Teaching and Learning in Project Maths:

Insights from Teachers who Participated in PISA 2012

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Rosemary Fish, and Lasairíona McGuinness

Educational Research Centre

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Table of Contents

Preface

Since its launch in 2008, Project Maths has been the subject of considerable discussion and debate amongst the mathematics education community and the general public. The initiative, which is being implemented on a phased basis, involves the complete revision of the mathematics curriculum at junior and senior cycles at post-primary level, with all five revised syllabus strands scheduled to be examined in 2014 for the Leaving Certificate, and 2015 for the Junior Certificate.

Project Maths began in 24 post-primary schools in 2008, and was rolled out across all post-primary schools in the country beginning in the autumn of 2010. The initiative has necessitated considerable inservice training and support from the Project Maths Development Team, a gradual complete overhaul of the examination papers and marking schemes, and the development of new textbooks and other instructional materials. A Common Introductory Course has been devised for the beginning of junior cycle to help to ensure that all students have the opportunity to engage with the same set of core mathematical concepts and content areas. A Bridging Framework aims to promote continuity in mathematics education between the senior classes at primary level and junior cycle at post-primary level.

The scale of the initiative, its timeframe, and its phased implementation represent significant challenges to mathematics teachers, students and school principals. However, if Project Maths is successful, it is envisaged that it will result in a deeper engagement with and understanding of mathematics on the part of students, and increased uptake of Higher level mathematics for both the Junior and Leaving Certificates.

This report describes the findings of a survey of mathematics teachers and mathematics school co-ordinators, implemented as part of PISA 2012 in Ireland. It examines teachers' views on mathematics teaching and learning in general, and on the implementation of Project Maths more specifically. Since PISA 2012 is based on a nationally representative sample of schools, we are provided with an opportunity to gain insights into Project Maths that are generalisable to national level.

In December 2013, when the mathematics achievement data of students in the PISA 2012 schools become available, we will be able to contextualise achievement outcomes with data from the teacher survey. These 'second-stage' analyses will provide empirical results on the effects of the implementation of Project Maths, though it must be borne in mind that it will be 2017 before the first full cohort of students will have experienced Project Maths all the way through post-primary education, from First through to Sixth Year.

This report is aimed primarily at teachers of mathematics and those involved in mathematics education and policymaking. It is also likely to be of interest to the international research community. The report is published at around the same time as a second one drawing on data from PISA 2012 which concerns mathematics in Transition Year. Both are available at www.erc.ie/pisa.

This report is divided into seven chapters. Chapter 1 provides an overview of PISA, while Chapter 2 describes Project Maths and existing research and commentary on the initiative. Chapter 3 describes the survey design, content of questionnaires, and survey respondents. Chapter 4 provides a description of the characteristics of mathematics teachers and the teaching of mathematics, while Chapter 5 discusses teachers' views on the teaching and learning of mathematics. Chapter 6, the main focus of this report, describes teachers' views on Project Maths at junior cycle. Chapter 7 provides a set of conclusions and recommendations, which are made at school level and at the broader level of the education system.

Acknowledgements

PISA is a large and complex exercise, and its implementation would not be possible without advice and support from many. Thanks, first and foremost, to the students, teachers and principals in the 183 schools that participated in PISA 2012. Thanks also to the Inspectors from the Department of Education and Skills who, working in collaboration with staff in schools, helped to ensure that PISA was administered in line with rigorous international standards.

In Ireland, PISA is overseen by the Educational Research Centre with the support of the Department of Education and Skills. The PISA National Advisory Committee advises on all aspects of PISA, from the content of the survey, to analysis and reporting. We are indebted to the Committee for their work on PISA, including their review of this report. Members of the PISA 2012 National Advisory Committee, along with ERC staff, are:

- Pádraig MacFhlannchadha (DES, Chair, from February 2012)
- Éamonn Murtagh (DES, Chair, to February 2012)
- Declan Cahalane (DES, joined 2012)
- Conor Galvin (UCD)
- Séamus Knox (DES, joined 2012)
- Rachel Linney (NCCA, joined 2012)
- Bill Lynch (NCCA, joined 2012, previously a member)
- Hugh McManus (SEC)
- Philip Matthews (TCD)
- Brian Murphy (UCC)
- Maurice OReilly (St Patrick's College, Drumcondra, joined 2012)
- Elizabeth Oldham (TCD)
- George Porter (DES, to February 2012).

Other ERC staff members involved in PISA 2012 are Peter Archer (Director), Gráinne Moran, Paula Chute, John Coyle, and Mary Rohan. We would also like to thank Seán Close for his review of an earlier draft of this report. Thanks to Jill Fannin, Breda Naughton and Anne O'Mahony in the Department of Education and Skills for their review and comments on the report.

Finally, our thanks to the OECD and to the international PISA 2012 consortium (led by ACER in Melbourne) for their work in overseeing PISA's successful implementation at international level.

Acronyms and Abbreviations Used

ACER	Australian Council for Educational Research
CPD	Continuing Professional Development
DEIS	Delivering Equality of Opportunity In Schools
DES	Department of Education and Skills
ERC	Educational Research Centre
ICTs	Information and Communication Technologies
NCCA	National Council for Curriculum and Assessment
NCE-MSTL	National Centre for Excellence in Mathematics and Science Teaching and Learning
NCTE	National Centre for Technology in Education
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
PDST	Professional Development Support Team
PMDT	Project Maths Development Team
RDO	Regional Development Officer
SD	Standard Deviation
SE	Standard Error
SEC	State Examinations Commission
SSP	School Support Programme
TALIS	Teaching and Learning International Survey

1. Introduction

1.1. PISA 2012: An Overview

The OECD's Programme for International Student Assessment (PISA) assesses the skills and knowledge of 15-year-old students in mathematics, reading and science. PISA runs in three-yearly cycles, beginning in 2000, with one subject area becoming the main focus, or 'major domain' of the assessment in each cycle.

In 2012, the fifth cycle of PISA, mathematics became the major focus of the assessment for the first time since 2003. A new element to PISA in 2012 is the computer-based assessments of mathematics and problem solving. Ireland also participated in the digital reading assessment that was introduced in PISA 2009. Sixty-seven countries/economies, including all 34 OECD members and 33 'partner' countries/economies participated in PISA 2012 (Table 1.1)[1].

Table 1.1. Countries/economies participating in PISA 2012

Albania	Estonia	*Latvia*	*Serbia*
Argentina	Finland	*Liechtenstein*	*Singapore*
Australia	France	*Lithuania*	Slovak Republic
Austria	*Georgia*	Luxembourg	Slovenia
Belgium	Germany	*Macao-China*	Spain
Brazil	Greece	*Malaysia*	Sweden
Bulgaria	*Hong Kong-China*	Mexico	Switzerland
Canada	Hungary	*Montenegro*	*Thailand*
Chile	Iceland	Netherlands	*Trinidad and Tobago*
China (Shanghai)	*Indonesia*	New Zealand	*Tunisia*
Chinese Taipei	Ireland	Norway	Turkey
Colombia	Israel	*Peru*	*United Arab Emirates*
Costa Rica	Italy	Poland	United Kingdom
Croatia	Japan	Portugal	United States
Cyprus	*Jordan*	*Qatar*	*Uruguay*
Czech Republic	*Kazakhstan*	*Romania*	*Vietnam*
Denmark	Republic of Korea	*Russian Federation*	

Note. Partner countries are in italics.

1.2. PISA in Ireland

In Ireland, around 5,000 students in 183 schools participated in PISA in March 2012. These students took paper-based tests of mathematics, science and reading, and completed a student questionnaire. The sample included students in each of the 23 initial Project Maths schools (referred to as 'initial schools' in this report)[2]. A sub-sample of these students, just under 2,400 also took part in the computer-based assessments of mathematics, problem solving and reading. It should be noted that, depending on the school and year level that students were in, they may or may not have

[1] Of these 67 countries, over 40 participated in the computer-based assessments of reading, mathematics, and/or problem solving.

[2] One of the original 24 Project Maths initial schools amalgamated with another school and therefore was not included as a Project Maths school in the sample for PISA 2012.

been studying some of the new Project Maths syllabus (see Chapter 2). Principals in participating schools were asked to complete a questionnaire about school resources and school organisation. In Ireland, teachers of mathematics were invited to complete a national teacher questionnaire. Mathematics school co-ordinators[3] were also invited to complete a short questionnaire. The survey sample and content of the mathematics teacher and mathematics co-ordinator questionnaires are described in more detail in Chapter 3 of this report.

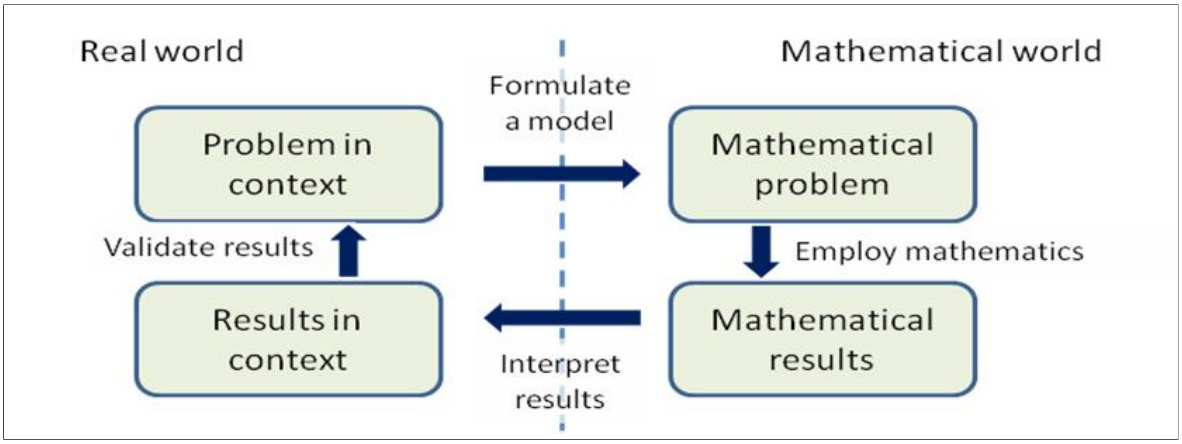
1.3. The Assessment of Mathematics in PISA

The PISA mathematics assessment focuses on active engagement in mathematics in real-world contexts that are meaningful to 15-year-olds. In PISA 2012, mathematical literacy (mathematics) is defined as

…an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to recognise the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens (OECD, in press).

Central to the PISA mathematics framework is the notion of mathematical modelling (Figure 1.1). This starts with a problem in a real-world context. The problem is then transformed from a 'problem in context' into a 'mathematical problem' by identifying the relevant mathematics and reorganising the problem according to the concepts and relationships identified. The problem is then solved using mathematical concepts, procedures, facts and tools. The final step is to interpret the mathematical solution in terms of the original 'real-world' context.

Figure 1.1. Mathematical modelling process in the PISA 2012 assessment framework



Source: OECD (in press).

The PISA mathematics framework is described in terms of three interrelated aspects: (i) the mathematical content that is used in the assessment items; (ii) the mathematical processes involved; and (iii) the contexts in which the assessment items are located.

PISA measures student performance in four <u>content</u> areas of mathematics: *Change and Relationships; Space and Shape; Quantity* and *Uncertainty*. The PISA 2012 survey will, for the first time, report results according to the mathematical <u>processes</u> involved (see Stacey, 2012). PISA

[3] A mathematics school co-ordinator is the staff member in each school who has overall responsibility for mathematics education – he or she is sometimes referred to as the head of the mathematics department or subject head.

mathematics items examine three mathematical processes: *formulating* situations mathematically; *employing* mathematical concepts, facts, procedures, and reasoning; and *interpreting*, applying and evaluating mathematical outcomes. PISA also identifies seven fundamental mathematical capabilities that underpin each of these reported processes. These are *communicating; mathematising; representing; reasoning and argumentation; devising strategies; using symbolic, formal, and technical language and operations;* and *using mathematical tools.*

An important aspect of mathematical literacy is the ability to use and do mathematics in a variety of contexts or situations and the choice of appropriate mathematics strategies is often dependent on the context in which the problem arises. Four categories of mathematical problem situations or contexts are defined: *personal, occupational, societal* and *scientific*. In total, 85 mathematics items, drawing on all four situations, were included in the PISA 2012 assessment, though individual students were asked to complete a subset of these items.

1.4. PISA Mathematics and the Mathematics Curriculum in Ireland

While a comparison of the PISA mathematics framework to the current junior cycle (Project Maths) curriculum has not yet been conducted, a comparison between PISA mathematics and the previous junior cycle curriculum can be found in the PISA 2003 national main report (Cosgrove, Shiel, Sofroniou, Zastrutzki & Shortt, 2005)[4]. This review found substantial differences between the content of the Irish junior cycle mathematics syllabi and the content of the PISA 2003 assessment. The concepts underlying PISA mathematics items were deemed to be unfamiliar to between a third to a half of junior cycle students, depending on syllabus level studied, and the majority of the contexts and item formats were also judged to be unfamiliar to most junior cycle students. In particular, none of the PISA items were deemed to fall into the junior cycle areas of geometry and trigonometry, and just 5% were located in the algebra strand. It may be noted that the PISA 2012 mathematics assessment now includes a higher proportion of items assessing algebra, trigonometry and geometry, in response to criticisms from some countries that the 2003 version had not included a sufficient emphasis on formal mathematics (OECD, in press).

Considerable differences were also found between the PISA assessment and the Junior Certificate mathematics examination (Cosgrove et al., 2005). While the majority of PISA 2003 items assessed Connections and Reflections competency clusters, the majority of items from Junior Certificate examination were classified as assessing skills associated with the Reproduction cluster. In other words, most of the questions on the Junior Certificate assessed routine mathematics skills in abstract contexts, rather than non-routine skills embedded in real-life situations. Also, the PISA assessments use a variety of item formats, such as multiple choice, short response and constructed response items, while the Junior Certificate examination mostly included short response items. A full comparison of the PISA assessments and the Junior Certificate examinations can be found in Close (2006).

1.5. Mathematics Achievement in Previous Cycles of PISA

The first three cycles of PISA indicate that mathematics performance of students in Ireland is at or just below the OECD average. In 2003, when mathematics was last a major focus in PISA, Ireland achieved a mean mathematics score of 502.8, which was not significantly different from the average

[4] The comparison focused on junior cycle mathematics rather than mathematics at senior cycle, since the majority of PISA students – about two-thirds – are in junior cycle.

across OECD countries[5]. However, there was variation in Irish performance across the different mathematical content areas assessed in PISA: students in Ireland performed significantly above the OECD average on the Change and Relationships and Uncertainty content subscales, while they performed significantly lower than the OECD average on the Space and Shape subscale and not significantly differently to the OECD average on the Quantity subscale (Table 1.2).

Table 1.2. Mean scores and standard deviations on the PISA 2003 mathematics content subscales: Ireland and OECD average

	Space & Shape		Change & Relationships		Quantity		Uncertainty	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Ireland	476.2**	94.5	506.0*	87.5	501.7	88.2	517.2*	88.8
OECD	496.3	110.1	498.8	109.3	500.7	102.3	502.0	98.6

*Significantly above OECD average.
**Significantly below OECD average.

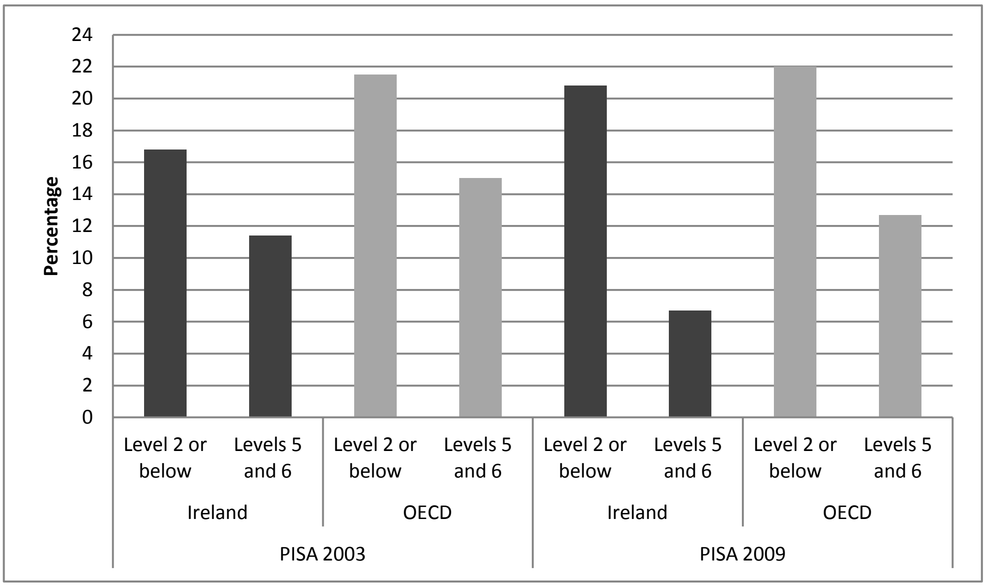
Ireland recorded a significant decline, of 16 points (about one-sixth of a standard deviation), in mathematics performance between 2003 and 2009[6] (at a time when the pre-Project Maths curriculum was in place). This was the second largest drop of all countries that participated in both cycles of PISA. The majority of this decline occurred between 2006 and 2009, when Ireland's mean score changed from 501.5 to 487.1. Ireland's position relative to the OECD average also changed, from being at the OECD average in 2003 and 2006, to being significantly below it in 2009. As mentioned previously, results for PISA 2012 will be available in December 2013.

As well as a drop in average mathematics achievement, there have been changes in the proportions of high and low achieving students in Ireland. In 2003, Ireland had significantly fewer low achieving students (i.e. students performing below proficiency Level 2) (16.8%) than on average across OECD countries (21.5%). In 2009 the percentage in Ireland increased to 20.8%, which did not differ significantly from the OECD average (22.0%). On the other hand, Ireland has seen a decline in the proportion of higher achieving students (i.e. students performing at Level 5 or above) in mathematics, from 11.4% in 2003 to 6.7% in 2009, which is below the corresponding OECD average (12.7%) (Figure 1.2). This indicates that, aside from an overall decline in mathematics achievement in Ireland, there has been a drop in the achievement of students which has been more marked at the higher end of the achievement distribution.

