of samples showing no evidence or 'novice' standards of communication. In some material based on worksheets and class test papers, where clearly students are asked to explain their answers and have been given the opportunity to communicate their thinking, many have left this part of the question blank or provided incorrect, unclear statements.

In the four 'expert' level samples from 3rd years there are three excellent mind-maps where communication of ideas and synthesis of relevant information are present. These samples could only be evaluated under a limited number of process standards and it should be noted that due to their complexity, they are unlikely to be the outcome of a single lesson.

4.3.5 Connections between mathematics topics

There appears to be a tendency to see the various strands and topics in the revised syllabuses as discrete subject areas, and mathematics is not treated in the sample material as an integrated field of study. The poor use of connections across mathematical topics and subject areas is evident in a high proportion of material where there is no evidence of students making any connections outside of the narrow topic that they are studying: 31 out of 37 phase one lessons and 95 out of 117 non-phase one lessons fall into this category.

Table 4.9: Evidence of making connections between mathematics topics in phase one and non-phase one schools

	Year group	No evidence	Novice	Practitioner	Expert
Phase one	2nd year	5	0	0	0
	3rd year	9	0	0	0
	5th year	6	1	0	0
	6th year	11	0	1	4
Non-phase one	1st year	7	0	0	0
	2nd year	6	0	0	0
	3rd year	36	8	4	0
	5th year	15	2	0	0
	6th year	31	0	8	0

4.3.6 Representations

There is little evidence of students using the range of representations available across all of the strands of the revised syllabuses to solve problems, illustrate or extend their thinking.

Table 4.10: Evidence of representations in phase one and non-phase one schools

	Year group	No evidence	Novice	Practitioner	Expert
Phase one	2nd year	0	3	2	0
	3rd year	4	1	4	0
	5th year	6	1	0	0
	6th year	3	3	5	5
Non-phase one	1st year	2	5	0	0
	2nd year	2	4	0	0
	3rd year	19	14	13	2
	5th year	5	8	4	0
	6th year	11	18	8	2

The most common representations came from Strand 1 (Statistics and Probability): the use of stem and leaf plots; the number line; graphs; area models; Venn diagrams; bar charts; pie charts; and tables. A lack of accuracy means that many of the samples fall within 'novice' standard. Overall, the students in the non-phase one schools are less likely to use representations, or they produce ones that are at 'novice' standard. Only four students produced work at 'expert' level.

4.3.7 Discussion

There is emerging evidence that the revised mathematics syllabuses are impacting on students' learning in relation to each of the mathematical processes described in the preceding section. This is as might be expected at this stage of the curriculum's implementation. While analysis of students' work reveals that elements of the revised mathematics syllabuses are visible in almost all of the material reviewed, the findings suggest that the processes promoted through the revised syllabuses are not yet fully embedded in the written output from mathematics lessons. Evidence from the samples of students' work presented suggests that students are being presented with tasks that do not require them to engage widely with the mathematical processes promoted through the revised syllabuses. This is surprising given that in other parts of this research, teachers suggest that such approaches are being widely implemented.

There is evidence of some engagement with real-life contexts in students' written work. It is interesting to note that students' written work often includes visual models and tools (for example, an area model for solving quadratic equations and factorising in algebra). Reflecting the findings of the attitude survey, there is very limited evidence of students working collaboratively to solve mathematical problems and only one sample of students' work appears to include the use of ICT. Again, this is of interest as both teachers and students involved in the case studies provide examples of ways in which ICT has been introduced into mathematics lessons.

While it is likely that it will take time for students to consolidate new ways of learning in their written outputs, this also suggests that teachers may benefit from further support to translate their teaching approaches (for example, investigations and practical activities) into students' written work. This may include more opportunities for students to engage in problem-solving processes, draw out connections between mathematics topics and communicate more effectively in written form. It may be beneficial for students to receive further encouragement to explain, justify and provide evidence for their answers; and to understand more deeply the relationships and connections between mathematics topics within and across all strands of the revised mathematics syllabuses.

5. Students' achievement and attitudes towards mathematics

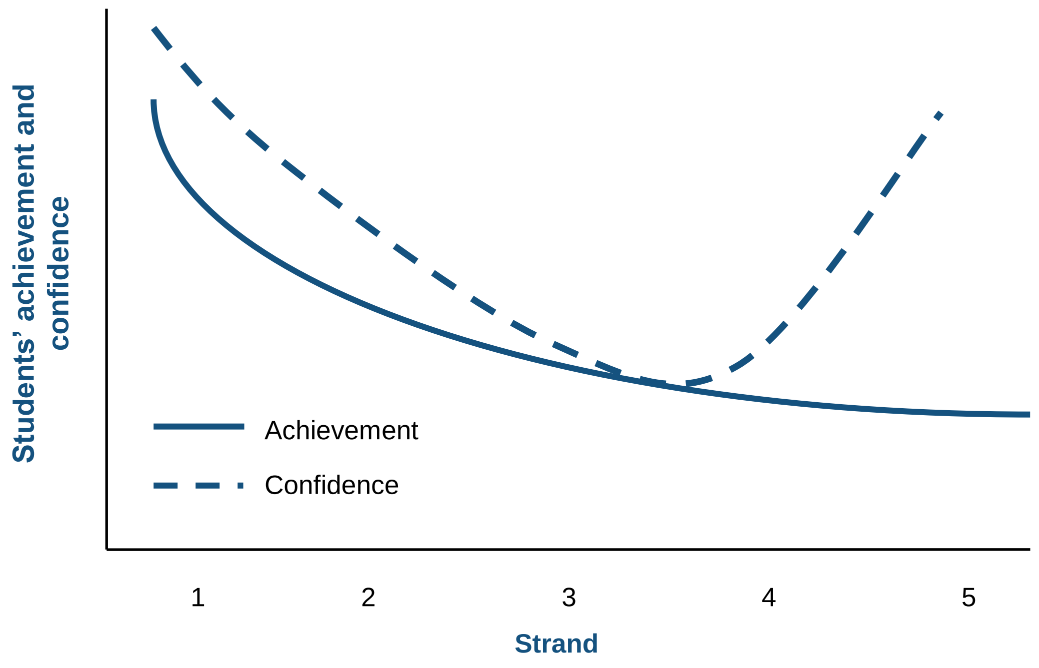
Key findings

The variables that affect students' attitudes and achievement

- Overall, following a greater number of strands, or schools having greater experience of teaching the revised syllabuses, does not appear to be associated with any improvement in students' achievement and confidence.
- Students' confidence and achievement in mathematics is significantly associated with examination entry level and gender. Of note, girls are less confident about mathematics than boys and perform less well at Junior Certificate.

Students' achievement and confidence across the five strands

Whilst achievement is highest in Strand 1 (Statistics and Probability) and lowest in Strand 5 (Functions), confidence is actually highest in both of these strands and lowest in Strand 3 (Number) and Strand 4 (Algebra). Note, this diagram is illustrative only, and not to scale.



The relationship between confidence and achievement

- In this research study, confidence in mathematics does not always correspond to achievement. Although students who are further through their studies perform better than those who are at an earlier stage, higher levels of confidence are not associated with students who have almost completed their studies.
- Furthermore, results show that students are confident in relation to Strand 5 (Functions), but do not perform highly when assessed in this area. While girls are less confident in their mathematical ability across all strands explored, at Leaving Certificate level, they perform as highly as boys.

This section explores the impacts of the revised mathematics syllabuses on students' achievement, learning and motivation. The section draws on evidence collected via the assessments and the surveys. Section 5.1 presents the findings of a multi-level modelling exercise to investigate the effect of a range of variables on students' achievement and confidence in mathematics. Sections 5.2 and 5.3 set out in more detail comparisons between phase one and non-phase one students' achievement in the classes of 2012 and 2013, including additional comparison with international TIMSS data where appropriate. Further details of students' performance in, and attitudes towards, individual strands of the revised syllabuses are provided in Appendix D.