Males significantly outperformed females in Ireland in 2003 and 2006; however, in 2009 the gender difference was not significant. The performance of both male and female students dropped significantly from 2003 to 2009 (from 510.2 to 490.9 for males and from 495.4 to 483.3 for females), with most of the decline occurring between 2006 and 2009. In 2009, both male and female students in Ireland performed on average significantly lower than their OECD counterparts. Ireland saw an increase in the proportion of low-achieving males (from 15.0% to 20.6%) and females (from 18.7% to 21.0%) between 2003 and 2009, with the increase greater among male students. There has also been a marked decrease in the percentage of high-achieving males (from 13.7% to 8.1%) and females (from 9.0% to 5.1%) between 2003 and 2009.

[5] The OECD average for mathematics, set in 2003, is 500 points, and the standard deviation is 100.
[6] Comparisons of PISA results over different cycles assume that the scales are reliably consistent over time, which has not yet been conclusively demonstrated.

Figure 1.2. Percentages of students at or below Level 2, and at Levels 5 and 6 on PISA mathematics in 2003 and 2009: Ireland and OECD average



1.6. PISA 2012 Reporting

This report is published at around the same time as a second report that also draws on information collected in the national teacher and mathematics school co-ordinator questionnaires. The second one concerns Transition Year mathematics *(Transition Year Mathematics: The Views of Teachers from PISA 2012)*. These two reports are the first national publications on PISA 2012.

The first international results from PISA 2012 will be published by the OECD in December 2013. Results will be reported in four volumes:

- *Volume 1:* Performance in mathematics, reading and science
- *Volume 2:* Quality and equity
- *Volume 3:* Engagement and attitudes
- *Volume 4:* School and system-level policies and characteristics.

Two additional reports/volumes will be published by the OECD in the spring and summer of 2014. These are:

- *Volume 5:* Performance on computer-based problem-solving
- *Volume 6:* Performance on financial literacy (an optional assessment in which Ireland did not participate).

The ERC will release a national report on PISA 2012 in December 2013 which will complement the OECD's reporting. Additional reporting designed to provide a fuller understanding of PISA 2012 outcomes will also be published by the ERC in 2014.

All national PISA publications are at www.erc.ie/pisa, while the OECD's reports are at www.pisa.oecd.org.

1.7. Conclusions

It is reasonable to conclude that the performance of students in Ireland on PISA mathematics has, to date, been somewhat disappointing, although, as discussed in Chapter 2, there are a number of developments underway which aim to improve mathematics standards, along with changes to our education system more generally. The decline in mathematics achievement between 2003 and 2009 is nonetheless a cause for concern. Further consideration of the possible reasons for this decline, which highlight the complexity of the issue, are discussed in Cartwright (2011), Cosgrove, Shiel, Archer and Perkins (2010), LaRoche and Cartwright (2010), and Shiel, Moran, Cosgrove and Perkins (2010). We will not know how students fared on the PISA 2012 paper-based and computer-based assessments of mathematics until December 2013. As well as overall achievement in mathematics in PISA 2012, we will need to examine the performance of students at the high and low ends of the achievement distribution, since the PISA 2009 results suggest a dip in the performance of high-achieving students in particular.

Previous analyses that compare the junior cycle mathematics syllabus and examinations with PISA mathematics indicate that the syllabus in Ireland that was in place prior to the introduction of Project Maths tended to emphasise the application of familiar concepts and routines in abstract (purely mathematical) contexts. These points underline the importance of the Project Maths initiative, which is considered in Chapter 2.

As of yet, there has not been a comparison of the revised (Project Maths) syllabus and examinations on one hand, and the PISA 2012 assessment framework for mathematics and the PISA mathematics test on the other, and there would be merit in making this comparison as Project Maths becomes more established in schools.

2. Project Maths: An Overview

2.1. What is Project Maths?

Project Maths is a national curriculum and assessment initiative. The project, which involves changes in the syllabi, their assessment, and the teaching and learning of mathematics in post-primary schools, arose from detailed consideration of the issues and problems that had been identified over several years. These have been highlighted in a number of sources: research in Irish classrooms (Lyons, Lynch, Close, Sheerin & Boland, 2003), Chief Examiner's reports (for the Junior Certificate in 2003 and 2006, and for the Leaving Certificate in 2000, 2001, and 2005; see www.examinations.ie), the results of diagnostic testing of third-level undergraduate intake (Faulkner, Hannigan, & Gill, 2010), trends in international mathematics education (Conway & Sloane, 2006), and results of international assessments such as PISA (Cosgrove et al., 2005). Broadly speaking, these revealed major deficiencies in students' understanding of some of the basic concepts in mathematics, and significant difficulties in applying mathematical knowledge and skills in other than routine or well-practised contexts. For this reason, there was an identified need to provide significant support for teachers in adopting changed practices that were sustainable (NCCA, 2005). The mathematics syllabi that were in place prior to Project Maths attempted to incorporate some of the current changes, but 'because of the amount of change that had taken, and was taking, place in the junior cycle in other subject areas [at the time of introducing the previous syllabi, in 2000], *it was specified that the outcomes of the [NCCA's] review would build on current syllabus provision and examination approaches rather than leading to a root and branch change of either*' (NCCA/DES, 2002, p. 6, italics in original).

Project Maths focuses on developing students' understanding of mathematical concepts, the development of mathematical skills, and the application of knowledge and skills to solving both familiar and unfamiliar problems, using examples from everyday life which are meaningful to students (NCCA/DES, 2011a, 2011b). These aims are similar to those outlined in the PISA 2012 mathematics assessment framework, which is intended to represent the most up-to-date international views on mathematical knowledge and skills in adolescents (see Chapter 1), and although PISA is certainly not a key driver of the Project Maths initiative, it is one source of influence. One of the key elements of Project Maths is a greater emphasis on an investigative approach, meaning that students become active participants in developing their mathematical knowledge and skills. This implies not only changes in the content of the syllabi, but also, and more fundamentally, perhaps, changes to teaching and learning approaches.

Project Maths also aims to provide better continuity between primary school mathematics and junior cycle mathematics. To this end, a Bridging Framework has been developed, which maps the content of fifth and sixth class mathematics onto junior cycle mathematics[7]. A Common Introductory Course in mathematics[8] is now completed by all students in the first year of the junior cycle, meaning students do not study a specific syllabus level until a later stage. Also, in the revised syllabi, there is no separate Foundation Level syllabus. However, a Foundation Level examination will continue to be provided.

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[7] http://action.ncca.ie/en/mathematics-bridging-framework

[8] http://www.projectmaths.ie/documents/handbooks_2012/handbooks_revised_feb_2012/first_yr_HB_2012.pdf

It is an objective of Project Maths to increase the uptake of Higher level mathematics at Leaving Certificate to 30%, and to 60% at Junior Certificate. To incentivise this, 25 bonus points[9] are now awarded to students who take Higher level mathematics for the Leaving Certificate and who are awarded a grade D3 or higher (www.cao.ie).

Learning outcomes are set out under five strands:

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

A comparison of the old and revised syllabi has not been published, partly to encourage a flexible interpretation of the revised syllabi[10]. However, an inspection of the old and revised syllabus documents indicates that some topics have been de-emphasised to allow for the development of a deeper understanding by students of the material that *is* covered. For example, there is a rebalancing of calculus at Leaving Certificate level[11], and vectors and matrices are not on the Leaving Certificate syllabus. An area which now receives more emphasis in the revised syllabi is statistics and probability.

Since Project Maths is as much about changing teaching and learning practices as it is about changing content, it was considered desirable to introduce the changes simultaneously at junior and senior cycles. This was intended to allow teachers to embed the changed teaching approaches at both junior and senior cycles at the same time. Furthermore, it was felt that teachers could focus on specific strands of mathematics regardless of the level at which these were being taught, and that support could be targeted at all mathematics teachers at the same time, although this approach meant that students commencing Fifth Year at the start of the implementation of Project Maths would not have had exposure to changes at junior cycle.

A phased approach to the changes in the syllabus was adopted. The combinations of strands to be changed in the first phase (Strands 1 and 2) was selected on the basis that these strands affected only one of the two examination papers; they also contained both familiar (Strand 2) and unfamiliar (some of Strand 1) material. By retaining some elements of the old syllabus, it was thought that teachers could concentrate on incorporating changes in the revised strands only.

Project Maths represents a new model of curriculum development in Ireland in that it involved implementing and testing out a draft curriculum from ‘ground-level’ upwards. It was introduced in an initial group of 24 schools in September 2008. These 24 schools have been referred to as both ‘pilot’ and ‘initial’ schools. In this report, we refer to them as initial schools, since Project Maths is not a pilot programme in the formal sense of the term.

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[9] In Ireland, students gain entry to post-secondary education through a ‘points scheme’ that is operated through the CAO (Central Applications Office). The provision of bonus points was not initiated as part of Project Maths.

[10] This stands in strong contrast to the syllabi previously in place, where a detailed topic-by-topic comparison between the 2000 syllabi and the previous ones was published (NCCA/DES, 2002, Appendix 1).

[11] That is, there is a reduction in the range of functions that students are expected to integrate, along with an increase in the range and types of applications that are expected, and a greater level of understanding of fundamental technical aspects of calculus.

The initial schools were selected (by the ERC) from 225 volunteer schools in such a way as to ensure that they were broadly representative of the national population of schools. This sample comprised four community/comprehensive schools, seven vocational schools, and 13 secondary schools, four of which were mixed sex. Roll-out of Project Maths to all schools began in September 2010, with the final strand being introduced into all schools in September 2012 (see Table 2.1).

Table 2.1. Timeline for Project Maths

	Junior Cycle			Senior Cycle		
Timeline	**Strands 1 and 2**	**Strands 3 and 4**	**Strand 5**	**Strands 1 and 2**	**Strands 3 and 4**	**Strand 5**
Sep-2010						
Jun-2011				Changes to Paper 2		
Sep-2011	Changes to Paper 2					
Jun-2012 **(PISA – Mar-2012)**					Changes to Paper 1, New Paper 2	
Sep-2012		Changes to Paper 1, New Paper 2				
Jun-2013						New Paper 1, New Paper 2
Sep-2013			New Paper 1, New Paper 2			
Jun-2014						
Sep-2014						
Jun-2015						

Strands 1 and 2 of the revised syllabi were first examined in all schools in 2012 at Leaving Certificate level. The Junior Certificate Examination will include these two strands in 2013, and the first examination of all Strands (1-5) takes place in 2014 at Leaving Certificate level and 2015 at Junior Certificate level. In 2017, a first cohort of students will have experienced all five strands of Project Maths right through post-primary, from First to Sixth Year.

The timeframe for the implementation of Project Maths should be borne in mind with respect to the time at which the PISA 2012 survey was conducted (i.e. spring 2012) in that the results in this report come at an early, and transitional, stage of implementation; a majority of PISA 2012 students would not have experienced the revised mathematics syllabus.

Teachers in initial schools participated in summer courses[12] that focused on the syllabus strands. Their work was also supported by school visits from a Regional Development Officer (RDO). In a general sense, the work of initial schools was supported by the RDOs through meetings, seminars, and online resources (Kelly, Linney, & Lynch, 2012). To support these changes across all schools, a programme of professional development consisting of workshops that focus on changing classroom practice, and evening courses that emphasise mathematics content are being delivered by the Project Maths Development Team (PMDT), and the National Centre for Technology in Education (NCTE)/Professional Development Support Team (PDST) is delivering courses on ICTs.

An additional support is the new Professional Diploma in Mathematics for Teaching, which is aimed at 'out-of-field' teachers of mathematics over the next three years. There are 390 places on the course, which began this autumn, and 750 have already enrolled for the course (DES press release,

[12] Elective summer mathematics courses were organised by the National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) in the University of Limerick to meet the growing professional development needs of teachers. Materials from the summer courses are available at http://www.nce-mstl.ie.

September 22, 2012). The National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) based in the University of Limerick (www.nce-mstl.ie) leads its delivery of this course, which is fully funded by the Department of Education and Skills.

2.2. What are the Existing Views/Findings on Project Maths?

As of yet, no research on the impact of Project Maths, e.g. on student achievement, has been published. However, an interim report on Project Maths, based on research commissioned by the NCCA and conducted by the National Foundation for Educational Research (NFER, UK) will include information on students' attitudes and achievement, and is expected in November 2012. Also, when the results of PISA 2012 become available at the end of 2013, it will be possible to look at both the achievements and attitudes of PISA students in the context of when Project Maths was implemented in their schools. Again, it should be borne in mind that we are currently in the early stages of the full implementation of Project Maths.

The remainder of this section offers a brief review of the research and commentary on Project Maths, up to the time of writing of this report (November 10, 2012).

A survey of mathematics teachers in the initial schools was carried out through meetings with these teachers by staff of the NCCA in December 2011, with follow-up meetings in April 2012. It sought information from teachers on the impact of Project Maths on teaching practices, mathematics departments and students' experiences (Kelly, Linney & Lynch, 2012). The authors identified six themes emerging from the interviews with school staff: *new roles; supporting change and using resources; issues of assessment; time; issues of change;* and *feedback on syllabus strands*.

Key findings from Kelly et al. (2012) may be summarised as follows. First, teachers struggled with the *new role* of facilitating students as active learners, and reported that it was common to revert to the traditional examination preparation techniques as the State Examinations approached. Indeed, teachers reported that the examinations were impacting negatively on the new teaching and learning approaches. They also underlined their need for appropriate support and resources to allow them to continue to develop in this new role. Second, some teachers commented positively on the *changes in their teaching* and collaboration between teachers was viewed as valuable. They also reported a general increase in the use of ICTs and other resources during teaching, and with this, less emphasis on textbooks. Third, *time* was highlighted as an issue by teachers, who commented on the difficulties posed by the time required to meet and plan, cover the syllabus, and to use different kinds of assessment.

Kelly et al. (2012) also reported that tests, homework and sample examination questions were cited as the principal forms of assessment, and teachers commented that they needed support in using alternative methods of assessment in class. There was a view among teachers that the syllabus was too long, and that further consideration needed to be given to its length, particularly in light of the increased emphasis on problem-solving and context-based tasks. However, comments from some of the teachers suggested that, as teachers develop their familiarity with the connections between the strands, they can make more efficient and effective use of their time. It is too early to make this conclusion confidently though – the issue will become clearer as implementation of all five strands progresses.

Some commentary on Project Maths has come from the third-level sector[13]. A report from the School of Mathematical Science in University College Cork has cautioned against the 'unrealistic expectations' of, and 'the exaggerated claims' being made about, Project Maths (Grannell, Barry, Cronin, Holland & Hurley, 2011, p. 3). The authors express concerns generally about the ensuing mathematical knowledge and skills of third-level entrants, and more specifically about the removal of core material that was included on the pre-Project Maths syllabus, particularly vectors. They are also concerned about the burden that has been placed on teachers.

The report of the Taskforce on Education of Mathematics and Science at Second Level (Engineers Ireland, 2010), includes the following observations: first is the low level of take-up of Higher level mathematics for the Leaving Certificate along with mediocre mathematics standards internationally; second, the 'generally untapped resource' (p. 1) that Transition Year represents; third, the major challenges or 'quantum leap required in the transitioning of teaching methods' (p. 2); and fourth, the broad issue of adequate resourcing of Project Maths.

The lack of textbooks to support Project Maths has been highlighted by some commentators (e.g. Engineers Ireland, 2010; Grannell et al. 2011). However, the Project Maths website (www.projectmaths.ie) cautions against over-reliance on textbooks, and encourages teachers to use supplementary resources. Lubienski (2011) has argued that the Project Maths leaders 'appear to be circumventing textbooks as opposed to leveraging them' (p. 45) and, comparing two of the textbooks in common use at the time, comments that: 'one text [was] presenting traditional boxed formulas and examples for students to follow and the other text [was] structuring a sequence of investigations through which students derive the formulas'. Lubienski suggests that instead of circumventing textbooks, Project Maths leaders should assist teachers in critically analysing the contents of texts and selecting the most appropriate to their own needs and the goals of Project Maths.

Lubienski (2011) considered Project Maths from a US perspective. Her findings are based on interviews with members of the Project Maths Development Team (PMDT) and the NCCA, and visits to three of the initial schools. She comments positively on the collaborative nature of the initiative; its adherence to the timeline; responsiveness to feedback from the initial schools; teacher professionalism; and changes in teachers' practices. She also highlights some key difficulties raised by the interviewees. The first is the decision to implement Project Maths at both junior and senior cycles at the same time. Lubienski (2011, p. 31) comments that this was 'the subject of the majority of complaints… from Irish teachers.' The second was the lack of availability of sample papers at the time of her study, while the third was the length and difficulty of the statistics strand, particularly for senior cycle students.

Lubienski (2011) also raises two 'high-level' issues in her review. First is the high emphasis in Ireland that is placed on the Leaving Certificate examination, which, in her view, constrains instruction and places teachers in the role of 'exam coach'. This stands in contrast to the US, where students sit the independently-administered Scholastic Aptitude Test (SAT) or American College Test (ACT). She comments that the examinations-driven approach in Ireland may give rise to teaching and learning that emphasises form over substance (or procedural over conceptual knowledge), and a blurring in the distinction between instruction and assessment. Second, time pressure appears to stem from

[13] It should also be noted that the third-level sector has representation on the NCCA's course committees through the Irish Universities Association (see NCCA, 2012).

two system-level or structural sources – pressure to cover the syllabus (partly, she notes, with the inclusion of Religious Education and Irish as core subjects), and short class periods (35-40 minutes) relative to the US (45-50 minutes).

Since September 2008 (when Project Maths was first introduced), there have been over 500 media reports on Project Maths. Common themes in these reports are concerns over the 'dumbing down' of the subject, the content of the revised syllabi (e.g. too much emphasis on problem-solving, not enough on formal or pure mathematics), and effects of Project Maths on the level of preparedness of students for third-level courses in mathematics, science, engineering and technology.

Some media reports have commented on the immediate effects of the awarding of bonus points for Higher Level mathematics, noting that there has been a marked increase, from 16% to 22% in the number of students taking Higher level mathematics for the 2012 Leaving Certificate (e.g. Irish Independent, August 15, 2012). Some express concerns that the bonus points scheme may affect the CAO points requirements for college entry in a very general way, with an increase in points required for entry to many courses, some of which do not require Higher level mathematics (e.g. Irish Times, August 16, 2012).