5.1 Students' overall achievement and attitudes towards mathematics

Multi-level modelling[27] allows the impact on all students to be explored, taking account of a range of student characteristics (for example, phase of study, gender (boys or girls) and examination entry level). Multi-level modelling also enables us to take into account timing differences between the data collection exercises conducted with each year group.

This is important because students in the class of 2012 participated in the research as they were reaching the end of their studies, whereas those in the class of 2013 were just beginning their final year of study. As a result, the class of 2013 had received less mathematics tuition than the previous year group at the time of the study. This difference in schooling may lead to the expectation that the class of 2012 would perform better and achieve higher results than the class of 2013.

A number of background variables have been explored to investigate their effect on students' achievement and confidence in mathematics. These include:

- phase (phase one or non-phase one)
- survey date (Spring or Autumn 2012)
- gender (girls or boys)
- examination entry level (Foundation, Ordinary or Higher Level)
- school type (vocational, community and comprehensive or secondary school).

It is important to note that only Strand 1 (Statistics and Probability) and Strand 2 (Geometry and Trigonometry) are factored into the multi-level modelling analysis, as these are the only strands in which all students involved in the study have been assessed. Further consideration of the students' achievement and confidence across all five strands is provided later in this section.

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[27] Further technical details on the multi-level modelling analysis are provided in Appendix A

5.1.1 Variables impacting on students' achievement and confidence in mathematics

Multi-level modelling reveals that the following variables significantly impact on students:

- **assessment date:** the timing of the assessment is a significant predictor of achievement among Junior Certificate students, and among Leaving Certificate students in relation to Strand 2 (Geometry and Trigonometry). As might be expected, students in the class of 2013 perform less well than the class of 2012
- **examination entry level:** again, as might be expected, Foundation Level and Ordinary Level students generally have less confidence in mathematics and lower achievement than Higher Level students
- **gender:** gender is a significant predictor of confidence in mathematics at both Junior and Leaving Certificate. It is also a significant predictor of achievement. Girls are less confident about mathematics than boys and have lower achievement at Junior Certificate. At Leaving Certificate, girls have lower achievement than boys in relation to Strand 1 (Statistics and Probability)
- **some school types**[28]**:** Junior Certificate students in vocational schools have lower achievement than those in secondary schools.

5.1.2 Variables that are not impacting on students' achievement and confidence in mathematics

Multi-level modelling also reveals that the following background characteristics are **not** impacting on students' confidence and achievement in mathematics:

- **phase**: whether a student is in a phase one or non-phase one school does not significantly impact on their confidence or achievement in mathematics at either Junior and Leaving Certificate
- **survey date:** the timing of the attitude survey is not a significant predictor of students' confidence in mathematics at either Junior or Leaving Certificate
- **some school types:** again, whether the school is community and comprehensive or secondary does not significantly impact on students' confidence or achievement in mathematics at either Junior or Leaving Certificate.

5.1.3 Interpretation of the multi-level model analysis

School phase (phase one and non-phase one) is not a significant predictor of students' confidence or performance in the revised mathematics syllabuses. The findings suggest that

[28] The post-primary school types included in the analysis are: secondary schools (managed by boards of management, religious communities/trustees or individuals); vocational schools (managed by local vocational education committees (VECs)); and community and comprehensive schools (managed by management boards supporting local interests). For further information, see http://www.citizensinformation.ie/en/education/

background characteristics, such as gender rather than phase, are more closely associated with achievement and confidence in mathematics. This tells us that, overall, there does not appear to be any improvement in students' achievement and confidence as a result of following a greater number of strands, or as a result of schools having greater experience of teaching the revised syllabuses. However, delving deeper suggests some apparent differences between phase one and non-phase one students within individual strands of the revised syllabuses. Further details are provided in section 5.2.

The timing of the testing periods is a significant predictor of students' mathematics achievement[29], telling us that students' performance in mathematics continues to develop throughout their studies. The exception to this case is the similar performance of Leaving Certificate students in the classes of 2012 and 2013 in relation to Strand 1 (Statistics and Probability). It is likely that this is because students in the class of 2013 are able to draw on previously taught knowledge and practised skills in relation to this strand. By contrast, students are less likely to be able to use previous knowledge to answer questions in relation to Strand 2 (Geometry and Trigonometry) as success in this strand requires knowledge of specific theorems, which students may not have covered at the time of data collection.

Interestingly, confidence in mathematics is not affected by the survey date. This suggests that confidence remains consistent throughout the academic year, or is acquired early in students' studies and remains at this level, as well as that confidence and achievement in mathematics are not always closely associated.

Perhaps unsurprisingly, the findings also show that Foundation and Ordinary Level students have lower achievement and lower confidence in mathematics than their Higher Level peers[30]. It is interesting to note that there are larger differences between Foundation, Ordinary and Higher Level students in relation to Strand 1 (Statistics and Probability), than Strand 2 (Geometry and Trigonometry) at both Junior and Leaving Certificate. This indicates that students of all examination entry levels find Strand 2 difficult, whereas difficulties are more acutely experienced by Foundation and Ordinary Level students in relation to Strand 1.

In general, girls appear to have less confidence and have lower achievement than boys in the revised mathematics syllabuses. Additionally, students attending vocational schools appear to have lower levels of confidence and achievement than those in secondary or in community and comprehensive schools (which may have a different intake). This may point to differences between the learning preferences of different groups of students and resulting impact on their responses to the revised mathematics syllabuses, rather than being related to the characteristics of the new syllabuses.

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[29] Students who participated in the research in Autumn 2012 were at the beginning of the academic year, whereas those who participated in Spring 2012 were approaching the end of their studies. Therefore, students in the Autumn 2012 cohort had experienced less teaching time than the Spring 2012 cohort.

[30] Examination level was identified by students when completing the survey and assessment materials.

5.2 Comparison of the performance of phase one and non-phase one students in the classes of 2012 and 2013

This section considers in more depth student achievement in each individual strand of the revised syllabuses, and makes comparison between the performance of students in the classes of 2012 and 2013. To recap, an overview of the strands studied by each group of students is outlined in Table 5.1.

Table 5.1: Strands studied by students participating in the assessment

	Year group	Years of study	Strands studied by phase one students	Strands studied by non-phase one students
Junior Certificate	**Students who completed the survey and tests in Spring 2012**	**2009-12**	Strands 1-4	No strands
	Students who completed the survey and tests in Autumn 2012	**2010-13**	Strands 1-5	Strands 1-2
Leaving Certificate	**Students who completed the survey and tests in Spring 2012**	**2010-12**	Strands 1-5	Strands 1-2
	Students who completed the survey and tests in Autumn 2012	**2011-13**	Strands 1-5	Strands 1-4

In interpreting the results it is important to note that, overall, phase (phase one or non-phase one) is not associated with improvements in students' achievement. Therefore, this section takes a closer look at the patterns emerging across strands for illustrative purposes. Also, as set out in section 5.1, timing differences between the two data collection exercises is an important consideration. Discussion of the findings is therefore based on the expectation that the class of 2013 would perform **less well** than the class of 2012 as a result of receiving fewer months of teaching at the time of participating in the research.

5.2.1 Overview of students' performance across strands

Figure 5.1 provides an illustrative overview of both Junior and Leaving Certificate students' performance across each of the five strands of the revised mathematics syllabuses. This is true of students in the classes of both 2012 and 2013.

Figure 5.1: An illustrative overview of students' achievement in mathematics (not to scale)

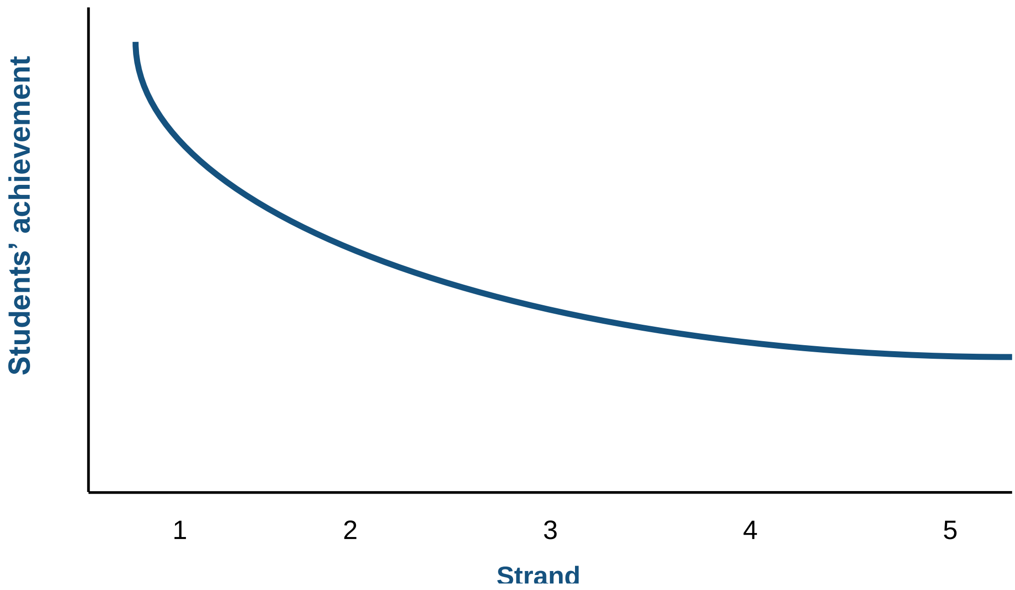

Figure 5.1 shows that, overall, both Junior and Leaving Certificate students have highest achievement in Strand 1 (Statistics and Probability). Students also perform well in items relating to Strand 2 (Geometry and Trigonometry) and Strand 3 (Number). Students perform least well in items relating to Strand 4 (Algebra) and Strand 5 (Functions). Broadly, this corresponds with students' confidence in each strand (see section 5.3). The exception is Strand 5 (Functions), where students generally report high levels of confidence. For greater detail of students' performance in each of the individual strands, including by examination entry level where appropriate, see Appendix D.

5.2.2 Comparison of phase one and non-phase one Junior Certificate students' performance

In all strands of the revised mathematics syllabuses, the performance of phase one students in the classes of 2012 and 2013 are broadly comparable. By contrast, non-phase one students in the class of 2013 do less well than the class of 2012. As set out above, we would expect the performance of the class of 2013 to be lower than the class of 2012 in both phase one and non-phase one schools as they had received less schooling at the time of participating in the research. As the performance of phase one students has not followed this trend, this suggests that, in some strands, phase one students are performing better than their non-phase one peers.

Comparison of Junior Certificate students' performance in the classes of 2012 and 2013 in a booklet covering Strands 1, 2 and 5[31]

This booklet measures students' performance in three strands of the revised syllabuses: Strand 1 (Statistics and Probability); Strand 2 (Geometry and Trigonometry) and Strand 5 (Functions). The booklet was completed by both phase one and non-phase one students in the classes of 2012 and 2013.

Phase one: Between the classes of 2012 and 2013, there was an increase in student achievement by over five per cent in five questions and a decrease in student achievement in only three questions. The proportion of questions omitted has remained broadly constant and at a lower level than among non-phase one students.

Non-phase one: Between the classes of 2012 and 2013, there has been a decrease in student achievement by over five per cent in 14 questions. The effect is most noticeable on the questions assessing Strand 2 (Geometry and Trigonometry).[32] The proportion of questions omitted for three of the items has increased by 6-10 per cent.

Comparison of the performance of Junior Certificate students in the classes of 2012 and 2013 in a booklet covering Strands 3, 4 and 5[33]

This booklet measures students' performance in three strands of the revised syllabuses: Strand 3 (Number); Strand 4 (Algebra) and Strand 5 (Functions). The booklet was completed by only phase one students in Spring and Autumn 2012.

Amongst phase one schools, there is a fairly consistent level of achievement with students' achievement in one question decreasing by 6-10 percentage points and increasing by more than five percentage points in three questions between the classes of 2012 and 2013. Two questions, which were omitted by the highest proportion of students in the class of 2012, have been completed by over ten per cent more students in the class of 2013.

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[31] Booklet reference JC1/2/5. Please note that students were only assessed on Strand 5 (Functions) in Autumn 2012. Further detail of students' performance in all strands is provided in Appendix D.
[32] The facilities of all but one of the Strand 2 (Geometry and Trigonometry) items have decreased by more than five percentage points.
[33] Booklet reference JC3/4/5. Please note that students were only assessed on Strand 5 (Functions) in Autumn 2012. Further detail of students' performance in all strands is provided in Appendix D.

The key findings show that in Strand 1 (Statistics and Probability) and Strand 2 (Geometry and Trigonometry), the performance of phase one students in the classes of 2012 and 2013 are broadly comparable. By contrast, the performance of non-phase one students has fallen between the two year groups. As outlined above, we would expect students in the class of 2013 to perform less well than those in the class of 2012 as a result of receiving less schooling at the time of the research. This indicates that in relation to these strands, phase one students are performing better than would be expected.

The strong performance of students in phase one schools compared to their non-phase one peers suggests that they may have developed a wide range of mathematical skills as a result of studying a greater number of strands (for example, problem solving and an ability to make connections between mathematics topics), making them better able to apply their knowledge to unfamiliar topics. Given the timing differences in the assessment periods, the strong performance of students in the phase one class of 2013 relative to the class of 2012 (who studied fewer strands of the revised syllabuses) further supports the argument that students' ability to draw on their wider mathematical knowledge and apply this to new contexts appears to increase with the number of strands studied.

The contrast between the performance of phase one and non-phase one students is particularly notable in Strand 2 (Geometry and Trigonometry). While the performance of phase one students is broadly comparable between the classes of 2012 and 2013, in non-phase one schools the class of 2013 students do less well than the class of 2012. It is likely that there are topic areas within this strand (for example, knowledge of mathematical theorems) which the class of 2013 had not yet been taught at the time of the assessment. Without such knowledge, the students would have found these items difficult to complete. The performance of phase one students in this instance again suggests that they are better able, and more confident, to draw on their mathematical skills in other areas.

The performance of phase one and non-phase one students cannot be compared in relation to Strand 3 (Number), Strand 4 (Algebra) and Strand 5 (Functions) as only phase one students were assessed in these strands. However, again the performance of phase one students is comparable between the classes of 2012 and 2013.

Comparison of Junior Certificate students' performance with international standards

Students in the classes of 2012 and 2013 perform similarly to international students who participated in TIMSS 2007. Phase one students have shown a strong performance on items assessing Strand 1 (Statistics and Probability). However, phase one students appear to find Strand 4 (Algebra) especially difficult when compared to international standards. Overall, their knowledge of subject areas relating to Strand 2 (Geometry and Trigonometry) and Strand 3 (Number) appear to be similar to that internationally.

5.2.3 Comparison of phase one and non-phase one Leaving Certificate students' performance

This section explores the performance of the phase one and non-phase Leaving Certificate students in the class of 2013, and makes comparison to the performance of the class of 2012. Again, key findings are presented in the box below and further discussed in the interpretation which follows.

Comparison of the performance of Leaving Certificate students in the classes of 2012 and 2013 in a booklet covering Strands 1, 2 and 5

This booklet measures students' performance in three strands of the revised syllabuses: Strand 1 (Statistics and Probability); Strand 2 (Geometry and Trigonometry) and Strand 5 (Functions). The booklet was completed by phase one and non-phase one students in the classes of 2012 and 2013.