A review of the recommendations made in the report of the Project Maths Implementation Support Group (DES, June 2010) indicates that already, attempts are being made to address some areas of concern. First, the report recommended that schools allocate a minimum of one mathematics class per day for all students. This was included in a Circular sent to schools in September 2012 (Circular Number 0027/2012) asking that every effort be made to provide students with a mathematics class every day, particularly at junior cycle. One would also hope that, as the Framework for Junior Cycle (DES, 2012) is implemented (see the next section), the reduction in the numbers of subjects taken by students, together with the specification of a minimum amount of instructional hours for English, Irish and mathematics, will help to further alleviate time pressures reported by teachers. Second, the Implementation Support Group report recommended encouraging rather than discouraging students to take Higher Level mathematics at Leaving Certificate level, and to award excellence in mathematics (as is already done in schools for English and Irish during prize-giving ceremonies). This may go part (but by no means all) of the way in helping more students achieve their full potential in mathematics (recall that in Chapter 1, we noted the relatively low performance of students in Ireland at the upper end of the PISA mathematics achievement distribution). Third, it recommends a review of third level entry processes and requirements, including bonus points for Higher Level mathematics. As noted earlier, bonus points were awarded for the first time in 2012, coinciding with an increase in the percentages taking Leaving Certificate mathematics at higher level. Fourth, it contains recommendations for addressing gaps in teacher qualifications and professional development. Also as noted, the new Professional Diploma in Mathematics for Teaching commenced in autumn 2012, and Project Maths has included the delivery of fairly intensive CPD by the PMDT and NCTE.

2.3. Project Maths in the Wider Context of Educational Reform

We have already commented that, at the time of teacher survey that formed part of PISA 2012 in Ireland, Project Maths was at a relatively early stage of implementation. Project Maths is also occurring within a wider context of educational reform. The National Strategy to Improve Literacy and Numeracy Among Children and Young People, 2011-2020 (DES, 2011) may be regarded as a key reference for the broader educational context at this time. Although Project Maths began before the Strategy was published, its objectives fit well into its overarching framework.

In the Strategy, numeracy and mathematics appear to be used interchangeably. It states that 'Numeracy encompasses the ability to use mathematical understanding and skills to solve problems and meet the demands of day-to-day living in complex social settings' (DES, 2011, p. 8). The Strategy places the development of numeracy within the role of all teachers, not just teachers of mathematics. It sets out the following five goals and targets for outcomes at post-primary level that are relevant to mathematics/numeracy (DES, 2011, p. 18):

- Ensure that each post-primary school sets goals and monitors progress in achieving demanding but realistic targets for the improvement of literacy and numeracy skills;
- Assess the performance of students at the end of second year in post-primary education, establish the existing levels of achievement, and set realistic targets for improvement;
- Increase the percentage of 15-year old students performing at or above Level 4 (i.e. at the highest levels) in PISA reading and mathematics tests by at least 5 percentage points by 2020;
- Halve the percentage of 15-year old students performing at or below Level 1 (the lowest level) in PISA reading and mathematics tests by 2020; and
- Increase the percentage of students taking the Higher Level mathematics examination at the end of junior cycle to 60 per cent by 2020, and increase the percentage of students taking the Higher Level mathematics examination at Leaving Certificate to 30 per cent by 2020.

In order to achieve these targets, the Strategy sets out a number of supportive actions. With respect to initial teacher education, it proposes changes to both the content and length of the courses. It also sets out ways to better support newly-qualified teachers, and recommends focusing continuing professional development (CPD) on literacy, numeracy and assessment, with a minimum participation of 20 hours every five years. The Strategy specifies CPD and resource materials for school principals and deputy principals for effective teaching approaches, assessment, and self-evaluation. It emphasises the importance of assessment in informing current standards and identifying areas for improvement at individual, school and national levels, and notes that assessment for learning (AfL) 'is not used sufficiently widely in our schools and we need to enable teachers to improve this practice' (DES, 2011, p. 74). It notes that AfL needs to be combined with AoL (assessment of learning), chiefly in the form of standardised tests, and highlights the lack of standardised mathematics tests currently in place at post-primary level. The Strategy specifies the development of standardised tests for use in post-primary schools in 2014, with the requirement that post-primary schools administer these tests at the end of second year in 2015. It specifies how schools should use the results of these assessments for individual learning, reporting to parents, and school self-evaluation. It is also intended that the results of these assessments will be used to monitor trends in achievement nationally. To complement this, the Strategy recommends continued participation in international assessments, in order to benchmark national achievement levels against international ones.

In discussing the mathematics curriculum, the Strategy is supportive of the recommendations made by the Project Maths Implementation Support Group (DES, 2010), and indicates that Project Maths is designed to address many of the long-standing concerns about mathematics teaching and learning at post-primary level. It notes, however, that '…the adoption of this radically new approach to the subject is challenging for teachers and has to be supported by extensive continuing professional development' (DES, 2011, p. 52).

The *Framework for Junior Cycle* (DES, 2012) follows from *Innovation and Identify: Ideas for a New Junior Cycle* (NCCA, 2010) and *Towards a Framework for Junior Cycle* (NCCA, 2011). The framework highlights the lack of progress made by some students in English and mathematics in the earlier stages of post-primary school, as well as the dominant influence of the Junior Certificate examination on the experiences of junior cycle students. It describes reforms to both the content of the junior cycle curriculum, and 'most particularly to assessment' (p. 1).

Eight principles underpin the new junior cycle: quality, wellbeing, creativity and innovation, choice and flexibility, engagement and participation, inclusive education, continuity and development, and learning to learn (DES, 2012, p. 4). Four of the 24 statements of learning in the framework are of particular relevance to mathematics, though almost all have some relevance (DES, 2012, pp. 6-7). The four are that the student:

- recognises the potential uses of mathematical knowledge, skills and understanding in all areas of learning;
- describes, illustrates, interprets, predicts and explains patterns and relationships;
- devises and evaluates strategies for investigating and solving problems using mathematical knowledge, reasoning and skills; and
- makes informed financial decisions and develops good consumer skills.

The Framework identifies 18 junior cycle subjects (DES, 2012, p. 11), along with seven short courses. It is planned that there will be a reduction in the number of subjects taken by students, with most taking 8-10 subjects in total. Short courses will count as half of a subject. The Framework specifies that a minimum of 240 hours of instruction be provided for English, Irish and mathematics, a minimum of 200 hours for other subjects, with 100 hours for up to four short courses.

It is envisaged that students will study a mix of subjects and short courses. Subjects are to be revised over a period of about five years, starting with English in 2014-2015, with no revisions to the new mathematics curriculum until 2017-2018. All subjects and short courses will be described in specification documents, which are to include the following elements: aims and rationale; links with statements of learning, literacy, numeracy, and other key skills; overview (strands and outcomes); expectations for students; and assessment and certification.

Literacy and numeracy are recognised as key skills, along with managing self, staying well, communicating, being creative, working with others, and managing information and thinking (DES, 2012, p. 9).

Aside from these substantial changes to the content and specifications of the curriculum, assessment in junior cycle is seen as the 'most significant change' (DES, 2012, p. 18). The Junior Certificate examination is to be phased out, and replaced by school-based assessment (culminating in a School Certificate). Given the proposed scale of this reform, the SEC will continue to be involved in the initial stages, particularly with respect to English, Irish and mathematics, and the timeline for the changes to assessment will mirror that for the revision of subjects and courses (see DES, 2012, p. 25 and p. 39). English, Irish and mathematics will continue to be assessed at both Higher and Ordinary levels, while other subjects will be assessed at Common level.

2.4. Conclusions

There can be little doubt that Project Maths is a highly ambitious curricular reform initiative, and it is too early yet to expect to observe its effects on mathematics education, particularly students' mathematics achievement, since implementation (in the form of examination of all five syllabus strands) will not be complete until 2014 (at Leaving Certificate)/2015 (at Junior Certificate).

There has been a considerable amount of commentary on Project Maths, some of it is based on opinion rather than fact, and of course dependent on the particular stage of implementation of the initiative. We suggest that commentary on Project Maths is best interpreted in the broader context of educational reform, i.e. the implementation of the new junior cycle framework, and the overarching strategy to improve literacy and numeracy.

In reviewing the research conducted on Project Maths to date, we have noted the lack of empirical data, particularly achievement data, and data from parents, though the forthcoming interim report from the NFER (due before the end of 2012) can be expected to provide some information on the opinions and mathematics achievements of students. Additional data on achievement will be analysed and reported on in the international and national reports on PISA 2012 in December 2013 (see Chapter 1).

Commentary on the omission of some aspects of mathematics from senior cycle raises concerns about its suitability for candidates who want to enter third-level courses which have high mathematics or mathematics-related content. We suggest, however, that the changes brought about by Project Maths at post-primary level should be managed as a two-way process across both the post-primary and third-level sectors (see Chapter 7).

Views from the teachers themselves, particularly regarding the time required to become familiar with and implement the revised syllabus, and the constraints imposed on them by the examinations should also be treated with concern, though the reform of the junior cycle can be expected to alleviate some of the time pressure experienced by teachers. Further, while the full impact of the introduction of CAO bonus points for Higher Level mathematics may not yet be apparent, we have concerns that introducing bonus points could have the unintended consequence of a focus on Higher level uptake and grades attained, to the detriment of due consideration of actual mathematics standards achieved by all students. We note, however, that a review of the provision of bonus points is expected in 2014 (DES, personal communication, September 2012).

3. Survey Aims, Questionnaires and Respondents

3.1. Aims of the Survey and Content of Questionnaires

The teacher and mathematics school co-ordinator[14] questionnaires are national instruments, administered only in Ireland as part of PISA 2012. Their content was established and finalised on the basis of discussions with the PISA national advisory committee (membership of which is shown in the Acknowledgements to this report), the literature review (see Chapter 1), and analyses of the field trial data, which were conducted in March 2011.

The aims of administering the questionnaires were fourfold:

1. To obtain a reliable, representative and up-to-date profile of mathematics teaching and learning in Irish post-primary schools.
2. To obtain empirical (numeric) and qualitative (text) information on the views of a nationally representative sample of teachers on the implementation of Project Maths; and to compare this information across teachers in initial schools and teachers in other schools.
3. To obtain information on aspects of Transition Year mathematics.
4. To make findings available to teachers and school principals, the DES, NCCA, and partners in education in an accessible format and timely manner.

With respect to the second aim, it is our view that, since Project Maths was implemented in an earlier timeframe in the initial schools, comparisons between initial schools and other schools could provide some indication of any issues or changes to do with the implementation of Project Maths in initial and later stages, though it should be borne in mind that national roll-out of Project Maths was informed by the experiences of the initial schools.

With respect to the third aim, the results from questions on Transition Year mathematics are reported in a separate ERC publication *(Transition Year Mathematics: The Views of Teachers from PISA 2012)*. Transition Year has been highlighted as being in need of review, particularly in light of Project Maths and educational reform more generally (e.g., DES, 2010; Engineers Ireland, 2010).

With respect to the fourth aim, to expedite the dissemination of the results from these national questionnaires, it was decided to publish reports on them prior to the availability of students' achievement scores and other PISA 2012 data. However, the examination of the data discussed in this report with respect to students' mathematics achievement in PISA 2012 will be a next step. As noted in Chapter 1, students' mathematics achievement will be available in December 2013.

The mathematics teacher questionnaire consisted of five sections as follows:

- Background information (gender, teaching experience, employment status, qualifications, teaching hours, participation in CPD)
- Views on the nature of mathematics and teaching mathematics
- Teaching and learning of students with differing levels of ability
- Views on Project Maths
- Teaching and learning in Transition Year mathematics (if applicable to the teacher).

[14] Mathematics school co-ordinators may also be referred to as 'mathematics subject heads' or 'mathematics department heads'.

Most of the information from the survey was numeric (i.e. consisting of pre-coded 'tick-box' responses); however, teachers also wrote comments on Project Maths and on the use of differentiated teaching practices. This report includes the results from both numeric and written responses.

The mathematics school co-ordinator questionnaire was considerably shorter than the teacher questionnaire and asked about the following:

- Organisation of base and mathematics classes for instruction
- Distribution of students across mathematics syllabus levels
- Arrangements for Transition Year mathematics (if available/taught in the school).

It is important to note that the content of the questionnaires that were administered impacts on what this report does and does not cover. In particular, this report does not examine teachers' views on Applied Mathematics (taken at Leaving Certificate level by about 2.5% of students; www.curriculumonline.ie, www.examinations.ie). Results do not address the opinions of other groups such as principals, students and parents, or if they do, they do so indirectly (e.g. teachers' views on the opinions of students and parents). Also, while the teacher questionnaire does consider various aspects of the content and skills underlying the revised syllabi, the results cannot be viewed as a review of the revised curriculum. Finally, since a majority of students taking part in PISA are in junior cycle, some of the questions on Project Maths are targeted specifically to junior cycle: there is no equivalent, specific focus on teachers' views at senior cycle.

3.2. Demographic Characteristics of Mathematics Teachers and School Co-ordinators

Tables 3.1 and 3.2 show some of the characteristics of the teachers and mathematics school co-ordinators who participated in the survey, which was conducted in schools in Ireland that participated in PISA 2012.

Table 3.1. Demographic characteristics of teachers participating in the PISA 2012 mathematics teacher survey

Characteristic	N	%
Gender		
Female	844	65.2
Male	451	34.8
Years Teaching Experience		
One to two	83	6.3
Three to five	207	15.7
Six to ten	287	21.8
Eleven to twenty	334	25.4
Twenty one or more	405	30.8
Employment Status		
Permanent	852	66.0
Fixed term > 1 year	201	15.6
Fixed term < 1 year	238	18.4

Note. Data are weighted to reflect the population of teachers.

Table 3.2. School-related characteristics of mathematics teachers and school co-ordinators participating in the PISA 2012 teacher survey

Characteristic	Teachers		Co-ordinators	
	N	%	N	%
Sector/Gender Composition				
Community/Comprehensive	219	16.6	95	13.4
Vocational	330	25.0	232	32.9
Secondary all boys	226	17.1	111	15.6
Secondary all girls	298	22.6	132	18.7
Secondary mixed	248	18.8	137	19.4
DEIS/SSP Status				
No	1041	78.8	506	71.5
Yes	280	21.2	202	28.5
Initial Project Maths School				
No	1267	95.9	684	96.7
Yes	54	4.1	23	3.3
Fee Pay Status				
No	1207	91.3	656	92.7
Yes	114	8.7	52	7.3
School Size				
Small (<400)	275	20.8	289	40.9
Medium (401-600)	481	36.4	226	31.9
Large (601-800)	370	28.0	124	17.6
Very Large (>801)	195	14.7	68	9.6

Note. Data are weighted to reflect the population of teachers/co-ordinators.

The schools were sampled at random, and are nationally representative of the population of post-primary schools. In each school, all teachers of mathematics were selected to participate. All results are weighted.[15] Overall, 80.3% of teachers returned a questionnaire, and 93.4% of school co-ordinators returned a questionnaire. Sixty-five percent of mathematics teachers were female (Table 3.1). This is consistent with the profile of teachers who participated in the OECD's TALIS survey, in which 69% were female (Gilleece, Shiel, Perkins & Proctor, 2008). About three-tenths of teachers indicated having 21 or more years of experience, 47.2% had between six and 20 years of experience, 15.7% between three and five years, and 6.3% reported having fewer than two years of teaching experience. Years of experience reported by mathematics teachers is again broadly similar to those reported in TALIS (Gilleece et al., 2008), as well as in a recent national survey (Uí Ríordáin & Hannigan, 2009).

Two-thirds of teachers (66.0%) were permanently employed; of the remaining respondents, similar proportions of teachers were on fixed-term contracts of more than a year (15.6%) and on fixed-term contracts of less than a year (18.4%). The proportion of permanently employed teachers is less than the figure of 74% reported in TALIS (Gilleece et al., 2008) while the number of teachers with fixed-term contracts of more than a year is somewhat higher (8% in TALIS).

[15] See the Technical Appendix for information on response rates the computation of the sampling weights used in analyses for this report.

A quarter of teachers were in vocational schools, 22.6% in all girls' secondary schools, 18.8% in mixed secondary schools, 17.1% in all boys' secondary schools, and 16.6% in community/comprehensive schools. One-fifth of teachers (21.2%) were in DEIS (SSP) schools[16] and four percent of teachers responding were working in Project Maths initial schools (recall that we sampled all 23 initial schools). Just under a tenth of teachers were based in fee-paying schools. Most schools (64.4%) had student enrolments of between 401 and 800 students, one fifth of schools were small (<400) and the remaining 14.7% were very large schools of over 800 students.

The characteristics of mathematics co-ordinators were broadly similar to those of mathematics teachers (Table 3.2).

3.3. Conclusions

As part of PISA 2012 in Ireland, mathematics teachers and mathematics school co-ordinators completed questionnaires which provide information on the contexts for teaching and learning mathematics, views on mathematics, and specifically on Project Maths. This is a nationally representative sample of teachers, so results can be generalised to teachers of mathematics nationally. Once the achievement data of students in PISA 2012 are available in 2013, the information gathered from teachers will help us to contextualise and better understand achievement.

[16] DEIS, Delivering Equality of Opportunity in Schools, provides additional, targeted resources to primary and post-primary schools that have high concentrations of disadvantage, under the School Support Programme (SSP) (DES, 2005).

4. General Characteristics of Mathematics Teachers and Organisation of Mathematics

4.1. Teacher Background and Qualifications

This section describes the qualifications of mathematics teachers who took part in the survey, including work in other professions prior to entering teaching.

The Teaching Council (2012) specifies that in order to teach mathematics at post-primary level, teachers should have completed at least a primary degree in which mathematics was a major subject (minimum of 30% of the period of the degree) and that the breadth and depth of the syllabi undertaken are such as to ensure competence to teach mathematics to the highest level in post-primary education.

Three-fifths of teachers overall had completed a primary degree that incorporated mathematics up to final year, a proportion which was almost identical across Project Maths initial and other schools (Table 4.1). Only three percent of teachers overall had completed a primary degree that did not include mathematics as a subject. The remainder (35.4%) had completed a primary degree with mathematics in first year/first and second year only.

Table 4.1. Percentage of teachers who hold primary degrees with varying quantities of mathematics content: Overall, and in initial and other schools

Degree Content	Overall	Initial Schools	Other Schools
Primary degree with mathematics up to final year	60.0	60.2	60.0
Primary degree with mathematics in first and second year	20.1	15.4	20.3
Primary degree with mathematics in first year only	15.3	21.5	15.0
Primary degree that did not include mathematics as a subject	3.3	1.3	3.4
None of the above	1.2	1.8	1.2

Table 4.2 shows the type of primary degree held by teachers. The most commonly-held primary degree was a BA or BSc with mathematics (58.3%). About 13% of teachers held a B Comm/Business degree, and the same proportion held a BA or BSc without mathematics. Just 6.3% held a B Ed with mathematics. The distribution of primary degree types was similar in initial schools and other schools (Table 4.2).