Phase one: Generally, students in the classes of 2012 and 2013 perform similarly. In Strand 5 (Functions), however, student achievement has decreased between the classes of 2012 and 2013 by more than ten per cent in three questions, but has increased in none of the questions. There is also a clear difference between the two year groups in the number of students omitting questions, with all items being missed out by a greater percentage of students (generally more than 10 per cent) in the class of 2013.

Non-phase one: The performance of non-phase one students in the classes of 2012 and 2013 are comparable. However, student achievement has decreased by more than five per cent in eight of the 13 questions assessing Strand 2 (Geometry and Trigonometry). Ten of the 13 items assessing Strand 2 were omitted by over five per cent more students in the class of 2013 than the class of 2012.

The key findings show that students studying at phase one schools have shown very little change in performance across the two year groups for Strand 1 (Statistics and Probability) and Strand 2 (Geometry and Trigonometry). Additional analysis reveals that this is also the case for Strand 3 (Number) and Strand 4 (Algebra)[34].

It is clear, however, that the phase one Leaving Certificate students in the class of 2013 are finding Strand 5 (Functions) more difficult than the class of 2012, and appear to have less confidence in attempting an answer. It is possible that as a more difficult topic within the syllabus, this strand is left until students' final year of study before it is taught, making the timing difference between the two testing periods more noticeable than for the other strands.

Non-phase one students in the classes of 2012 and 2013 have, like their phase one peers, performed similarly in Strand 1 (Statistics and Probability). This supports the findings of the multi-level modelling analysis, which shows that, at Leaving Certificate, the timing of the assessment is not a significant predictor of achievement in Strand 1 (Statistics and Probability). As mentioned in section 5.1, this suggests that students in the class of 2013 are able to draw on previously taught knowledge and practised skills in relation to this strand.

Students' performance in Strand 2 (Geometry and Trigonometry) reveals a different pattern. Here, phase one students outperform their non-phase one peers. Again, this is indicative that phase one students are better able to draw on their wider mathematical skills and knowledge and suggests that students' abilities within an individual strand may increase with the number of strands studied overall.

Non-phase one students did not complete items assessing Strand 3 (Number), Strand 4 (Algebra) or Strand 5 (Functions) so no further comparisons can be made between the year groups for this group of students.

[34] Comparisons across cohorts cannot be made for Strand 5 (Functions) as students were only assessed in these items in Autumn 2012. For further detail of students' performance in all strands, see Appendix D.

Comparison of Leaving Certificate students' performance with international standards

Phase one students in both the classes of 2012 and 2013 performed much better than the average score of international students on many of the items relating to Strand 1 (Statistics and Probability) and Strand 2 (Geometry and Trigonometry).

It is important to note that this may be expected, as Leaving Certificate students are older than those who participated in the international studies (the only ones available which explore students' achievement in, and attitudes towards, mathematics). However, the international studies are designed for a wide range of students, with some designed to challenge more able students and others to be more widely accessible. This makes them relevant for this research.

5.2.4 Types of questions that students find more difficult

Across all strands of the revised syllabuses there is variation in the achievement of students. Students appear to find particular types of questions more difficult than others. Analysis of the students' achievement patterns identifies three broad question types that appear most challenging for students, as set out below. These patterns are the same for both Junior and Leaving Certificate students in phase one and non-phase one schools.

Reading and interpreting large amounts of information

While students often perform well in this type of question, they appear to lack confidence when asked to draw conclusions from a considerable amount of written information. This is particularly notable for Leaving Certificate students in Strand 1 (Statistics and Probability), given their high performance in other questions types relating to this topic. Several factors may make this type of question more difficult, including that students often have to:

- interpret and classify a large number of statements
- understand the 'big picture' as well as individual data
- appreciate that some information is not relevant or is inconclusive in order to gain full credit.

Showing working and justifying answers

Students appear to find open-ended questions requiring them to show their working, and use reasoning to justify their answers, particularly difficult. Often, this is despite having arrived at the correct answer. This reflects findings based on the analysis of a small sample of students' work set out in section 4, which suggests that students are not being given these types of tasks in a classroom setting. In Strand 2 (Geometry and Trigonometry), for example, Junior Certificate students appear to have used mental or estimation methods rather than written justification to arrive at their answers. Therefore, they were often unable to receive full marks for this type of question.

Likewise, in both Strand 3 (Number) and Strand 4 (Algebra), Junior and Leaving Certificate students appear to find broader, open ended questions more challenging than multiple choice questions or those demanding a specific calculation to be performed. The challenge posed by this type of question is particularly pronounced when students are asked questions requiring them to apply their knowledge in unfamiliar ways. For example, in Stand 4 (Algebra) Leaving Certificate students were asked to form a quadratic function from its graph. The graph shows the points at which the function cuts both axes. In general, students struggled with this question. While all students following the revised syllabus study quadratic equations, it may be that they are more familiar with solving equations to find the roots, rather than working backwards as this item requires.

Multi-step questions

Students appear to find multi-step items more complex than others. For example, in Strand 2 (Geometry and Trigonometry), Leaving Certificate students were asked to calculate the width of a flat window in a semi-circular room. To answer correctly, students must recognise the need to bisect a sector of the circle to form two right-angled triangles. They must then apply the ratio for the sine of an angle to calculate the relevant length. Therefore, this item requires thorough knowledge of trigonometric ratios and the geometric properties of triangles. It also benefits from the ability to construct an accurate diagram. In general, students struggled with this type of question.

5.3 Comparison of phase one and non-phase one student attitudes between the classes of 2012 and 2013

This section considers in more depth students' attitudes towards the individual strands of the revised syllabuses. Results are taken from the surveys and expanded on using detail from the case studies. Again, comparison between phase one and non-phase one students is useful to draw out distinctions within individual strands. Overall, however, it is important to note that phase of study is not associated with improvements in students' attitudes.

5.3.1 Overview of students' attitudes across strands

In order to gauge students' confidence in mathematics, they were asked how they would feel about approaching a range of different mathematical problems which may arise during their lessons[35] (see Appendix C, Tables 30-37). Overall, students appear generally confident in many of the areas explored, spanning all five strands of the revised syllabuses. Figure 5.2 provides an illustrative overview of both Junior and Leaving Certificate students' confidence across each of the five strands of the revised mathematics syllabuses.

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[35] Please note that students were asked about their confidence in relation to particular aspects of each syllabus strand rather than a strand as a whole.

Figure 5.2: An illustrative overview of students' confidence in mathematics (not to scale)