Table 4.2. Percentage of teachers who hold primary degrees of various types: Overall, and in initial and other schools

Degree Type	Overall	Initial Schools	Other Schools
B Comm or Business degree	13.0	19.1	12.7
B Eng	3.0	2.5	3.0
BA or BSc with mathematics	58.3	63.3	58.1
BA or BSc without mathematics	13.1	8.2	13.3
B Ed with mathematics	6.3	3.1	6.4
B Ed without mathematics	2.4	0.4	2.5
Other	3.9	3.5	3.9

The most common postgraduate qualification, held by 56.3% of teachers, was a Higher or Postgraduate Diploma in Education (H Dip/PGDE) that included a specific focus on mathematics education (Table 4.3). The percentage of teachers with this qualification was slightly lower in initial schools than other schools, though initial schools had a slightly higher percentage of teachers with a H Dip/PGDE without a specific focus on mathematics education (29.1% vs. 22.1%). Ten percent of teachers reported having no postgraduate qualification. Of these, 75.6% indicated that they had a primary degree which included mathematics for two years or more.

Table 4.3. Percentages of teachers with various postgraduate qualifications: Overall, and in initial and other schools

Postgraduate qualification	Overall	Initial Schools	Other Schools
No postgraduate qualification (includes B Ed)	10.3	7.3	10.7
Postgraduate degree related to mathematics (but not the teaching of mathematics)	4.7	6.4	4.7
Postgraduate degree related to the teaching of mathematics	5.2	8.7	5.1
Postgraduate degree unrelated to mathematics or the teaching of mathematics	11.2	10.8	11.4
Higher Diploma in Education/Postgraduate Diploma in Education *with* Mathematics	56.3	49.3	57.7
Higher Diploma in Education/Postgraduate Diploma in Education *without* Mathematics	22.0	29.1	22.1

Note. Teachers could hold more than one postgraduate qualification.

The manner in which teachers were asked about their qualifications does not allow us to make a direct comparison with Teaching Council guidelines. However, it is likely that 15.5% of mathematics teachers (i.e., those with a BA, BSc or B Ed *without* mathematics) would not meet the requirements[17]. No inferences can be made about a further 16.9% (i.e., those with a B Comm or Business degree, or 'other' primary degree), as the mathematical content of these degree types is unknown and may vary from institution to institution. The remaining 67.6% (i.e., those with a B Eng, or a BA, BSc or B Ed *with* mathematics) are likely to meet the criteria, though again this is impossible to determine definitively from the data. Therefore, our best estimate from the information available is that somewhere between 68% and 85% of mathematics teachers surveyed were qualified to teach mathematics according to Teaching Council guidelines.

Overall, 76.3% of mathematics teachers reported that they had studied mathematics teaching methods at some point in their preservice teacher preparation. Note that this percentage does not tally exactly with the information presented in Tables 4.2 and 4.3, as the former concern qualifications, while the latter concerns material studied. The percentage of teachers in initial schools who had studied mathematics teaching methods in their teacher preparation was just slightly lower (73.9%) than those in other schools (76.4%).

Teachers were asked whether or not they had worked in a profession prior to teaching, and three in ten indicated that they had. More teachers in vocational schools and community/comprehensive schools indicated that they had worked in another profession prior to teaching than in other school types. Slightly more teachers in DEIS (SSP) than in non-SSP schools, as well as in initial than in other schools, reported having worked in another profession prior to teaching (Table 4.4).

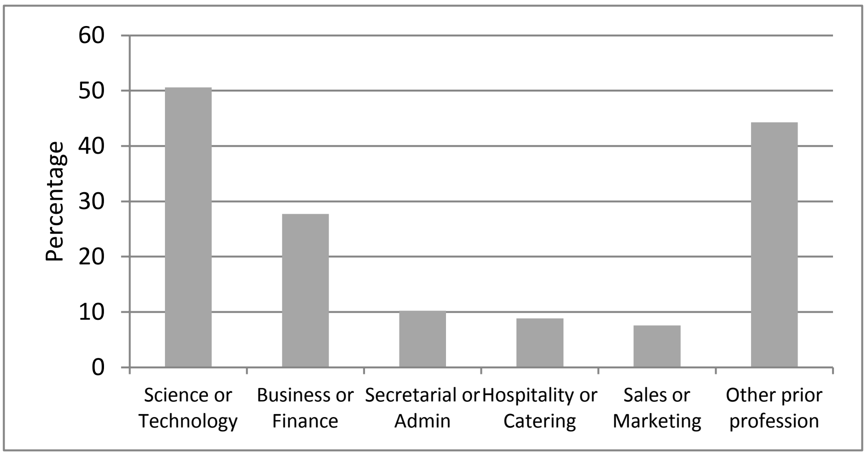
[17] It is not possible to be definitive about this, as some of this group may hold qualifications that feature substantive mathematics content, e.g., science.

Table 4.4. Percentage of mathematics teachers who worked in a profession in another field prior to teaching: Overall, and by school characteristics

	Yes	No
Overall	29.9	70.1
School Sector/Gender Composition		
Community/Comprehensive	35.0	65.0
Vocational	36.3	63.7
Boys' Secondary	25.8	74.2
Girls' Secondary	26.8	73.2
Mixed Secondary	24.3	75.7
DEIS		
No	28.4	71.6
Yes	35.3	64.7
Initial Project Maths School		
No	29.7	70.3
Yes	33.2	66.8

Of those teachers who had worked in another profession before teaching, the most frequently reported fields were science or technology (50.6%), business or finance (27.7%), and other (44.3%), with a sales or marketing background being least frequent (7.6%) (Figure 4.1). A little under a third of teachers who had worked in a different profession prior to teaching (29.4%) had done so for five years or more, nearly half (46.2%) had worked in another profession for two to four years, while about a quarter of this group (24.2%) had about a year's experience.

Figure 4.1. Teachers' professional backgrounds prior to teaching



Note. Teachers could select more than one prior profession. Percentages apply to the 29.9% of teachers who indicated that they had worked in a prior profession.

Teachers were asked to indicate how adequate they thought their qualifications were for preparing them to teach mathematics in post-primary schools. Table 4.5 shows overall levels of agreement/disagreement across five aspects of their qualifications (for all teachers, regardless of qualification type). In general, there was agreement that teachers' courses of study had prepared them to teach mathematics, with between 62% and 78% agreeing or strongly agreeing with the five aspects under consideration. 'Mathematical content' and 'General teaching methods/pedagogy' were the most strongly endorsed aspects (77-78% agreed or strongly agreed with these two) while the highest level of disagreement was in relation to 'Teaching methods/pedagogy of mathematics' and 'Assessment of mathematics' (33.5% disagreed or strongly disagreed with the former, and 37.6% with the latter).

Table 4.5. Perceived adequacy of qualifications for preparing mathematics teachers to teach mathematics in post-primary schools

Aspect of qualification	Strongly Disagree	Disagree	Agree	Strongly Agree
Mathematical content	5.2	17.8	46.5	30.5
Teaching methods/pedagogy of mathematics	6.6	26.9	44.9	21.6
Assessment of mathematics	6.6	31.0	45.1	17.3
General teaching methods/pedagogy	4.9	17.2	49.9	28.0
Assessment in general	5.2	21.5	50.0	23.3

4.2. Teaching Hours and Classes/Levels Taught

Teachers were asked how many hours per week they spent teaching mathematics to each year level as well as hours each week spent teaching all other subjects. On average, teachers reported teaching a total of 9.2 hours of mathematics a week, with 9.8 hours spent teaching other subjects (Table 4.6). Note that the average number of hours taught at each year level correspond to teaching hours, not class periods per week. These figures are similar to those reported in a recent survey of mathematics teachers (Uí Ríordáin & Hannigan, 2009). In the current study, approximately 52% of all teaching time per week was spent teaching mathematics. The percentage of teaching time spent teaching mathematics was slightly higher for teachers in initial schools (59.8%) than those in other schools (51.1%) with teachers in initial schools spending on average 10.5 hours per week teaching mathematics compared to 9.2 hours per week in other schools.

Table 4.6. Average hours spent teaching per week: Overall, and in initial and other schools

Year Levels*	All		Initial Schools		Other Schools	
	Mean	SD	Mean	SD	Mean	SD
First Year mathematics	2.87	0.71	2.95	0.68	2.87	0.71
Second Year mathematics	2.92	0.59	3.01	0.57	2.91	0.59
Third Year mathematics	3.00	0.60	3.06	0.70	2.99	0.59
Transition Year mathematics	2.33	0.70	2.37	0.73	2.33	0.70
Fifth Year mathematics	3.28	0.70	3.20	0.75	3.29	0.69
Sixth Year mathematics	3.40	0.70	3.37	0.63	3.40	0.71
Other levels/programmes e.g. Repeat LC or PLC - mathematics	2.44	0.85	2.35	0.67	2.45	0.86
Total hours teaching mathematics per week	9.2	5.2	10.5	5.1	9.2	5.2
Hours teaching all other subjects	9.8	6.4	8.1	6.5	9.9	6.4
Total hours teaching per week	18.9	4.5	18.6	4.0	18.9	4.6
Percentage of all teaching time spent teaching mathematics	51.5	29.3	59.8	30.3	51.1	29.2

*Teachers who indicated that they did not teach any hours at a given year level were excluded from the calculation of means and standard deviations for that year level. The total number of hours spent teaching mathematics is based on the sum of hours across year levels.

Table 4.7 shows the percentage of teachers teaching mathematics at junior cycle at each syllabus level. Note that percentages exceed 100% as teachers could teach more than one level. Most teachers indicated teaching Ordinary or Higher level, with a third of mathematics teachers teaching Foundation level. One in eight teachers (12.2%) did not teach junior cycle at the time of the survey. Proportions were very similar across initial and other schools.

Table 4.7. Percentages of teachers teaching Junior Cycle mathematics levels since 2009: Overall, and in initial and other schools

	All		Initial Schools		Other Schools	
Level	Yes	No	Yes	No	Yes	No
Foundation Level	30.6	69.4	27.3	72.7	30.7	69.3
Ordinary Level	76.2	23.8	76.9	23.1	76.1	23.9
Higher Level	70.1	29.9	69.1	30.9	70.1	29.9

Note: Teachers could select more than one level. 8.3% of respondents were missing data on this question.

4.3. Teaching and Classroom Activities

Teachers were asked to indicate how much emphasis they placed on various teaching and classroom activities in a typical week in teaching mathematics to Third Year students (Table 4.8). The response options were none, low, medium or high emphasis. About 42% of teachers were not teaching Third Years at the time of the survey, and these are excluded from the analysis. Overall highest emphasis was placed on whole class teaching activities (72.9% indicated placing high emphasis on this) followed by keeping order in the classroom (45.0%) and individual student learning activities (41.7%). Ten percent of teachers reported placing no emphasis on group learning activities.

Table 4.8. Percentages of teachers placing no, low, medium or high emphasis on various teaching/classroom activities in Third Year

Activity	None	Low	Medium	High
Whole class teaching activities	0.6	4.8	21.7	72.9
Individual student learning activities	1.7	17.9	38.7	41.7
Student group learning activities	10.0	41.4	34.4	14.1
Student assessment activities	1.2	11.0	49.9	37.9
Keeping order in the classroom (maintaining discipline)	7.2	25.8	22.0	45.0
Administrative tasks, e.g. recording attendance	1.5	48.7	21.2	28.6

Note. 7.6% to 8.2% of respondents were missing data on these items.

Table 4.9 shows levels of emphasis placed on various teaching and classroom activities in initial and other schools. Responses for the ‘none’ and ‘low’ categories have been collapsed into one category to make three: little to no emphasis, medium emphasis, and high emphasis. Teachers in both initial and other schools placed highest emphasis on whole class teaching. However, across other teaching/classroom activities, teachers in initial and other schools appeared to have slightly different profiles. More teachers in other than in initial Project Maths schools placed little to no emphasis on student group learning activities (52% vs. 44.5% respectively) and student assessment (12.2% vs. 5.9%).

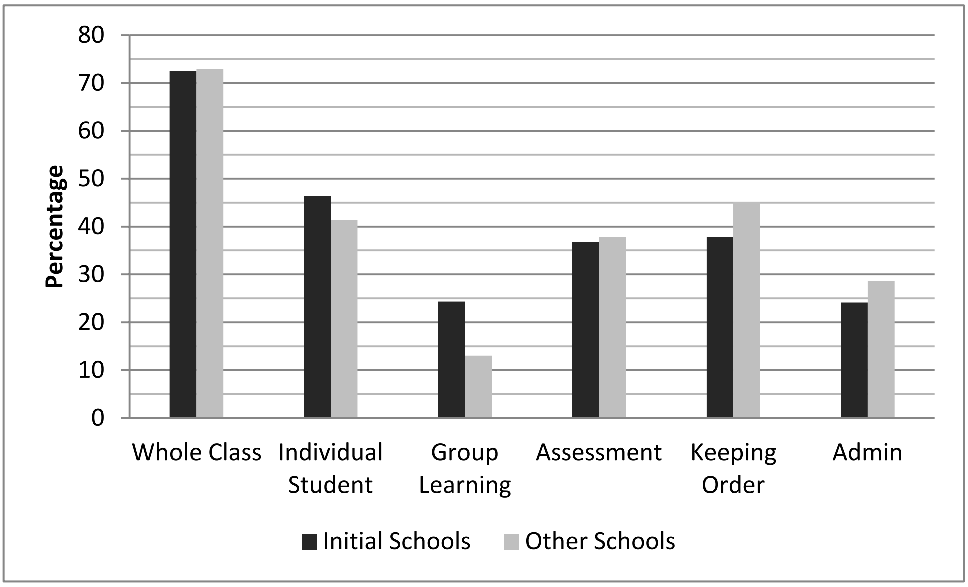
Table 4.9. Emphasis on each teaching/classroom activity in Third Year: Initial schools and other schools

Activity	Initial Schools			Other Schools		
	None/Low	Medium	High	None/Low	Medium	High
Whole class teaching activities	5.6	21.5	72.9	1.2	26.3	72.5
Individual student learning activities	19.9	38.7	41.4	18.2	35.6	46.3
Student group learning activities	52.0	35.0	13.0	44.5	31.2	24.3
Student assessment activities	12.2	49.9	37.8	5.9	57.3	36.8
Keeping order in the classroom	33.2	21.7	45.1	32.5	29.7	37.8
Administrative tasks, e.g. recording attendance	50.5	20.8	28.7	45.8	30.2	24.1

Note. 7.6% to 8.2% of respondents were missing data on these items.

Figure 4.2 shows teaching and classroom activities on which teachers placed high emphasis in initial and other schools. More teachers in initial schools than in other schools reported placing a high emphasis on individual student learning (a difference of 5%), and on group learning activities (a difference of 11.3%). Teachers in initial schools placed lower emphasis than teachers in other schools on keeping order in the classroom (a difference of 7.3%) and administrative tasks (a difference of 4.6%).

Figure 4.2. Percentages of teachers in initial schools and other schools who reported placing a *high* emphasis on various teaching and classroom activities when teaching mathematics to Third Year students



4.4. Ability Grouping for Mathematics Classes

Figure 4.3 shows the percentages of schools that group students by ability for their base classes[18] and mathematics classes for each year level. This information is based on responses from mathematics co-ordinators. Ability grouping for mathematics is the focus of this section; grouping for base classes is provided for comparative purposes. In First Year, the frequency of ability grouping is quite low, at 17.3% and 14.3% for base and mathematics classes respectively. Ability grouping for base classes increases in Second, Third, Fifth and Sixth Years, but remains at around 40% in all cases. In contrast, ability grouping for mathematics classes increases to 80.9% in Second Year and remains

[18] A 'base class' is usually identified for administrative purposes, e.g. recording attendance.

above 90% in Third, Fifth and Sixth Years. Ability grouping for mathematics is lower in Transition year (43.5%), but higher than ability grouping for base classes at this year level (13.6%).

Figure 4.3. Ability grouping for base and mathematics classes, by year level

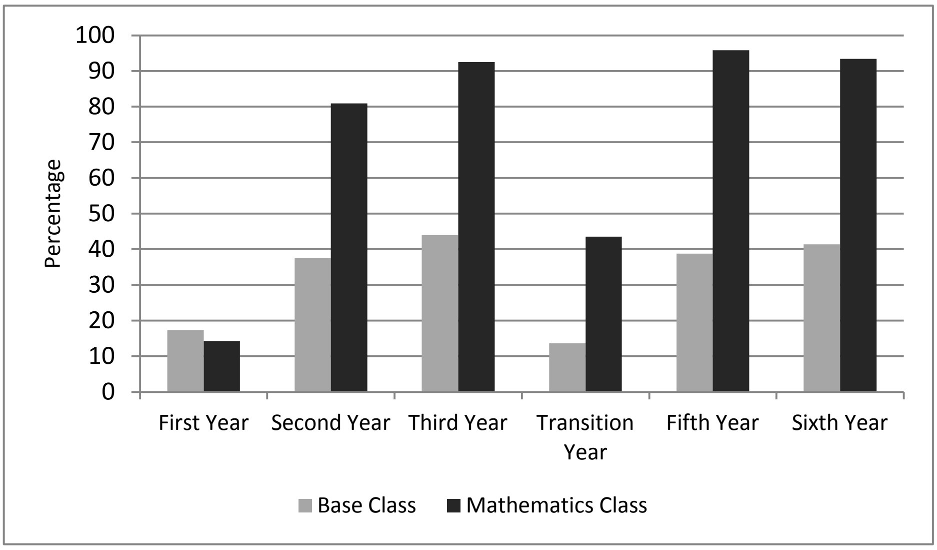


Table 4.10 shows the prevalence of ability grouping for mathematics classes, and for students' base classes, by the total enrolment size of the school.

Table 4.10. Prevalence of ability grouping for base classes and mathematics classes by school enrolment size: First to Sixth Year

Year level/Class	Very Small (300 or fewer)	Small (301-400)	Medium (401-600)	Large (601-800)	Very large (801 or more)
Base class	%	%	%	%	%
First year	28.1	14.1	15.2	10.6	20.5
Second year	50.2	35.5	39.4	27.4	28.7
Third year	62.4	37.0	49.8	28.3	28.7
Transition year	15.0	5.4	22.4	5.1	9.4
Fifth year	47.4	22.4	47.7	32.8	32.2
Sixth year	47.4	29.5	50.5	32.8	35.8
Mathematics class	%	%	%	%	%
First year	15.9	10.2	14.1	13.8	19.4
Second year	80.0	70.8	82.2	87.1	87.2
Third year	100.0	75.8	94.1	92.9	100.0
Transition year	23.3	38.8	50.3	53.6	44.6
Fifth year	100.0	88.7	93.3	100.0	100.0
Sixth year	79.6	95.5	96.5	100.0	100.0

Note. 0.5% to 6.2% of respondents were missing data on these items.

One might expect that the approach taken to grouping students into classes for instruction would be related to the enrolment size: in smaller schools, ability grouping into separate classes might be less prevalent, as there would be fewer students and hence fewer class groups at each year level. However, this is not generally the case, either for assignment to students' base classes, or to their mathematics classes. Across schools of all enrolment sizes, the prevalence of ability grouping for mathematics classes rises dramatically between First and Second Year, and remains high up to Sixth Year, with the exception of Transition Year. It should be noted that the pattern of grouping might be different in schools with extremely small enrolment sizes, i.e. for some of the schools in the 'Very Small' group in Table 4.10, but this is not examined in further detail here.

Table 4.11 shows the prevalence of ability grouping for base and mathematics classes across school characteristics (DEIS/SSP status, initial/other schools, and school sector/gender composition). Ability grouping of base classes appears to be consistently more common in DEIS than non-DEIS schools for all years, though especially in First Year (39.4% in DEIS and 8.0% in non-DEIS schools). However, this pattern appears to be reversed for mathematics, with ability grouping after First Year less prevalent in DEIS than non-DEIS schools. Initial schools were less likely to report ability grouping of base classes than other schools across all years. Differences between initial and other schools were not notable for mathematics ability grouping.

Patterns of ability grouping varied a little across school type. Base class ability grouping tended to be more prevalent than the overall averages across most years in boys' secondary schools. The opposite pattern was true for girls' secondary schools, where ability grouping of base classes tended to be less prevalent than the overall averages. Ability grouping for base classes differed between some school types by more than 30% from Third Year upwards. For example, prevalence of base class ability grouping in senior cycle ranged from 20.6% (girls' secondary schools) to 53.4% (mixed secondary schools). The range was smaller for mathematics class ability grouping which was very prevalent (over 85%) from Third Year upwards across all school types, with the exception of Transition Year for which there was a range of 26.2% to 54.5% across the school characteristics considered in Table 4.11.

Table 4.11. Prevalence of ability grouping for base classes and mathematics classes: Overall, and by DEIS status, pilot status, and school sector/gender composition

Year level/Class	All	Non - DEIS	DEIS	Initial	Other	Comm/ Comp	Vocat- ional	All boys sec	All girls sec	Mixed sec
Base class										
First year	17.3	8.0	39.4	9.5	17.5	24.6	16.0	25.7	13.7	10.7
Second year	37.6	31.3	52.3	28.6	37.9	37.4	40.2	45.7	25.4	38.6
Third year	43.9	36.7	60.9	33.3	44.3	37.4	49.4	53.9	25.4	49.9
Transition year	13.6	11.2	22.1	5.0	14.0	11.4	8.7	33.1	2.3	16.5
Fifth year	38.8	37.9	40.9	28.6	39.2	21.1	45.9	50.7	20.6	47.1
Sixth year	41.4	38.4	48.2	28.6	41.9	23.8	48.9	50.7	20.6	53.4
Mathematics class										
First year	14.3	8.5	28.5	9.5	14.4	22.2	10.1	21.2	14.3	10.0
Second year	80.9	83.5	74.6	85.7	80.8	89.2	70.1	84.1	83.7	88.1
Third year	92.5	96.3	83.0	95.2	92.4	91.7	86.0	92.3	96.7	100.0
Transition year	43.5	44.5	40.2	40.0	43.7	54.5	26.2	49.4	51.0	41.4
Fifth year	95.8	98.6	88.7	95.2	95.8	91.7	94.8	100.0	99.2	93.6
Sixth year	93.4	93.8	92.3	100.0	93.2	91.7	86.5	93.1	100.0	100.0

Note. 0.5% to 6.2% of respondents were missing data on these items.

Overall, the widespread prevalence of ability grouping for mathematics in Third, Fifth and Sixth Years regardless of various school characteristics suggests that this practice may be led by broad, system-level features, such as the structure of the syllabus and examinations, rather than school-level structures or policies.

4.5. Patterns of Mathematics Syllabus Uptake

Mathematics co-ordinators were asked to estimate the percentage of students in their schools studying mathematics at each syllabus level during the 2011-2012 school year. Table 4.12 shows a steady decrease in the number of students studying Higher level mathematics from 51.2% in Second Year to 20.3% in Sixth Year, while the percentages taking Ordinary/Foundation level mathematics increases from 35.5% in Second Year to 75.6% by Sixth Year. Of note is the drop in the percentage of students studying mathematics in senior cycle, from 31.9% to 20.3%, implying that about a third of students who begin senior cycle studying mathematics at Higher level end up taking Ordinary or Foundation level. First Years tend to study mathematics at Common level (in line with the implementation of the Common Introductory Course), though 10.6% were reported to be taking Higher level and 5% taking Ordinary/Foundation level.

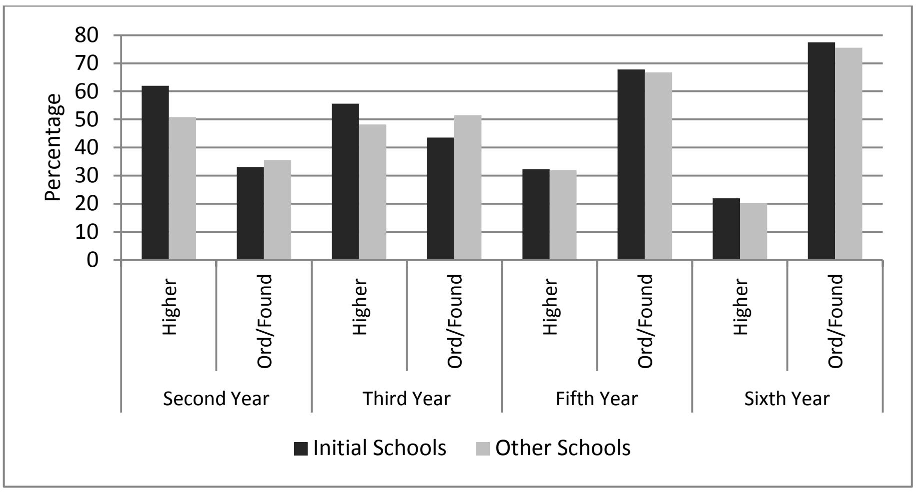
Table 4.12. Percentages of students studying mathematics at each syllabus level, by year level (mathematics school co-ordinators' estimates)

Year/Syllabus level	Higher		Ordinary/Foundation		Common	
	Mean	SD	Mean	SD	Mean	SD
First year	10.6	26.8	5.0	15.3	84.4	36.2
Second year	51.2	29.1	35.5	25.3	12.8	33.1
Third year	48.5	20.8	51.3	20.8	0.2	1.3
Fifth year	31.9	15.6	66.7	15.4	1.4	5.7
Sixth year	20.3	15.3	75.6	18.2	4.1	15.7

Note. 4.7% to 10.5% of respondents were missing data on these items.

As noted in Chapter 1, one objective of Project Maths is to increase uptake of Higher level mathematics for both the Junior and Leaving Certificates. Patterns of syllabus level uptake in initial and other schools (again as estimated by mathematics school co-ordinators) are shown in Figure 4.4.

Figure 4.4. Percentages of students studying mathematics at each syllabus level by year level (mathematics school co-ordinators' estimates): Initial schools and other schools

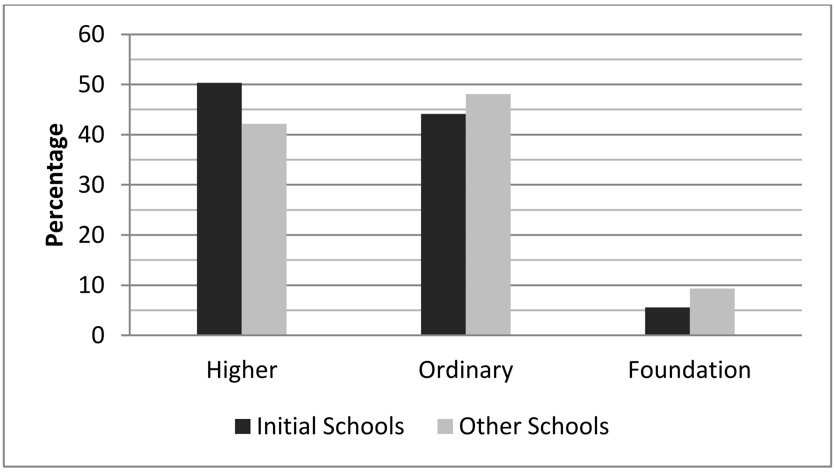


Note. The difference is statistically significant for Higher level uptake in Second Year.

For clarity, the graph only displays Higher and Ordinary/Foundation levels (i.e. excludes common level). First Year is also excluded. A general pattern of slightly more frequent Higher level and slightly lower Ordinary/Foundation level uptake in initial schools than other schools emerges. Though differences are slight in most years, the pattern is more pronounced in Second and Third Years. The only statistically significant difference in Higher-level uptake is at Second Year level.

Figure 4.5 shows the percentage of students who *actually took* the Junior Certificate mathematics examination in 2011 at each syllabus level, for initial and other schools (as estimated by school co-ordinators). Fewer than 1% did not sit the examinations and for clarity these are not included on the graph. In initial schools, a significantly higher proportion of students sat the Junior Certificate mathematics examination at Higher level than in other schools. Though the differences were not statistically significant for the other syllabus levels, it can be noted that marginally fewer students in initial schools sat the examinations at Ordinary and particularly Foundation level. The data in Figure 4.5 are comparable to those for the 2011 Junior Certificate mathematics examination overall, in which 46% sat Higher level, 47% sat Ordinary level, and 7% took Foundation level (www.examinations.ie).

Figure 4.5. Percentages of students who took the Junior Certificate mathematics examination in 2011 at each syllabus level (mathematics school co-ordinators' estimates): Initial schools and other schools



Note. The difference is statistically significant for Higher level uptake.

4.6. Continuing Professional Development (CPD)

Teachers were asked to indicate the number of hours of continuing professional development (CPD) relating to mathematics in which they had engaged, how much of this was outside school time, and what obstacles they had encountered in attending CPD related to mathematics education. When answering this question, teachers were advised that CPD was intended to cover both formal and informal activities. It should also be noted that the model of support for initial schools is much different to other schools, with workshops delivered in a shorter space of time, and in-school support available from a designated RDO. On average, mathematics teachers reported spending 45.2 hours (SD = 25.9) engaging in CPD in the last three years[19]. Thirteen percent had attended less than 16 hours of CPD, 68.3% had attended between 16 and 64 hours and the remaining 17.9% had attended over 64 hours.

[19] The hours of CPD discussed in this section should be treated as broad estimates, since they are values that were recoded from the original response categories as follows: None=0; 1-8=4; 9-16=12; 17-24=20; 25+=28.

Table 4.13 shows the average number of hours of participation in different kinds of CPD in the last three years for all mathematics teachers, as well as the averages for teachers in initial and other schools. Overall, the highest levels of participation were for formal CPD on Project Maths (20.2 hours) and self-directed CPD (study of Project Maths materials; books or journals on mathematics education etc.) (14.2 hours). The least time was spent on formal courses designed to address a gap in qualifications to teach mathematics (1.5 hours), formal postgraduate study that included mathematics or mathematics education (1.6 hours) and formal CPD relating to the Junior Certificate mathematics syllabus (other than Project Maths) (1.8 hours).

Table 4.13. Hours of CPD participation in the last three years: Overall, and in initial schools and other schools

Type of CPD	All			Initial Schools			Other Schools		
	Mean	SE	SD	Mean	SE	SD	Mean	SE	SD
Formal CPD on Project Maths	20.2	0.34	9.6	21.9	0.74	9.6	20.1	0.35	9.6
Formal CPD on the Junior Certificate mathematics syllabus other than Project Maths	1.8	0.18	5.2	1.9	0.34	4.8	1.8	0.19	5.2
A formal CPD course designed to address a gap in your qualifications to teach mathematics	1.5	0.19	5.7	2.9	0.56	7.9	1.4	0.20	5.6
In-school professional development activities relating to mathematics	3.0	0.23	5.7	7.2	1.41	9.1	2.8	0.23	5.4
Self-directed CPD, e.g. study of Project Maths materials; of books or journals on mathematics education	14.2	0.34	11.4	18.2	1.74	11.5	14.1	0.34	11.4
External meetings relating to mathematics, e.g. the Irish Maths Teachers Association	2.9	0.23	5.9	3.7	0.65	6.3	2.9	0.24	5.9
Formal postgraduate study that included mathematics or mathematics education (e.g., M.A., M.Ed.)	1.6	0.19	6.3	2.1	1.62	7.4	1.6	0.19	6.3
Total CPD Hours	45.2	0.87	25.9	57.9	4.92	29.4	44.7	0.87	25.6

Note. Grey shading indicates a statistically significant difference ($p < .05$).

There were some significant differences[20] between teachers in initial and other schools in the average number of CPD hours undertaken during the three years preceding the survey. Teachers in the initial schools spent slightly more time than teachers in the other schools attending formal CPD on Project Maths (21.9 vs. 20.1 hours), formal CPD courses designed to address a gap in qualifications (2.9 vs. 1.4 hours) and self-directed CPD (18.2 vs. 14.1 hours). The largest differences observed between initial-school and other-school teachers were in the amount of in-school professional development activities relating to mathematics (7.2 vs. 2.8 hours) and the total number of CPD hours (57.9 vs. 44.7), with teachers in initial schools engaging in more hours than their counterparts in other schools for both categories. This may reflect the more widespread provision in and encouragement of CPD in schools in which Project Maths was introduced earlier.

[20] Formal tests of significance are carried out on group mean differences, but not on group percentages, in this report.

Teachers also indicated whether they had participated in CPD during or outside of school time. Responses were quite varied: 19.3% indicated that none of their CPD had taken place outside of school time; 29.4% indicated that a minority was outside of school time; while about a quarter (25.2%) indicated that about half of CPD was outside of school time; a similar percentage indicated that all or a majority occurred outside of school time. There were no substantial differences between teachers in initial schools and other schools in response to this question. It may be recalled from Chapter 2 that CPD for Project Maths occurred both during and outside of school hours.

Teachers were asked to indicate, which obstacle(s), if any, prevented them from participating in mathematics-related CPD (see Table 4.14). The most frequent reasons cited were a lack of time, both outside of school hours (45.9%) and during school hours (24.2%). Other obstacles included location of courses (18.4%), not being informed of courses (16.7%), lack of availability of courses (16.5%), lack of incentive (financial or otherwise) (14.3%) and lack of personal resources to pay for CPD (13.4%). The least frequently indicated obstacle was lack of school resources to pay for CPD (5.6%). Approximately a third of teachers (31.6%) indicated that nothing had prevented them taking part in CPD[21].

Teachers in the initial and other schools identified broadly similar obstacles to CPD attendance that they indicated, as shown in Table 4.14. Teachers in initial schools, however, were less likely (a difference of 5% or more) to indicate that not being informed of courses and a lack of time outside of school hours had affected their participation in CPD attendance, and more likely than teachers in other schools to indicate that location of courses had prevented CPD participation.

Table 4.14. Percentage of teachers indicating factors that prevented participation in CPD related to mathematics education: Overall, and in initial schools and other schools

Factor	Overall	Initial Schools	Other Schools
Lack of availability of courses	16.5	15.5	16.6
Not being informed of courses	16.7	10.8	16.9
Location of courses	18.4	23.6	18.2
Lack of time during school hours	24.2	28.3	24.0
Lack of time outside of school hours	45.9	40.5	46.2
Lack of incentive (financial or otherwise)	14.3	15.3	14.3
Lack of school resources to pay for CPD	5.6	9.5	5.5
Lack of personal resources to pay for CPD	13.4	15.8	13.3
None of the above (nothing prevented me)	31.6	33.3	31.5

Note. Teachers could select more than one obstacle to CPD attendance.

[21] In interpreting these results, it should be noted that teachers are assigned to workshops in one of the 21 education centres, each of which is associated with a cluster of schools. Also, for national roll-out workshops, an invitation for all named teachers with dates and venues is sent by the PMDT to the principal along with a request to update the database if teachers have changed. A general notice is also on www.projectmaths.ie and emailed to the 4,200 teachers who have signed up for the e-newlsetter. For modular courses, education centres contact local schools and run the course on demand (DES, personal communication, October 2012).

4.7. Key Findings and Conclusions

Based on a broad comparison between teachers' responses and Teaching Council guidelines, we estimate that two-thirds to five-sixths of the mathematics teachers who took part in our survey are qualified to teach their subject. These figures suggest that teachers who took part in the present study were better-qualified to teach mathematics than those who took part in the UL survey (Uí Ríordáin & Hannigan, 2009), in which 48% were described as not having a mathematics teaching qualification. However, the manner in which teachers were asked about their qualifications, as well as the sampling, differed somewhat across the two studies. The profile of teacher qualifications presented in this chapter is closer to a more recent survey conducted by the Teaching Council. On the basis of responses of about 3,300 teachers in 420 schools, this more recent survey found that two-thirds were fully qualified to teach mathematics, about three in ten had undergone some studies in mathematics, and only 2.5% had no third level qualifications/studies in mathematics (DES press release, September 29, 2011).

In addition to teachers who may not hold required qualifications, a further, unknown percentage of teachers are likely to benefit from the opportunity to upskill their existing qualifications. It is noteworthy that a sizeable minority of teachers in our study felt that their qualifications were inadequate in helping them to prepare for teaching mathematics, particularly in the areas of assessment and teaching methods. Hence, the new Postgraduate Diploma, available from the autumn of 2012 and running each year for three years, is unlikely to be adequate on its own in addressing teachers' professional needs. Continued, concentrated efforts will be required to provide appropriate, accessible CPD and support to mathematics teachers in the medium to long term.