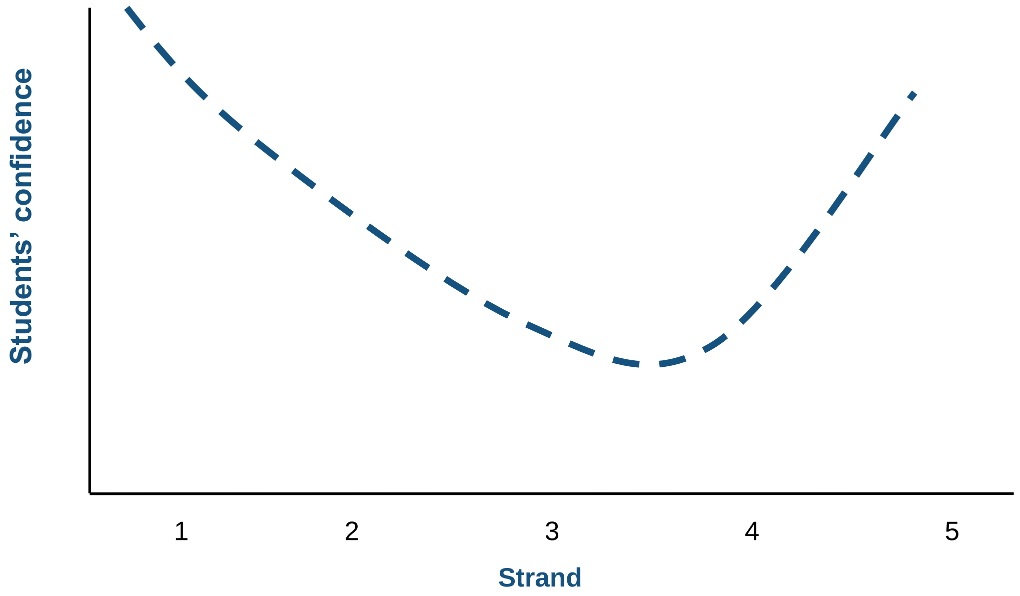


Figure 5.2 shows that Junior and Leaving Certificate students in both phase one and non-phase schools tend to feel most confident about Strand 1 (Statistics and Probability) and Strand 5 (Functions), and least confident in relation to Strand 3 (Number). Again, this corresponds with patterns of students' achievement in each of these strands (see section 5.2), with the exception of Strand 5 (Functions), where students generally demonstrate considerably lower levels of achievement than some other strands. Some key differences in students' attitudes within individual strands are detailed below.

5.3.2 Strand 1 (Statistics and Probability)

There is a statistically significant difference between the response of phase one and non-phase one students in the class of 2013, with phase one students appearing to be more confident in items relating to this strand than their non-phase one peers. Further comparison reveals that only amongst non-phase one Junior Certificate students is there a notable difference between year groups (with 85 per cent of the class of 2013 reporting they would find this ‘very easy’ or ‘easy’, compared to 72 per cent of the class of 2012).

Strand 1: Findings from the case studies

Students in both phase one and non-phase one schools are, in the main, confident in Strand 1 (Statistics and Probability) and find it enjoyable and interesting. Students tend to find it the most straightforward of all of the five strands, sometimes commenting that they are building on concepts learned at primary school or, in phase one schools, at Junior Certificate.

While Leaving Certificate students in phase one schools feel they are building on knowledge from Junior Certificate, those from non-phase one schools have experienced some difficulties with the unfamiliarity of the content and associated terminology.

In phase one schools, views of Strand 1 (Statistics and Probability) are similar between Junior Certificate and Leaving Certificate. However, in non-phase one schools, Leaving Certificate students are less positive than Junior Certificate students.

Some teachers feel this may be because older students are less comfortable with the learning approaches promoted, having studied a previous version of the syllabus at Junior Certificate.

5.3.3 Strand 2 (Geometry and Trigonometry)

Just over half of all students report relatively high levels of confidence in relation to Strand 2 (Geometry and Trigonometry). Students appear particularly confident in their ability to make different shapes. No significant differences in response emerge by phase or level of study.

Strand 2: Findings from the case studies

Generally, students from all strands and phases are positive, if slightly cautious, about Strand 2 (Geometry and Trigonometry). Students usually enjoy the introduction of real-life contexts into their learning (for example, how a professional rugby player chooses the angle at which to kick a rugby ball). However, Junior Certificate students at some non-phase one schools feel that these make questions difficult to access.

Leaving Certificate students at half of the non-phase one schools describe this strand as very difficult. Aside from difficulties with learning theorems and formulae, these students find it difficult to understand and develop a strategy to solve problems when they have to construct their own diagrams or visualise a situation. In contrast, this is mentioned as an issue by students at only one phase one school. This suggests that, in general, students' response to this type of learning improves with increased familiarity with classroom engagement in problem-solving techniques.

Junior Certificate students are generally more positive about this strand than Leaving Certificate students, particularly enjoying visual activities such as drawing and constructing shapes. Despite this, teachers generally feel that Leaving Certificate students would be well prepared for examination in these topics.

5.3.4 Strand 3 (Number)

Students appear generally positive about this strand, with around a half of all students reporting that they would find it 'easy' or 'very easy' to solve mathematical problems in this strand. Although a statistically significant difference emerges between the responses of phase one and non-phase one students, the percentages are very close and do not seem to support any meaningful interpretation of difference.

Strand 3: Findings from the case studies

Students' views about Strand 3 (Number) are quite mixed. They do not perceive it to be the most difficult strand, nor the most interesting. Students feel it is more similar to the previous version of the curriculum, and therefore a more familiar approach to mathematics, than other strands. Whilst some aspects of this strand appear to be challenging for students, this overall familiarity makes it seem easier which gives them more confidence in their abilities.

Minimal differences are evident between views of students in phase one and non-phase one schools. However, in some non-phase one schools, Junior Certificate students feel that this strand does not provide them with same number of engaging contexts and activities as other strands. There is little difference between the response of Junior Certificate and Leaving Certificate students to this strand. Notably, however, Leaving Certificate students perceive that it is more similar to their previous experience of mathematics compared to other strands. They are also aware of how they are applying skills and concepts learned in this strand to other areas of mathematics.

5.3.5 Strand 4 (Algebra)

Students responding to the survey report broadly positive levels of confidence for solving problems using algebra, with around two-thirds of all students finding it 'easy' or 'very easy'. Leaving Certificate students are more confident than their Junior Certificate peers. No statistically significant difference emerged between the responses of phase one and non-phase one students and there are no notable differences between the responses of students in the classes of 2012 and 2013.

Strand 4: Findings from the case studies

In contrast to the survey findings, attitudes to Strand 4 (Algebra) amongst case-study schools are very mixed and, in general, there are no clear distinctions in students' views by either phase or age group.

Students feel more motivated to learn algebra when it is taught in a way that makes it seem more relevant to everyday life, for instance using algebra to describe the growth pattern of sunflowers. Students' motivation and interest is also higher when they can see that it interlinks with other mathematics topics (the corollary of this is that if they find algebra difficult, students feel concerned that they will struggle with other mathematics that builds on its foundations).

In some schools, algebra is described as 'being taught the old way' via textbooks and exercises on the board, which does not necessarily help to engage students' interest. Teachers, particularly in non-phase one schools, comment that they need more time to develop more integrated practical approaches into their teaching to this strand, and would welcome further examples of real-life contexts to use in lessons.

5.3.6 Strand 5 (Functions)

Students report high levels of confidence in their ability to represent relationships graphically. Phase one students are significantly more confident than their non-phase one peers in this ability, however, there is an increase in the performance of non-phase one between the classes of 2012 and 2013 more so than their phase one peers. Leaving Certificate students are significantly more likely than Junior Certificate to state that they find items relating to this strand 'a little difficult' or 'difficult'.

Strand 5: Findings from the case studies

Most teachers in both phase one and non-phase one schools, and at both Junior Certificate and Leaving Certificate, feel that Strand 5 (Functions) is fairly ‘uncontroversial’, straightforward to teach and does not pose as many challenges to students as other strands. Of note, teachers report that students cope reasonably well with the topic. However, the assessment conducted as part of this research suggests that students do not always achieve highly in this strand.

Students at non-phase one schools are, in general, quite accepting of this strand and do not have strong feelings about it either way: they often report that it is ’easy enough’ and are particularly confident about drawing graphs. In comparison, students at phase one schools are more divided in their opinions, describing it variously as: easy; difficult; confusing; interesting; and boring, and students’ attitudes seem to be down to individual preference. Given that students expressed considerably stronger views about Strand 4 (Algebra), their relative indifference to this strand suggests that they may not fully recognise the connections between algebra and functions topics.

Leaving Certificate students (in phase one schools) who like the topic tend to enjoy the visual and practical aspects of drawing and interpreting graphs, and feel these are useful skills to learn. They find learning the concepts to be initially challenging but that, with practice, they can consolidate their understanding.