About three in 10 mathematics teachers had worked in a field other than teaching prior to entering the teaching profession, many of them in the science and technology and/or business and finance sectors. These are likely to have valuable and relevant prior experience that could be brought to bear on their work as teachers, and some may already be doing this. Also, the fact that 30% of mathematics teachers worked in another profession prior to teaching suggests that it is possible to attract individuals with a diversity of skills and experience into the teaching profession.

Teachers on average reported spending about nine hours per week, or just over half of their teaching hours, teaching mathematics. Teachers in initial schools spent proportionately more of their total teaching time on mathematics than teachers in other schools (10.5 vs. 9.2 hours per week). It should be noted that these figures reflect teaching hours rather than hours of instruction received by students. However, results from the PISA 2012 student questionnaire will include information on the amount of mathematics instruction received by students. These results will be available from December 2013, and it is planned to analyse them with reference to how they vary across school types and student characteristics, including year level.

Ability grouping ('streaming'/'setting') for mathematics class is very common. Our results suggest that it is occurring in over 90% of schools in Third, Fifth and Sixth Years. Although there is some variation across schools in the extent to which students are grouped into different classes by ability for mathematics instruction, the overall picture points to an issue that is structural or systemic. We also found that there is a steady decrease in the percentages of students studying Higher Level mathematics, from almost half (48.5%) in Third Year, to just 20% in Sixth Year. This sharp decline underlines the need for further encouragement of students to take Higher Level mathematics in senior cycle. Furthermore, the finding that there was a drop in numbers taking Higher Level, from about 32% in Fifth Year to 20% in Sixth Year, indicates that somewhere in the region of one-third of the students who initially study Higher Level mathematics in senior cycle end up taking Ordinary or Foundation level. The PISA results for mathematics (described in Chapter 1) also suggest a need to further challenge higher achievers, and to motivate and support students more in achieving their full potential in mathematics.

Teachers in our study reported placing a high emphasis on whole class and individual work during mathematics class with their Third Years. However, almost twice as many teachers in initial schools (24%) compared with other schools (13%) reported that they placed a high emphasis on engaging students in group learning activities during mathematics class, which can be regarded as a positive finding.

Finally, teachers reported having participated in an average of 45 hours of CPD, both formal and informal, over the past three years. The majority of CPD was on Project Maths, or self-directed in nature. It is likely that the information concerning CPD presented in this chapter, together with some of the results presented in Chapters 5 and 6, will be of relevance to future planning and delivery of CPD related to Project Maths.

5. Teaching and Learning Mathematics: Teachers' Views and Practices

5.1. General Views on the Teaching and Learning of Mathematics

The teacher questionnaire included a set of 12 statements on the nature of mathematics and the teaching and learning of mathematics. Teachers indicated their level of agreement/disagreement with each, and their responses are shown in Table 5.1 (on six items that indicate support for a more 'fixed' view of mathematics) and Table 5.2 (on six items that indicate support for a constructivist/applied view of mathematics).

A majority of teachers (88.0%) agreed or strongly agreed that some students have a natural talent for mathematics, while others do not, and that an effective approach for students who are having difficulty is to give them more practice by themselves in class (57.3%). In contrast, two-thirds of teachers disagreed or strongly disagreed that mathematics is a difficult subject for most students, while over 80% disagreed/strongly disagreed that mathematics is primarily an abstract subject, and that learning mathematics mainly involves memorising.

Table 5.1. Teachers' levels of agreement/disagreement with six statements indicating a fixed view of mathematics and the teaching and learning of mathematics (all teachers)

Statement	Strongly disagree	Disagree	Agree	Strongly agree
Some students have a natural talent for mathematics and others do not	2.1	9.9	67.3	20.8
If students are having difficulty, an effective approach is to give them more practice by themselves during the class	5.8	36.9	51.6	5.7
Mathematics is a difficult subject for most students	6.4	60.6	28.4	4.6
Few new discoveries in mathematics are being made	12.8	54.8	30.1	2.3
Mathematics is primarily an abstract subject	19.5	61.7	17.1	1.7
Learning mathematics mainly involves memorising	30.6	59.5	8.5	1.4

Table 5.2 shows that in general, a large majority of teachers agreed or strongly agreed with the six statements indicative of a constructivist or applied view of mathematics. In fact, 80% or more of teachers agreed or strongly agreed with all six statements, and this exceeded 95% for the first two (i.e., that there are different ways to solve most mathematical problems, and that more than one representation should be used in teaching a mathematics topic).

There are few differences in the response patterns of teachers in initial schools and other schools on the items assessing fixed views of mathematics, with one exception: teachers in initial schools were more inclined to disagree or strongly disagree that an effective approach for students with difficulties is to give them more practice by themselves (54.9%), compared to teachers in other schools (42.2%).

Responses of teachers in initial and other schools were also similar for the six items assessing constructivist/applied views of mathematics. However, teachers in initial schools were more inclined to disagree or strongly disagree that there are different ways to solve most mathematical problems (12.3%) than teachers in other schools (3.0%); they were also more likely to disagree or strongly disagree that to be good at mathematics at school, it is important for students to understand how mathematics is used in the real world (24.8% vs. 15.4%). These two differences are counter-intuitive:

one might expect teachers in initial schools to be somewhat more positively disposed towards a constructivist approach to the teaching and learning of mathematics (such an approach underpins Project Maths).

Table 5.2. Teachers' levels of agreement/disagreement with six statements indicating support for a constructivist or applied view of mathematics and the teaching and learning of mathematics (all teachers)

Statement	Strongly disagree	Disagree	Agree	Strongly agree
There are different ways to solve most mathematical problems	0.8	2.5	58.3	38.3
More than one representation (picture, concrete material, symbols, etc.) should be used in teaching a mathematics topic	0.9	2.6	49.9	46.6
Solving mathematics problems often involves hypothesising, estimating, testing and modifying findings	1.0	10.8	66.2	22.1
Modelling real-world problems is essential to teaching mathematics	0.5	11.7	63.1	24.6
To be good at mathematics at school, it is important for students to understand how mathematics is used in the real world	1.1	14.8	54.6	29.6
A good understanding of mathematics is important for learning in other subject areas	0.7	19.3	65.8	14.1

The items shown in Tables 5.1 and 5.2 were used to form two scales, each of which have an overall mean of 0 and standard deviation of 1[22]. The first scale can be interpreted as a measure of *fixed views of mathematics*, while the second is an indicator of *constructivist/applied views of mathematics*. Means on these scales did not differ significantly between teachers in initial schools and other schools; nor did they differ by DEIS status, school sector/gender composition, or teacher gender. In all cases, differences between sub-groups were less than 0.15 scale points (about one-seventh of a standard deviation).

5.2. Sources Used in Establishing Teaching Practices

Teachers were asked to rate the extent to which a range of sources influenced their decisions about the teaching practices that they use in mathematics lessons. Responses are shown in Table 5.3. A majority of teachers used sample/past examination papers and syllabus documents a lot (71.5% and 62.8%, respectively), while close to half of teachers made 'a lot' of reference to students' needs and interests and to textbooks (47.9% and 46.3%, respectively). Only three in 10 teachers (30.7%) reported drawing on CPD a lot, while 26.5% reported that they derived their teaching practices from or with other teachers in their school a lot. Use of the remaining resources was less common: in particular, 45.1% of teachers never used information on teaching practices in other countries. This pattern of results suggests that more 'traditional' sources of information (e.g. examination papers) are used more widely than more novel ones (such as information gained in CPD, or from books and journals).

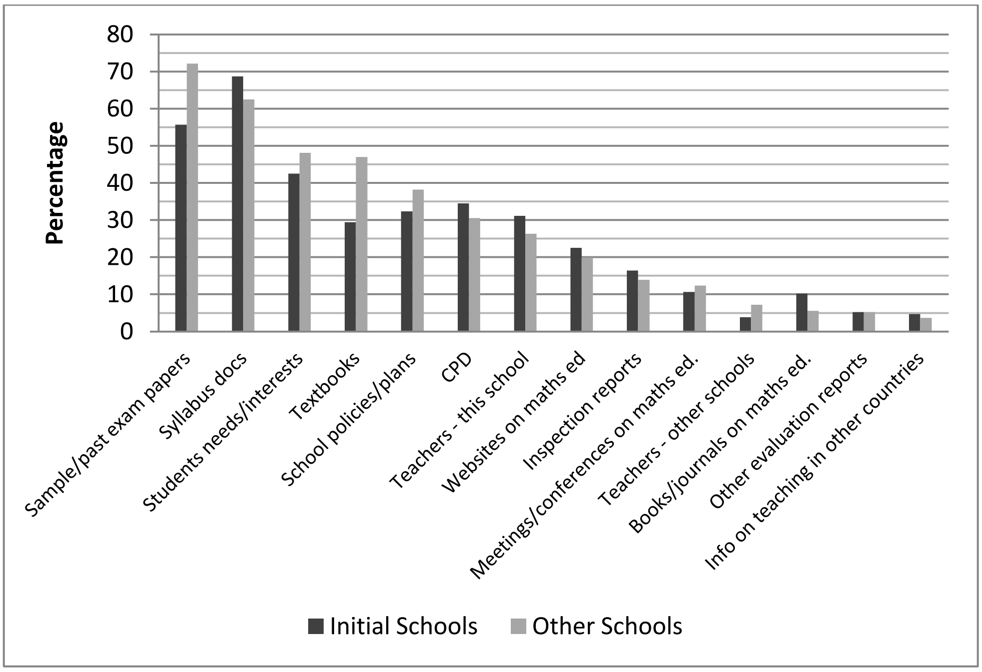
[22] The items are grouped in the manner shown in Tables 5.1 and 5.2 following the results of a principal components analysis. This technique shows how items 'cluster' together in terms of the response patterns. If items cluster together, it can be inferred that they are measuring a common underlying construct. Note, however, that these are not necessarily the best items for measuring views on mathematics; alternatively-worded questions may have provided a better measure. In particular, the scale indicating fixed views of mathematics has a low reliability of .42, so results should be interpreted with caution. See the Technical Appendix for information on how the scales were constructed.

Table 5.3. Extent to which teachers use various sources to influence decisions about teaching practices in mathematics lessons (all teachers)

Source	Not at all	A little	To some extent	A lot
Sample or past examination papers	0.3	3.7	24.5	71.5
Syllabus documents	1.8	10.0	25.5	62.8
Students' needs and interests	0.9	11.4	39.8	47.9
Textbooks	1.1	9.1	43.5	46.3
In-school policies and plans	3.7	17.2	41.2	37.9
Continuing Professional Development	2.9	17.3	49.1	30.7
Other teachers in this school	4.2	20.2	49.1	26.5
Websites on mathematics education	7.7	30.1	42.3	20.0
Inspection reports on teaching mathematics	11.8	32.0	42.1	14.0
Meetings/conferences on mathematics education	21.6	34.9	31.2	12.3
Teachers in other schools	31.4	37.2	24.4	7.0
Books and journals on mathematics education	29.8	41.2	23.2	5.8
Other evaluation reports	22.0	39.2	33.6	5.2
Information about teaching practices in other countries	45.1	38.0	13.1	3.8

Figure 5.1 shows the percentages of teachers in initial and other schools who reported using each of the sources listed in Table 5.3 a lot. Some differences are apparent. Teachers in other schools reported making more use of sample or past examination papers and textbooks, and, to a lesser extent, of in-school policies or plans and students' interests, compared to teachers in initial schools. On the other hand, teachers in initial schools reported slightly higher use of syllabus documents, other teachers in their school, books and journals on mathematics education, and CPD, than teachers in other schools.

Figure 5.1. Percentages of teachers in initial schools and other schools indicating that they used various sources 'a lot' when making decisions about teaching practices in their mathematics classes



5.3. Use of ICTs in the Teaching and Learning of Mathematics

Table 5.4 shows the frequency with which teachers reported using six ICT resources during their mathematics classes. Note that although 'data projector' did not explicitly refer to an interactive whiteboard, it would be reasonable to assume that many teachers would have included use of an interactive whiteboard under this category. The most commonly-used resources were a PC/laptop and a data projector, with 60% or more of teachers using these at least once a week. Spreadsheet packages were used much less frequently (48.9% of teachers never used these), and use of Internet sites, general and mathematics-specific software was intermediate.

Table 5.4. Teachers' use of ICT resources during mathematics classes

ICT Resource	Hardly ever/never	About once a term	About once a month	At least once a week
PC or laptop	12.4	8.2	17.1	62.3
Data projector	15.4	8.5	16.1	60.0
Internet sites	16.7	15.1	28.5	39.7
General software (e.g. PowerPoint, Word)	26.4	15.0	21.4	37.2
Mathematics-specific software (e.g. Geometer's Sketchpad, Geogebra, Logo)	25.3	21.4	28.3	25.0
Spreadsheets (e.g. Excel)	48.9	24.5	19.1	7.5

Just over 5% of teachers reported using all six resources at least once a week, and a further 24.5% of teachers reported using four or five of them with this frequency. These 29.7% of teachers may be regarded as *high users of ICT* during mathematics classes. At the other extreme, 6.0% of teachers indicated that they never or hardly ever used any of the resources shown in Table 5.4. A further 7.3% hardly ever or never used four or five of these resources, and these 13.3% may be regarded as *low users of ICT* during mathematics classes. Other teachers were categorised as medium ICT users.

There are substantial differences between the usage of ICTs by teachers in initial schools and other schools (Figure 5.2): 49.5% of teachers in initial schools were high users of ICTs, compared with 28.9% of teachers in other schools. Teachers in initial schools were more likely to report using each form of ICT at least once a week. In particular, teachers in initial schools were more likely to report using mathematics-specific software at least once a week than teachers in other schools (42.5% vs. 24.2%); they were more likely to report using general software at least once a week (50.3% vs. 36.7%). Use of spreadsheets was quite low in both groups, however (Figure 5.3).

Figure 5.2. Percentages of low, medium and high users of ICTs during mathematics classes: Teachers in initial schools and other schools

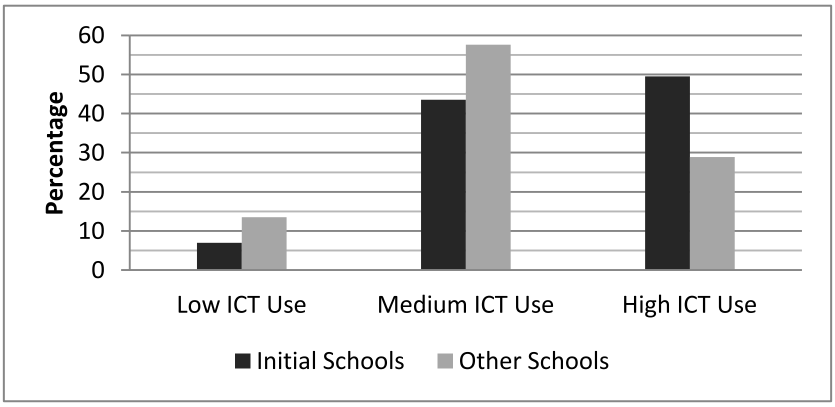
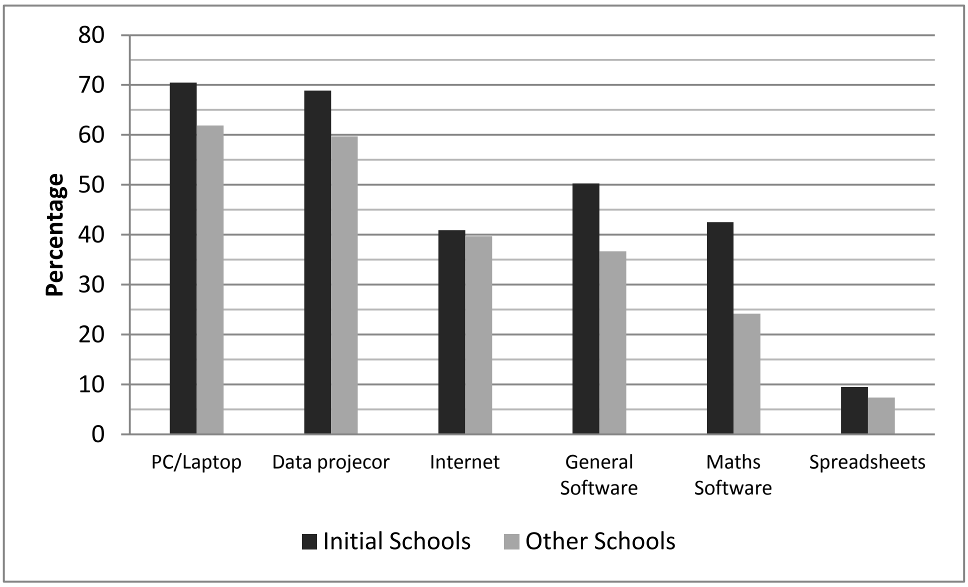


Figure 5.3. Percentages of teachers in initial schools and other schools who report using various ICTs at least once a week during mathematics classes



5.4. Ability Grouping for Mathematics

5.4.1. Teachers' Views on Ability Grouping

Teachers were asked about the extent to which they agreed or disagreed with 12 statements concerning ability grouping for mathematics classes at junior cycle level. When answering these questions, teachers were provided with the following definition:

<u>Class-based ability grouping</u> refers to the allocation of students of differing ability levels to different class groups for mathematics. This may be done on the basis of a standardised test, base class, or some other means, and generally reflects school policy.

Their responses are shown in Table 5.5 (on eight items that indicate an endorsement of ability grouping into different class groups) and Table 5.6 (on four items that suggest that ability grouping can have negative effects on some students). Note that we did not ask questions about the timing of class formation, i.e. when ability groupings are made.

There were very high rates of agreement with four of the statements in Table 5.5 (with over 75% of teachers agreeing or strongly agreeing). These were:

- 'Allocating students to mathematics classes based on some measure of academic ability is, overall, a good practice'
- 'Class-based ability grouping for mathematics facilitates a more focused teaching approach'
- 'Class-based ability grouping for mathematics accelerates the pace of learning for all students', and
- 'The best way to teach the mathematics curriculum effectively is in class-based ability grouped settings'.

Consistent with this, there was somewhat less widespread agreement with the statement 'Mixed-ability teaching in mathematics 'drags down' the performance of higher achievers' (64.0% agreed or strongly agreed). There were also mixed views on the statement that 'Mixed-ability teaching in mathematics is beneficial to lower-achieving students' (46.5% agreed or strongly agreed). A minority of teachers agreed with the remaining two statements: 'It is possible to teach the mathematics curriculum in mixed-ability settings without compromising on the quality of learning' (30.4%) and a negatively worded statement, 'Class-based ability grouping is not particularly beneficial for teaching and learning mathematics' (11.9%).