6. Students' aspirations for further study and careers involving mathematics

Key findings

Students' perceptions of the wider relevance and application of mathematics

- Students tend to recognise the broader application of mathematics, particularly in helping them to secure a place at the university of their choice and in their daily life. Reflecting the broader difference in the attitudes of Junior and Leaving Certificate students, Junior Certificate students are generally more positive about the broader application of their mathematics study than students studying for the Leaving Certificate.

Students' aspirations to further study of mathematics

- Almost all Leaving Certificate students plan to go on to further study when they finish their Leaving Certificate, and around half of all students intend to pursue further study involving mathematics.
- Almost all Junior Certificate students plan to stay on at school after their Junior Certificate, and the majority plan to take the Higher Level Leaving Certificate examination. The aspirations of students for Higher Level examination in phase one schools are higher than students from non-phase one schools. This may be a result of the revised syllabuses beginning to embed in phase one schools, and therefore instilling a greater enjoyment of, and confidence in mathematics amongst their students.

Students' appreciation of careers involving mathematics

- Around two-thirds of Leaving Certificate students stated that they do not intend to go into a job that involves mathematics.
- It appears that students are developing a general awareness of the importance of mathematics in further study and of its broader application, but in some cases, the specifics of this, such as a sound understanding of what careers will draw on their mathematical skills and knowledge, appears to be lacking.

This section sets out the impact of the revised syllabuses on students' aspirations for further study and careers involving mathematics. It begins by highlighting perceptions of the wider relevance and application of mathematics, before exploring students' plans for further study or careers. It draws on findings from the attitude survey conducted with the class of 2013 and case studies, and makes international comparison with TIMSS 2007 results as well as comparison with the survey completed by the class of 2012, where appropriate.

6.1 Students' perceptions of the wider relevance and application of mathematics

Students' views on the broader application of mathematics are firstly considered, followed by their understanding of jobs and career pathways involving mathematics.

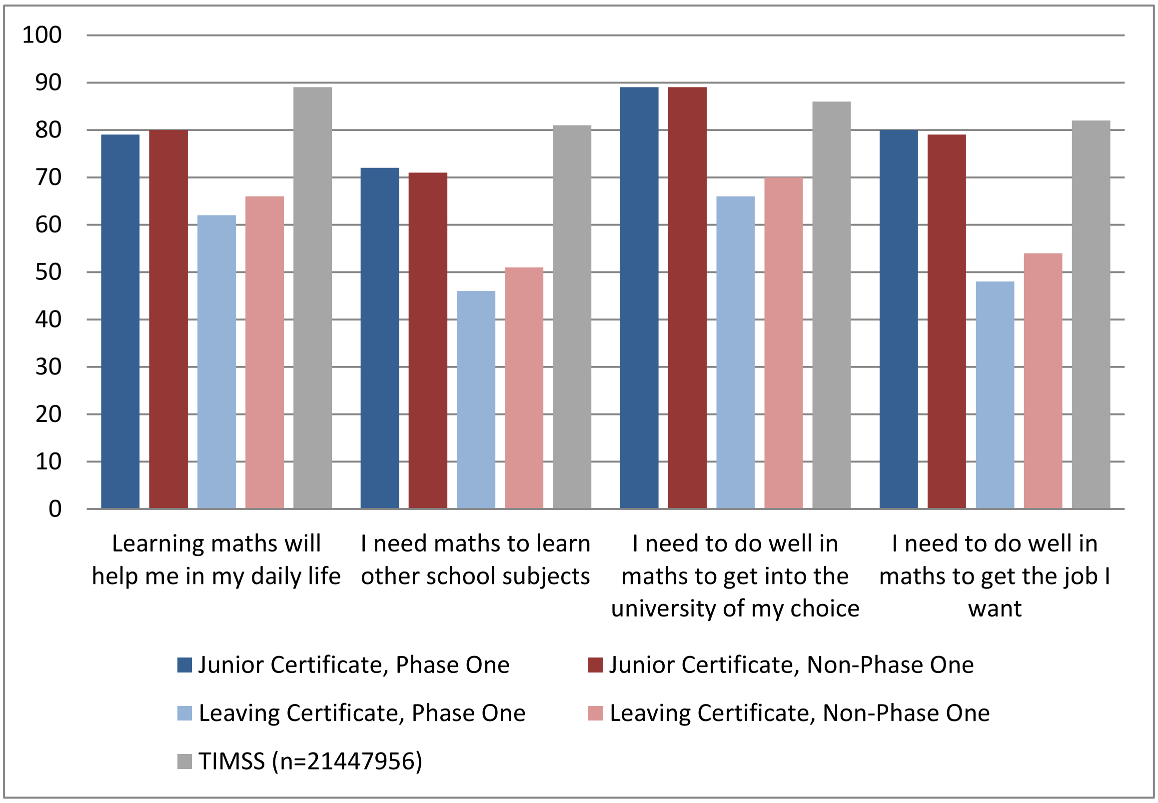
6.1.1 Students' views on the broader application of mathematics

To ascertain students' views on the broader application of mathematics, they were asked to comment on the extent to which they perceive it to be useful in the following ways:

- to help in daily life
- to aid learning in other school subjects
- to enable them to get into the university of their choice
- to enable them to get the job of their choice.

Students' responses to these questions are set out in Figure 6.1 (see Appendix C, Tables 41-44 for more detail). To provide international comparison, Figure 6.1 also contains the responses of students from TIMSS 2007 (aged, on average, 14 years old) who were asked the same question, to provide international comparison and context. Again, please note, that the TIMSS data is an international, rather than an Irish, average so direct comparisons cannot be made.

Figure 6.1: Percentage of students who agree ‘a lot’ or ‘a little’ with statements on the wider application of mathematics



Source: NFER student survey, Autumn 2012

As detailed in Figure 6.1, students tend to recognise the broader application of mathematics, particularly in helping them to secure a place at the university of their choice and in their daily life, but there are generally lower levels of agreement that they need mathematics to learn other school subjects. Of particular note, students studying for the Junior Certificate are significantly more likely than their Leaving Certificate counterparts to respond favourably to each of the statements, suggesting that they are more positive about the broader application of their mathematics study. This may reflect, or be a contributing factor, in their generally more positive attitudes towards mathematics. No significant differences were observed between the responses of students from phase one and non-phase one schools and further analysis reveals no notable differences between year groups.

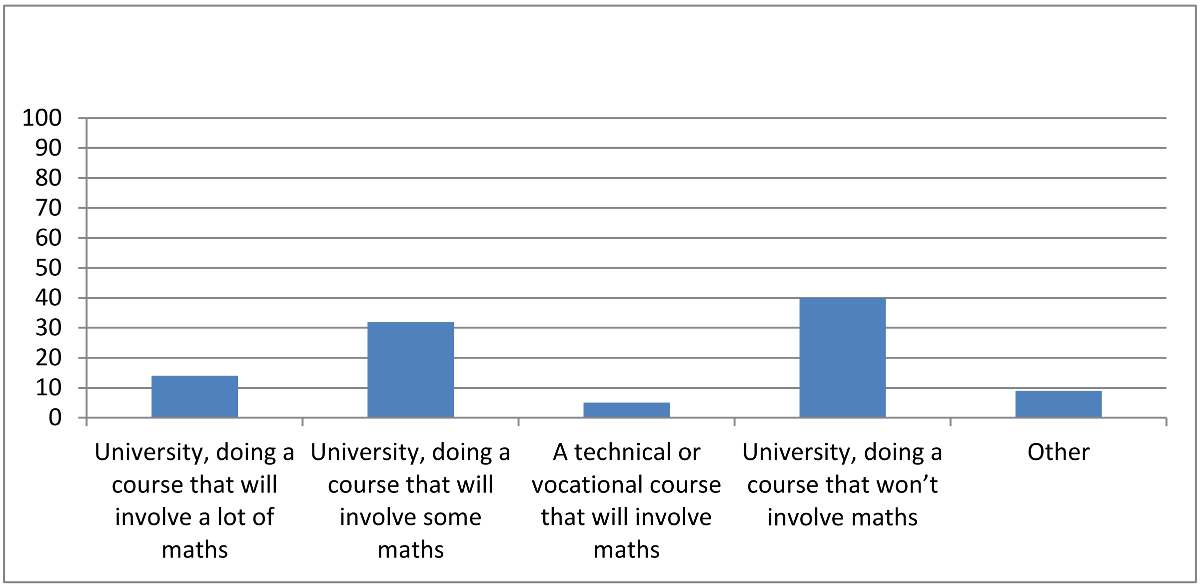
Figure 6.1 also shows that students in the TIMSS study responded more favourably to all of the statements, implying that they consider mathematics to be more relevant to their current and future study/careers, as well as to life in general. The views of Junior Certificate students are, however, often closer to the TIMSS data than their Leaving Certificate peers. As the Junior Certificate students are closer in age to the TIMSS average, it is possible that this may account for any difference.