Table 5.5. Teachers' levels of agreement/disagreement with eight statements indicating support for ability grouping in the teaching and learning of mathematics at junior cycle level

Statement	Strongly disagree	Disagree	Agree	Strongly agree
Allocating students to mathematics classes based on some measure of academic ability is, overall, a good practice	0.4	4.6	56.2	38.8
Class-based ability grouping for mathematics facilitates a more focused teaching approach	0.6	5.1	58.1	36.1
Class-based ability grouping for mathematics accelerates the pace of learning for all students	1.2	21.6	53.8	23.4
Class-based ability grouping is not particularly beneficial for teaching and learning mathematics*	28.1	60.1	10.0	1.9
Mixed-ability teaching in mathematics is beneficial to lower-achieving students	10.7	42.9	41.1	5.4
Mixed-ability teaching in mathematics 'drags down' the performance of higher achievers	4.1	31.9	48.4	15.6
It is possible to teach the mathematics curriculum in mixed-ability settings without compromising on the quality of learning	18.0	51.7	27.9	2.5
The best way to teach the mathematics curriculum effectively is in class-based ability grouped settings	2.0	14.7	55.2	28.2

*This statement is negatively worded, meaning that higher agreement is indicative of lower endorsement of ability grouping.

Table 5.6 indicates that 55.5% of teachers agreed or strongly agreed that ability grouping can have a negative impact on some students' self-esteem, which indicates that there is awareness that, despite widespread support for ability grouping in general (previous table), it can be damaging in some specific respects. About two-fifths of teachers (38.7%) agreed or strongly agreed that ability grouping was more beneficial for higher achievers than for lower achievers, which again indicates some awareness of the potential differential effectiveness of this practice. About three in ten teachers agreed with the remaining two statements in Table 5.6 ('Class-based ability grouping for mathematics slows the pace of learning of lower-achieving students' - 28.2%; and 'Class-based ability grouping results in lower expectations by teachers of the mathematical abilities of lower-achieving students'- 31.2%).

Table 5.6. Teachers' levels of agreement/disagreement with four statements indicating an awareness of the negative effects of ability grouping on some students in the teaching and learning of mathematics at junior cycle level

Statement	Strongly disagree	Disagree	Agree	Strongly agree
Class-based ability grouping for mathematics has a negative impact on some students' self-esteem	5.5	39.0	47.8	7.7
Class-based ability grouping for mathematics slows the pace of learning of lower-achieving students	12.3	59.5	24.4	3.8
Class-based ability grouping results in lower expectations by teachers of the mathematical abilities of lower-achieving students	14.0	54.8	26.6	4.6
Class-based ability grouping for mathematics benefits higher-achieving students more than lower-achieving students	11.3	49.9	25.8	12.9

These response patterns suggest that, although a vast majority of teachers support ability grouping in mathematics *in general* (e.g. with 95.0% agreement with the first statement in Table 5.5), there is less widespread consensus on the practice of ability grouping with respect to effects for *specific groups,* i.e. low and high achievers.

It should be borne in mind that these questions asked about teachers' views on ability grouping for mathematics in a general sense; their views may vary depending on the year level or topic being taught. Also, we did not ask teachers for their views on the relationship they may perceive between the structure of the mathematics syllabus and examinations on the one hand, and the need to group students by ability for mathematics on the other.

The items shown in Tables 5.5 and 5.6 were used to form two scales, each of which has an overall mean of 0 and standard deviation of 1[23]. The first scale can be interpreted as *support for ability grouping*, while the second is a measure of *awareness of the potential negative effects of ability grouping*, particularly with respect to low achievers.

Means on these scales did not differ between teachers in initial and other schools; nor did they differ by DEIS status or school sector/gender composition. However, female teachers had a significantly higher mean score (0.06) than male teachers (-0.11) on the scale measuring support for ability grouping. Female teachers also had a significantly lower mean score (-0.06) than male teachers (0.10) on the scale measuring awareness of the potential negative effects of ability grouping[24].

5.4.2. Views on Ability Grouping and Schools' Practices on Ability Grouping

In Chapter 4 (Section 4.4), we described the extent to which classes were grouped by ability for mathematics in the schools that participated in PISA 2012. Ability grouping for mathematics is very common after First Year: for example, 81% of mathematics co-ordinators reported that mathematics classes for Second Years were grouped by ability, and this rose to 93% in Third Year.

Table 5.7 compares the means on the two scales indicating *support for ability grouping* and *awareness of the potential negative effects of ability grouping* for teachers in schools which do and do not group students by ability for mathematics at each year level. Mean scores on the *support for ability grouping* scale tend to be lower for teachers in schools where mathematics classes are *not* grouped by ability, and this is statistically significant with respect to Second, Third and Transition Years. The differences at Fifth and Sixth Year levels are not significant. This arises because the standard errors at these class levels are large, mainly due to the small numbers of schools that do not practise ability grouping at these year levels.

Mean scores on the *awareness of potential negatives of ability grouping* scale are higher for teachers in schools where ability grouping for mathematics is *not* practiced. This is significant only at Second and Transition Year levels, however, again due to large standard errors.

Overall, these results suggest that school-level policy and practice on ability grouping may influence teachers' own views on ability grouping.

[23] The fourth item in Table 5.5 was reverse coded for this analysis. See the Technical Appendix for information on how the scales were constructed.

[24] In both cases, $p < .05$ but $> .01$. For details on how comparisons of means were made, see the Technical Appendix.

Table 5.7. Scale means (support for ability grouping and potential negatives of ability grouping) of teachers in schools that group and do not group students by ability for mathematics, First to Sixth Years

Year level	% of teachers in schools with grouping	Support for ability grouping				Potential negatives of ability grouping			
		Maths grouped		Maths not grouped		Maths grouped		Maths not grouped	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
First year	14.8	0.133	0.095	-0.024	0.039	-0.080	0.073	0.027	0.040
Second year	83.5	0.054	0.036	-0.286	0.092	-0.016	0.039	0.154	0.079
Third year	94.1	0.021	0.036	-0.381	0.203	-0.002	0.035	0.245	0.170
Transition year	45.7	0.119	0.054	-0.068	0.056	-0.081	0.048	0.071	0.056
Fifth year	96.3	0.010	0.038	-0.288	0.314	0.009	0.037	0.076	0.234
Sixth year	96.6	0.013	0.037	-0.390	0.309	0.008	0.037	0.107	0.212

Note. Teachers are missing 6.7% of data on the questions on ability grouping for mathematics, 11.1% of data on the support for ability grouping scale, and 6.3% on the potential negatives of ability grouping scale. Cells marked in bold indicate a significant difference ($p < .05$).

5.5. Use of Differentiated Teaching Practices

Teachers were asked how they provide different teaching and learning experiences for students of differing ability levels *within* their Third Year mathematics classes. Responses are shown in Table 5.8. In interpreting these, it should be noted that class groups may already reflect ability grouping between classes, and hence, there may be more limited opportunity for differentiated approaches. Two-thirds of teachers (65.5%) indicated that they taught Third Years at the time of completing the questionnaire, and the responses shown in Table 5.8 are based on these teachers only.

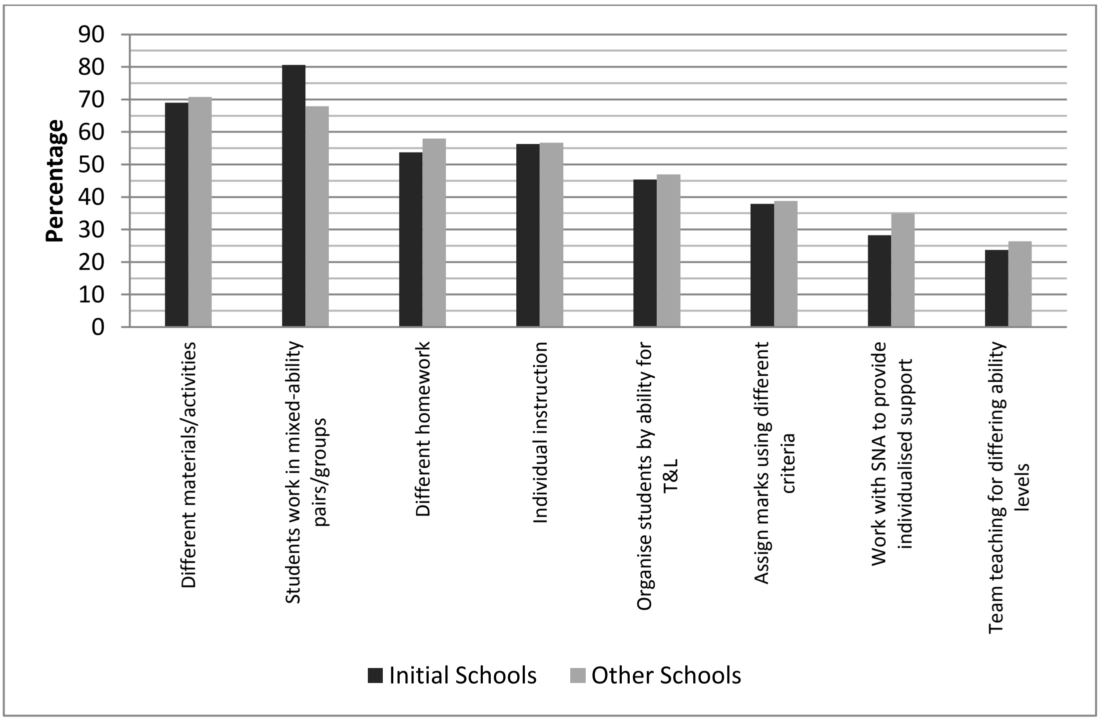
The four most commonly-used strategies (with 55-70% of teachers reporting using these sometimes or often) were providing different class materials or activities, having students work in mixed-ability pairs or groups, providing different homework tasks, and providing planned or structured (one-to-one) instruction. Team teaching was used considerably less frequently (with 61.1% never using this), as was working with a Special Needs Assistant (54.4% reported never using this). The use of these latter two approaches may be partly related to the availability of other staff to support their implementation. The remaining two strategies, organising students by ability for teaching and learning, and assigning grades on the basis of differing criteria, were used with moderate frequency.

A comparison of the extent to which teachers in initial schools and other schools used each of the strategies listed in Table 5.8 indicates that, in general, teachers use these practices with similar levels of frequency. However, there are two exceptions. Figure 5.4 shows that teachers in initial schools were more likely to report having students work in mixed-ability groups or pairs sometimes or often (81.0%) when compared to teachers in other schools (66.6%). Also, teachers in other schools were more likely to report working with an SNA sometimes or often (34.2%) than teachers in initial schools (26.0%).

Table 5.8. Frequency with which teachers use differentiated teaching and learning approaches within their Third Year mathematics classes: All teachers of Third Years

Strategy	Never	Rarely	Sometimes	Often
I provide different class materials or activities to students of differing ability levels	9.2	21.8	50.6	18.3
I get students to work in mixed-ability pairs or small mixed-ability groups	12.3	20.5	45.8	21.4
I assign different homework tasks to students of differing ability levels	14.2	29.1	37.6	19.0
I provide planned or structured individual (one-to-one) instruction that is embedded into whole-class teaching	20.9	22.9	35.7	20.4
Within a class group, I organise students by ability for teaching and learning activities	24.8	30.2	34.3	10.7
I assign grades or marks for homework, assessments or project work on the basis of differing criteria	27.0	35.8	25.9	11.2
I work with a Special Needs Assistant to provide individualised support during my mathematics class(es)	54.4	11.8	18.2	15.7
I participate in team teaching that caters for differing ability levels	61.1	14.7	15.4	8.8

Figure 5.4. Percentages of teachers using differentiated teaching and learning approaches 'sometimes' or 'often' within their Third Year mathematics classes: Teachers in initial schools and other schools



An additional 24.2% of teachers indicated that they used a strategy other than that listed in Table 5.8. However, only 8.8% or 116 teachers described these practices in written comments. These were subjected to content analysis, whereby comments addressing similar themes or topics were grouped into specific categories. The categorisation of comments was conducted initially by one researcher, and subsequently validated by a second researcher. In some cases, teachers' comments were subdivided if they fell under different categories. In total, 157 comments (or 1.35 comments per teacher) were identified for analysis. Of the 157 comments, 16.6% were from teachers in initial schools, and 83.4% from teachers in other schools. About one-third of comments (35.0%) were deemed not to concern differentiated teaching and learning strategies specifically, while the remaining 65.0% did. Table 5.9 shows the distribution of the themes for the sample overall (as a percentage of teachers who made comments), and by teachers in initial schools and other schools. Data in Table 5.9 are unweighted and should be interpreted in a broad, general sense.

Table 5.9. Types of strategies for differentiated teaching within classes identified in teachers' comments: All teachers, and teachers in initial schools and other schools

Theme	All Responses	Initial Schools	Other Schools
Peer-to-peer activities	22.9	23.1	22.9
Differentiation by task/teaching strategy	19.7	15.4	20.6
Use of tools and resources*	14.6	19.2	13.7
Extra classes or time/Withdrawal for extra support*	10.8	11.5	10.7
Use of practical materials/real life examples*	8.3	11.5	7.6
Student-led teaching and learning	6.4	3.8	6.9
One-to-one work: teacher and student	5.7	7.7	5.3
Differentiation by outcome	4.5	3.8	4.6
General/Other comments	7.0	3.8	7.6

Note. Data are unweighted. Frequencies are based on 8.8% of the entire teacher sample, i.e. only those teachers (n=116) who made written comments on this question.
*Some of the comments in these categories did not refer explicitly refer to differentiated teaching strategies.

It should be noted that two of the categories identified in the comments made by teachers overlap substantially with the 'closed' parts of this question (comparing Tables 5.8 and 5.9): i.e. *peer-to-peer activities* is similar to the fifth item in the set *(I get students to work in mixed-ability pairs or small mixed-ability groups),* while *one-to-one work* is similar to the eighth item: *(I provide planned or structured individual (one-to-one) instruction that is embedded into whole-class teaching).*

The most commonly-occurring category was *peer-to-peer activities* (almost 23% of all comments). Responses in this category referred to mixed-ability work in pairs or small groups, co-operative and collaborative learning, and peer learning and assessment. Typical teachers' comments in this category included the following:

Let students work in twos regardless of ability and let them help each other and explain how they thought a solution could be achieved.

I have used co-operative learning with small class groups.

About one-fifth of comments concerned *differentiation by task/teaching strategy.* These referred to setting students different tasks based on ability, and employing or modifying teaching strategies to encompass the range of abilities/interests in the class. Two examples of this category are shown below.

Have different targets/levels for students to reach, i.e. classwork/homework. Higher achieving do only one/two of easier questions and select more of the challenging questions. Weaker students get all the first (easier) questions.

If there is more than one method to teach a solution to a problem I demonstrate these methods to students, being conscious of the fact that students learn in different ways.

About 15% of comments referred to the use of various *tools and resources*. Teachers in initial schools made comments in this category slightly more frequently than teachers in other schools (19.2% vs. 13.7%). The responses in this category mentioned ICT-based or other resources that they used in their teaching, and references to these tended to be fairly specific, but not necessarily related to differentiated teaching. Examples include:

The use of ICT - students practice charts in Excel, students use Geogebra, students access materials from www.projectmaths.ie.

We talk through examples in PowerPoint which students take down into their notes. They use these as a guide to help them with more difficult questions for homework.

The fourth theme that was identified in teachers' comments concerned the provision of *additional support* to students, either through extra time outside of normal mathematics classes, or withdrawal of some students for more individualised instruction during mathematics classes. Examples include:

Individual small groups during lunchtime or other 'non-pressurised' times of the day, e.g. we eat and learn and get through a lot of work.

Low ability students are withdrawn by resource teacher to work on basic concepts of a topic when more higher-order material is being covered in mixed-ability setting.

About 8% of comments referred to the use of *practical materials or real-life examples*. Again, these were not necessarily related to differentiated teaching practices. Two examples from this category are shown below.

Use concrete materials as much as possible in the classroom.

Practical exercises: real life mathematics outside of classroom and inside classroom.

Several teachers (6.4%) made comments that referred to s*tudent-led teaching and learning activities*, such as *I allow students who understand a topic to teach others in the class during their work.* There is some overlap thematically between this category and *peer-to-peer activities*, referred to above. A similar percentage of teachers referred to individual work with students during class time; typically these would be students that the teacher perceives to be struggling with the material, e.g. *If a student has a difficulty with a concept (when the rest of the class is busy) I give her some one-to-one help and try to present the concept in a different way.* A small number of teachers referred to *differentiation by outcome*, e.g. *Demand different standards of homework within range of group.* Finally, 7% of comments were of a very general nature and/or didn't easily lend themselves to classification under the other categories.

5.6. Key Findings and Conclusions

Teachers in our study strongly endorsed items that are consistent with constructivist views on teaching and learning mathematics. For example, 80% or more of teachers agreed that there are different ways to solve most problems, that more than one representation should be used in teaching a mathematics topic, and that it is important to understand how mathematics is used in the real world. On the other hand, 88% agreed that some students have a natural talent for mathematics, while others do not, although only one-third of teachers agreed that mathematics is a difficult subject for most students.

We asked teachers about their views on ability grouping for mathematics; that is, the practice of grouping students into separate class groups on the basis of ability. The set of items was designed to tap two (not necessarily mutually exclusive) views – one supporting ability grouping, the other indicative of an awareness of the negatives of ability grouping for some students, particularly those of lower ability. There was high overall support for the practice of ability grouping. For example, 83% agreed with the statement 'The best way to teach the mathematics curriculum effectively is in class-based ability grouped settings'. On the other hand, there was awareness of the potential negatives of this practice: for example, 39% agreed that 'Class-based ability grouping for mathematics benefits higher-achieving students more than lower-achieving students'.

Teachers' views on ability grouping did not vary appreciably across school sector/gender composition, DEIS/SSP status, and initial school status. Small, though statistically significant, differences in the views of male and female teachers were apparent. Views did, however, vary substantially depending on whether teachers were in a school that grouped students by ability for their mathematics classes or not. For example, there was a difference of a third of a standard deviation on the scale measuring support for ability grouping for mathematics between teachers in schools where Second Year students were grouped for mathematics classes, compared to teachers in schools that did not group their Second Years. These findings suggest that school-level policy on ability grouping may have a direct effect on teachers' own views on this practice (or vice versa), more so than the other characteristics considered.