6.2 Students' aspirations for further study of mathematics

6.2.1 Leaving Certificate students

Ninety-four per cent of Leaving Certificate students plan to go on to further study when they finish their Leaving Certificate. There are no significant differences in responses of students from phase one and non-phase one schools. Figure 6.2 sets out these students' plans. The views of students from phase one and non-phase one schools are not significantly different, and are therefore presented together in Figure 6.2 (see Appendix C, Table 45).

Figure 6.2: Percentage of Leaving Certificate students planning to go on to different types of further study



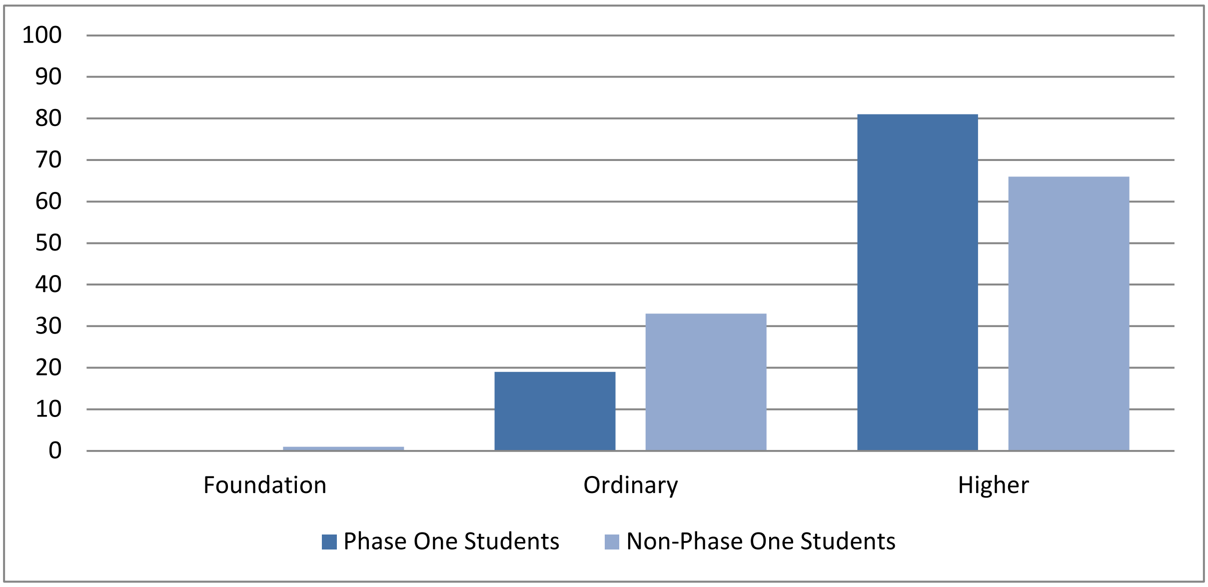
Source: NFER student survey, Autumn 2012

Figure 6.2 shows that around half (51 per cent) of all Leaving Certificate students in the class of 2013 who plan to go on to further study intend to go on to use mathematics to some extent. Thirty-two per cent intend to study a university course with 'some' mathematics involved, 14 per cent plan to study a course that will involve 'a lot' of mathematics and five per cent intend to take on a technical or vocational course that will involve mathematics (around the same as the class of 2012). This suggests that around half of students intend to study mathematics at a higher level, and appreciate its prominence in the further study that they intend to pursue.

6.2.2 Junior Certificate students

Almost all (98 per cent) of Junior Certificate students plan to stay on at school after their Junior Certificate. Figure 6.3 sets out these students' plans (see Appendix C, Tables 46-47).

Figure 6.3: Percentage of Junior Certificate students intending to take their Leaving Certificate at Foundation, Ordinary or Higher Level



Source: NFER student survey, Autumn 2012

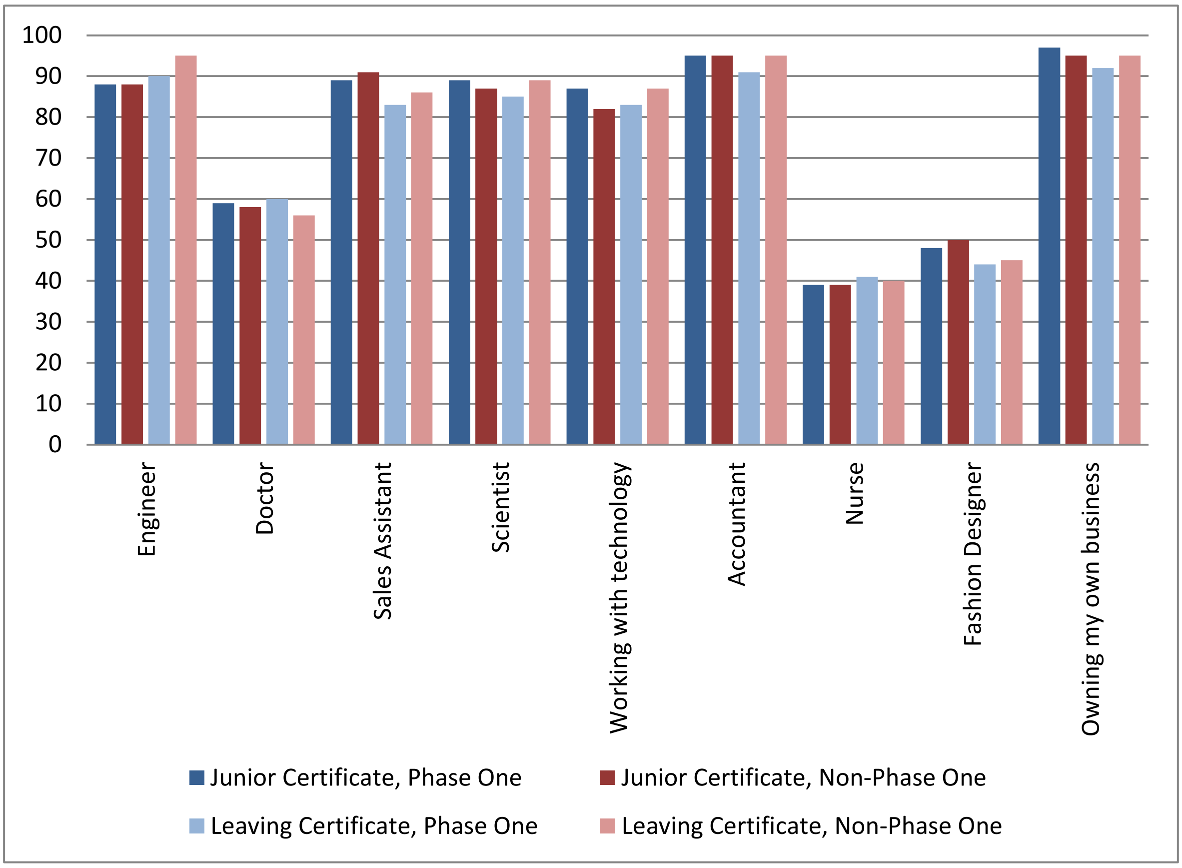
As set out in Figure 6.3, the majority of students from both phase one and non-phase one schools in the class of 2013 (81 and 66 per cent, respectively) who intend to stay on at school after their Junior Certificate plan to take the Higher Level Leaving Certificate examination (compared to 62 per cent of phase one students and 57 per cent of non-phase one students in the class of 2012). Thirty-three per cent of students from non-phase one schools plan to take their examination at Ordinary Level, compared to 19 per cent of students from phase one schools. The differences in responses between phase one and non-phase one students in the class of 2013 are statistically significant, suggesting that the aspirations of students for their Higher Level examination in phase one schools are higher than students from non-phase one schools. This may be a result of the revised syllabuses beginning to embed in phase one schools, and therefore instilling a greater enjoyment of, and confidence in mathematics amongst their students.

6.3 Students' appreciation of careers involving mathematics

6.3.1 Students' understanding of jobs and career pathways involving mathematics

To explore students' understanding of jobs and career pathways involving mathematics, they were provided with a list of ten different professions and asked to select which of these involved using mathematics. All of the jobs involved using mathematics to some extent. Students' responses are set out in Figure 6.4 (see Appendix C, Tables 48-56).

Figure 6.4: Percentage of students who think that mathematics is involved in different jobs/careers



Source: NFER student survey, Autumn 2012

There is a generally high level of awareness of the application of mathematics in jobs such as engineering, being a sales assistant, a scientist, working with technology, accountancy and owning your own business, and less awareness of the role of mathematics in being a doctor, nurse and fashion designer. Junior Certificate students are significantly more likely than Leaving Certificate students to think that being a sales assistant and being a fashion designer involve mathematics, and significantly less likely to recognise the role that mathematics plays in working with technology. Only one significant difference emerged between students in phase one and non-phase one schools: significantly more students from phase one schools recognise the role of mathematics in owning a business than those from non-phase one schools. There were no notable differences in the responses of students between the two year groups.

These results suggest that students appear to be generally aware of the role of mathematics in the majority of the jobs/careers listed. However, there is still a lack of awareness of the mathematical application of some jobs/careers. Perhaps further work is needed to demonstrate the application of mathematics across a broader spectrum of career choices. Section 6.3.2, below, explores this issue further.

6.3.2 Students' aspirations to pursue careers involving mathematics

Around two-thirds of Leaving Certificate students stated that they do not intend to go into a job that involve mathematics (see Appendix C, Table 57). This is an interesting finding given that around one-half of these students are intending to go on to further study that involves some mathematical elements. It is possible that students are aware of the broader application of mathematics and its importance in further study, but do not necessarily recognise its role in jobs or careers.

Those who do intend to go on to a job with a mathematical component were asked to specify what roles they were considering. The following were most frequently cited:

- engineering
- ICT/computer science/software development
- teaching
- business/management type roles
- finance/accountancy
- science-related
- medicine/health sciences.

Data collected from the case-study interviews suggests that some students lack an awareness of the role of mathematics in their chosen career or study pathway. For example, although they might state that mathematics will not feature in their plans, they go on to explain that they will be studying subjects such as chemistry, which has a substantial mathematical component.

The case-study interviews also asked students whether they felt they had a broad understanding of career routes that involve mathematics. Students' responses varied by school, suggesting that their teachers' focus on highlighting the relevance of mathematics to different career routes was central to their levels of awareness. Students do not always equate their awareness of different careers involving mathematics with their mathematics lessons. Rather, they default to considering their careers advice or careers lessons. In some cases, students talked about how their awareness of the importance of mathematics to careers or jobs generally had developed, but appeared to lack specific knowledge of which jobs contained mathematical elements. In sum, it appears that students are developing a general awareness of the importance of mathematics in further study and of its broader application, but in some cases, the specifics of this, such as a sound understanding of what careers will draw on their mathematical skills and knowledge, appear to be lacking.

7. Concluding comments

The methodology for this research has enabled patterns to be explored in: students' experiences of, and attitudes towards, mathematics (the attitude survey and case studies); their achievement (the assessment of students' performance); and the mathematics processes evident in students' work (analysis of students' written outputs from lessons). The research highlights that considerable progress has been made in implementing the revised mathematics syllabuses since the inception of the Project Maths initiative in 2008.

Although there is evidence that more traditional approaches to teaching mathematics remain widespread, across both phase one and non-phase one schools, there are numerous examples of promising practice in transforming the way that mathematics is delivered in the classroom. However, it appears that, in many cases, the approaches described by teachers and students are not yet being evidenced in students' written work. Whilst this is perhaps to be expected given the early stage of the curriculum's implementation, it may be useful to further support teachers to provide opportunities for students to engage more widely with the written processes promoted through the mathematics syllabuses.

At this stage of the curriculum's implementation, the revised mathematics syllabuses *taken as a whole* do not appear to be associated with any overall deterioration or improvements in students' achievement. Performance across each of the strands of the revised syllabuses varies. Overall, students perform most highly in Strand 1 (Statistics and Probability) and least well in Strand 4 (Algebra) and Strand 5 (Functions). It may, therefore, be beneficial to consider ways in which the delivery of these strands can be enhanced to improve outcomes for students. This could, for example, include teaching a greater proportion of the content of these strands at the beginning of the course to allow students more time to consolidate their learning, or to integrate the strands more closely.

There is emerging evidence of positive impacts on students' experiences of, and attitudes towards, mathematics. Furthermore, emerging impacts on students' achievement at individual strand level are apparent, and in some instances students appear to be successfully drawing together their knowledge across different mathematics topics. This suggests that students are beginning to acquire a deeper understanding of mathematics and how it can be applied.

It is interesting to note that within this study, students' confidence and achievement do not always appear to be linked. This issue is of particular importance for girls: whilst overall they appear to have lower confidence than boys, this not always associated with lower achievement. Conversely, in relation to Strand 5 (Functions), students report high levels of confidence despite having lower achievement than in other strands. It may be valuable to explore ways in which girls' confidence in mathematics can be increased, as well as to capitalise on students' apparent enthusiasm for particular topics more generally, with a view to improving achievement.

Generally, Junior Certificate students hold more positive views about mathematics than their Leaving Certificate peers. In part, this may be because they have experienced greater continuity of learning styles in their transition from primary school, compared to Leaving Certificate students who have experienced a more pronounced change to the previous version of the curriculum followed at Junior Certificate. This implies that continuity is central to the successful implementation of the revised syllabuses, and is a positive indication of students' direction of travel in mathematics. The difference in attitudes may also be a result of the added pressure experienced by Leaving Certificate students, whose performance in mathematics can impact on their assessment in all of their Leaving Certificate subjects, and ultimately impact on progression to further study and careers.

International comparison shows that students following the revised syllabuses are slightly less positive about mathematics, but more confident in their mathematics ability. Also, they do not appear to recognise the relevance of mathematics to their future study and careers to the same degrees as students in the international sample. For example, the majority of Leaving Certificate students state that they do not intend to pursue careers in mathematics, but seem not to recognise the prevalence of mathematics in many of their chosen careers. Therefore, it may beneficial to focus resources on widening students' awareness of the broader application of mathematics and its value in their academic and future careers.

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