In considering the results relating to general views on mathematics and ability grouping for mathematics, it is useful to bear the overarching context of the Junior and Leaving Certificate examinations in mind. For example, teachers may indicate that they agree with constructivist approaches to teaching mathematics, but this will not necessarily translate into practice; similarly, views on ability grouping for mathematics are influenced by what material is to be covered in class and how it is to be examined or assessed. High levels of support for constructivist approaches coupled with low reported usage of such approaches were also found in TALIS (Gilleece et al., 2009).

Teachers were asked about their use of differentiated teaching practices *within* mathematics classes. The four most commonly-used strategies were providing different materials/activities, having students work in mixed-ability pairs/groups, providing different homework tasks, and structured individual instruction. Team teaching and working with a Special Needs Assistant were used considerably less frequently (perhaps because these are contingent on staff availability, and in the case of the latter, on whether there were students in the class with special educational needs). Teachers in initial schools reported having students work in mixed-ability pairs/groups somewhat more frequently than teachers in other schools, which is a positive finding, since research points to the benefits of these kinds of approaches (see Smyth & McCoy, 2011).

About 9% of teachers wrote down additional differentiated teaching strategies that they used. The most common of these were peer-to-peer activities (e.g. co-operative learning, paired learning tasks)/student-led teaching and learning; differentiation by task or teaching strategy; the use of tools and resources to support differentiated teaching (including practical materials and real-life examples); and extra classes or time allocated to struggling students.

In preparing for their junior cycle mathematics classes, teachers reported relatively high usage of sample examination papers, syllabus documents, and textbooks, though students' interests were also frequently taken into account. There was somewhat less frequent use of sample examination papers and textbooks by teachers in initial schools than by teachers in other schools. Teachers in the initial Project Maths schools reported greater use of syllabus documents, CPD, other teachers in their school, websites and inspection reports than teachers in other schools. These results, overall, are consistent with results of the OECD's TALIS survey, in which relatively low incidences of exchange, co-ordination and collaboration between teachers were found (Gilleece et al., 2009). They also point to the dominant influence of the examinations (e.g. with more reliance on sample or past examination papers than on CPD and mathematics education websites).

There were large differences between teachers in initial schools and other schools in the extent to which ICTs were incorporated into mathematics classes. In particular, teachers in initial schools reported using both general and mathematics-specific software in class at least once a week to a greater extent than teachers in other schools. This is a positive finding in that one can infer that the increased use of ICTs by teachers in initial schools is occurring as a direct result of the CPD that they received (see Chapter 2); however, without information on the relative effectiveness of various types of ICT usage, caution should be exercised in drawing any general conclusions about this finding. This finding also points to discrepancies between teaching and learning activities and modes and methods of classroom assessment on one hand, and the structure and format of the Junior Certificate mathematics examination on the other.

6. Teachers' Views on Project Maths at Junior Cycle

Teachers of junior cycle were asked to complete a section in the questionnaire concerning Project Maths. Sections 6.1 to 6.4 in this chapter concern only the teachers who were teaching junior cycle mathematics at the time of PISA 2012, i.e. 88.8% of all teachers surveyed. Section 6.5, which examines comments made by teachers on Project Maths, includes all teachers who wrote comments, whether they taught junior cycle or not at the time of the survey. In considering the results presented in this chapter, it may be borne in mind that the findings are based on teachers' reports. The views of other stakeholders, particularly students, would provide a more complete picture on the implementation of Project Maths. In interpreting the results in this chapter, it should be borne in mind that the manner in which Project Maths was introduced set a challenging context (see Chapter 2), and this will come to bear on any appraisal of the initiative.

6.1. General Views on the Implementation of Project Maths

About half (50.2%) of respondents indicated that they had been teaching Project Maths at junior cycle; 45.3% for two years, and a small minority (4.6%) for longer than two years. Teachers were asked to indicate, overall, whether or not they agreed that Project Maths was having a positive impact on students' learning of mathematics (Table 6.1). What is striking about the results is that close to half of teachers (47.5%) indicated that they did not know if Project Maths was having a positive impact. This indicates, not unexpectedly, that it is too early in the implementation of Project Maths for teachers to have an informed opinion[25].

Slightly fewer teachers disagreed (22.8%) than agreed (29.7%) with the statement. A comparison of the responses of teachers in initial and other schools indicates that more teachers in initial schools were inclined to agree with the statement, and fewer teachers in initial schools indicated that they didn't know.

Table 6.1. Responses of teachers to the statement 'Overall, Project Maths is having a positive impact on students' learning of mathematics': All teachers, and teachers in initial and other schools

	All	Initial Schools	Other Schools
Strongly disagree	7.5	4.0	7.6
Disagree	15.3	12.5	15.4
Don't know	47.5	38.4	48.0
Agree	23.3	35.0	22.7
Strongly agree	6.4	10.1	6.3

Note. 8.4% of respondents were missing data on this question.

Teachers were asked to respond to a series of 19 statements on specific aspects of Project Maths. Table 6.2 shows their overall levels of agreement/disagreement. There is considerable variation in the responses, although there was only one statement with which a majority of teachers disagreed. This was 'Introducing the syllabus strands in three phases was a good idea' (62.2% disagreed or strongly disagreed).

[25] In Chapter 1, it was noted that first examination of all five strands of the revised curriculum does not take place until 2014 for the Leaving Certificate and 2015 for the Junior Certificate.

Table 6.2. Teachers' levels of agreement with 19 general statements on Project Maths (junior cycle only)

Statement	Strongly disagree	Disagree	Don't know	Agree	Strongly agree
The professional development workshops were useful to me	2.2	7.6	7.9	56.1	26.2
I find the www.projectmaths.ie website useful	1.9	7.0	6.9	64.6	19.5
The Common Introductory Course for First Year is a good idea	1.6	5.4	12.7	61.3	19.0
When planning mathematics lessons I use the syllabus published by the NCCA/DES	2.0	10.7	4.2	64.4	18.7
My students now have to do more 'thinking' in mathematics class	1.5	11.3	11	57.8	18.3
I now use a greater range of teaching and learning resources in my mathematics classes	1.5	11.8	5.8	63.3	17.7
The Bridging Framework to promote continuity between primary and post primary is a good idea	1.3	2.1	24	56.2	16.5
In my classroom I now encourage a greater level of discussion about mathematics	1.5	14.1	6.5	62.2	15.7
I find the www.ncca.ie/projectmaths website useful	2.2	11.6	16.0	60.2	10.0
The syllabus learning outcomes are clear	4.0	19.6	10.2	57.5	8.7
I find the new geometry course for post-primary schools useful	2.0	11.8	24.6	53.5	8.1
I find the NCCA student resource material for strand 1 useful	1.4	9.6	24.9	57.1	7.1
I find the NCCA student resource material for strand 2 useful	1.4	9.2	26.5	55.8	7.0
The in-school support for implementing the syllabus changes was adequate[26]	10.0	25.9	15.1	42.9	6.2
Support from the *Project Maths* development team (RDOs) was effective[27]	4.7	15.9	20.2	53.1	6.1
Introducing the syllabus strands in three phases was a good idea	38.5	23.6	10.4	22.5	4.9
The new textbooks support the *Project Maths* approach appropriately	13.3	32.1	14.6	38.0	2.1
Students welcomed the new approach to mathematics teaching and learning	7.6	30.8	31.2	28.4	1.9
Parents welcomed the new approach to mathematics teaching and learning	5.2	14.1	65.4	13.8	1.5

Note. 6.6% to 8.7% of respondents were missing data on these items.

Levels of agreement were high (in excess of 80%) for five of the statements, which covered the website at www.projectmaths.ie (84.2% agreed or strongly agreed that it was useful); using the syllabus in planning lessons (83.1% agreed that they used it); the usefulness of professional development workshops (82.3%); use of a greater range of resources in class (81.0%); and the view that the Common Introductory Course[28] in First year is a good idea (80.3%). Between 70% and 80% of teachers agreed with four further statements: that they now encourage a greater level of discussion in class (77.9% agreed or strongly agreed); that students now have to do more 'thinking'

[26] Only initial schools received in-school support from the PMDT.
[27] Only initial schools had a designated RDO.
[28] This is the minimum course to be covered by all students at the start of junior cycle (NCCA/DES, 2011a, Appendix).

in class (76.1%); that the Bridging Framework[29] is a good idea (72.6%); and that the website at www.ncca.ie/projectmaths is useful (70.2%).

Teachers were most inclined to express disagreement (with 20% or more disagreeing or strongly disagreeing) with the following five aspects of Project Maths: that it was a good idea to introduce the syllabus strands in three phases (62.2% disagreed or strongly disagreed); that the new textbooks support the Project Maths approach appropriately (45.3%); that students welcomed the new approach (38.5%); that the syllabus learning outcomes are clear (23.6%); and that support from the Project Maths development team was effective (20.6%).

Examining the extent to which teachers indicated that they didn't know (or didn't have an opinion on) the items in Table 6.2 can give an indication of aspects of Project Maths that may take longer to become established, or those with which teachers are less familiar. Teachers were particularly unsure whether or not parents welcomed the new approach to mathematics (65.4% indicated that they didn't know), and were also unsure if students welcomed it (31.2% didn't know). Further, around a quarter of teachers didn't know if they found the resource materials for Strands 1 and 2, and the new geometry course, useful. Also, although the level of agreement was high with the statement on the Bridging Framework, 24.0% of teachers indicated that they didn't know if this framework was useful. Similarly, 20.2% of respondents didn't know if support from the Project Maths team was useful.

Table 6.3 compares the responses of teachers in initial and other schools to the items shown in Table 6.2. The 'strongly agree' and 'agree' categories have been combined, as have the 'disagree' and 'strongly disagree' categories.

Levels of disagreement differed by more than 10 percentage points between the two groups of teachers on three of these items:

- teachers in other schools were more inclined to disagree that introducing the syllabus strands in three phases was a good idea (63.0% compared with 44.9%);
- teachers in initial schools were more inclined to disagree that parents welcomed the new approach (49.8% vs. 17.9%); and
- teachers in initial schools were more inclined to disagree that students welcomed the new approach (62.7% vs. 37.3%).

Teachers in initial schools tended to agree more than teachers in other schools that:

- the Common Introductory Course is a good idea (90.9% vs. 79.8%); and
- students now have to do more 'thinking' in class (86.7% compared with 75.6%).

On three items, teachers in other schools were more inclined than teachers in initial schools to respond that they didn't know: these were that

- parents welcomed the new approach (66.8% compared with 35.8%);
- students welcomed the new approach (31.9% vs. 17.8%); and
- the support from the Project Maths team was effective (20.6% compared with 10.0%).

[29] The Bridging Framework describes how content areas and concepts covered at 5th/6th class at primary level map onto the revised junior cycle syllabus (http://action.ncca.ie/curriculum-connections/bridging-documents.aspx).

Table 6.3. Levels of agreement with 19 general statements on Project Maths (junior cycle only): Teachers in initial schools and other schools

Statement	Initial Schools			Other Schools		
	Disagree/ Strongly disagree	Don't know	Agree/ Strongly Agree	Disagree/ Strongly disagree	Don't know	Agree/ Strongly Agree
The professional development workshops were useful to me	12.5	11.0	76.5	9.7	7.8	82.5
I find the www.projectmaths.ie website useful	12.7	11.5	75.9	8.7	6.7	84.6
The Common Introductory Course for First Year is a good idea	4.7	4.4	90.9	7.1	13.1	79.8
When planning mathematics lessons I use the syllabus published by the NCCA/DES	8.9	1.9	89.2	12.9	4.3	82.8
My students now have to do more 'thinking' in mathematics class	4.9	8.4	86.7	13.2	11.2	75.6
I now use a greater range of teaching and learning resources in my mathematics classes	6.9	9.7	83.3	13.6	5.6	80.9
The Bridging Framework to promote continuity between primary and post primary is a good idea	3.4	23.6	73.1	3.4	24.0	72.6
In my classroom I now encourage a greater level of discussion about mathematics	10.3	9.0	80.6	15.8	6.4	77.8
I find the www.ncca.ie/projectmaths website useful	20.3	18.9	60.8	13.5	15.9	70.6
The syllabus learning outcomes are clear	29.7	7.3	63.0	23.3	10.3	66.4
I find the new geometry course for post-primary schools useful	15.6	23.0	61.5	13.8	24.6	61.6
I find the NCCA student resource material for strand 1 useful	15.6	23.3	61.1	10.7	24.9	64.4
I find the NCCA student resource material for strand 2 useful	16.3	23.5	60.2	10.3	26.7	63.0
The in-school support for implementing the syllabus changes was adequate	42.4	10.6	47.0	35.5	15.4	49.2
Support from the *Project Maths* development team (RDOs) was effective	28.7	10.0	61.3	20.2	20.6	59.1
Introducing the syllabus strands in three phases was a good idea	44.9	11.6	43.5	63.0	10.4	26.6
The new textbooks support the *Project Maths* approach appropriately	38.2	13.5	48.3	45.7	14.6	39.7
Students welcomed the new approach to mathematics teaching and learning	62.7	17.8	19.5	37.3	31.9	30.8
Parents welcomed the new approach to mathematics teaching and learning	49.8	35.8	14.4	17.9	66.8	15.3

Note. 8.0% to 12.9% of teachers in other schools were missing responses on these items. Rates of missing data for teachers in initial schools were less than 5%.

6.2. Perceived Changes in Students' Learning

Teachers were asked to indicate, for a set of 17 statements relating to students' learning of mathematics, whether they perceived that there had been a change, ranging from a large negative one, to a large positive one, with the implementation of Project Maths. These responses were recoded as follows: large negative change: -2; moderate negative change: -1; no change: 0; moderate positive change: +1; and large positive change: +2. Thus, a negative score on an item signifies a perceived negative change, while a positive score signifies a perceived positive change. Scores at or close to zero indicate no perceived change.

Table 6.4 shows the mean scores on each of these items overall, and for teachers in initial schools and in other schools. The 'Diff' column shows the difference in the average rating or response on each item between teachers in initial schools and teachers in other schools. Differences that are statistically significant (p <.05) are shaded in grey[30].

Table 6.4. Perceived changes in 17 areas of learning:
All teachers, and teachers in initial schools and other schools (junior cycle only)

Area of Learning	All			Initial Schools			Other Schools			Diff (initial-other)
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	
Students' understanding of key concepts in Statistics and Probability	0.718	0.572	0.023	0.798	0.510	0.066	0.713	0.576	0.024	0.085
Students' levels of awareness of the relevance of mathematical applications in other disciplines	0.608	0.575	0.019	0.715	0.467	0.058	0.602	0.580	0.020	0.113
Students' understanding of key concepts in Geometry and Trigonometry	0.565	0.596	0.023	0.589	0.650	0.072	0.564	0.593	0.024	0.025
Students' ability to solve real-life problems involving mathematics	0.546	0.631	0.021	0.614	0.620	0.045	0.542	0.632	0.021	0.073
Students' ability to work collaboratively in groups	0.520	0.595	0.023	0.689	0.507	0.053	0.511	0.598	0.024	**0.178**
Students' problem-solving strategies	0.494	0.627	0.022	0.537	0.696	0.045	0.492	0.623	0.023	0.045
Students' ability to explain how they solved mathematics problems	0.476	0.672	0.026	0.625	0.615	0.063	0.468	0.674	0.028	**0.157**
Students' ability to try different strategies to solve a problem	0.473	0.622	0.027	0.704	0.550	0.065	0.460	0.623	0.028	**0.244**
Students' grasp of fundamental mathematical concepts and principles	0.437	0.639	0.023	0.654	0.581	0.051	0.426	0.640	0.024	**0.228**
Sense of challenge experienced by higher-achieving students	0.367	0.718	0.029	0.573	0.644	0.039	0.356	0.720	0.030	**0.216**
Students' understanding of the vocabulary and language of mathematics	0.358	0.879	0.032	0.395	0.914	0.115	0.356	0.878	0.034	0.039
Students' interest in mathematics	0.338	0.616	0.023	0.366	0.611	0.110	0.336	0.617	0.024	0.029
Students' ability to work independently in mathematics classes	0.321	0.615	0.022	0.318	0.607	0.086	0.321	0.616	0.023	-0.003
Students' confidence in their mathematics skills	0.280	0.670	0.028	0.124	0.817	0.164	0.288	0.660	0.029	-0.165
Performance of students in class tests you have administered	0.260	0.629	0.024	0.229	0.721	0.114	0.262	0.624	0.025	-0.032
Conceptual learning experienced by lower-achieving students	0.250	0.730	0.030	0.292	0.778	0.109	0.248	0.728	0.031	0.044
Students' ability to persist when they have difficulty solving a problem	0.191	0.651	0.026	0.244	0.648	0.055	0.188	0.652	0.027	0.056

Note. 13.8% to 16.8% of teachers were missing responses on these items. In the 'Diff' column, values in shaded in grey are statistically significant (p < .05).

[30] The standard errors have been corrected for sampling error using the replicate weights, as described in the Technical Appendix.

Across all teachers (first column of data), there has been a perceived positive overall change on all aspects of students' learning considered in this question. The largest positive overall changes were associated with students' understanding of key concepts in statistics and probability (0.72); awareness of the relevance of mathematics in other disciplines (0.61); understanding of key concepts in geometry and trigonometry (0.57); ability to solve real-life problems (0.55); ability to work collaboratively in groups (0.52); and problem-solving strategies (0.49). The smallest (positive) changes are associated with students' confidence in their mathematics skills (0.28); performance on class tests (0.26); conceptual learning experienced by lower achievers (0.25); and ability to persist when having difficulty in solving a problem (0.19).

Generally, teachers in initial schools reported larger positive changes than teachers in other schools. These differences are statistically significant on five of the 17 items: collaborative group work, students explaining how they solved a problem, students trying different strategies, their grasp of fundamental concepts and principles, and the sense of challenge experienced by higher achievers.

6.3. Levels of Confidence in Teaching Aspects of Project Maths

Teachers were asked to rate their levels of confidence in teaching 14 aspects of Project Maths at junior cycle. Responses of teachers overall are shown in Table 6.5.

Table 6.5. Levels of confidence in teaching 14 aspects of Project Maths: All teachers (junior cycle only)

Aspect of Project Maths	Not at all confident	Not too confident	Moderately confident	Very confident
Teaching statistics	0.8	4	39.1	56.1
Teaching geometry and trigonometry	0.6	6.7	41.8	50.9
Teaching probability	1.5	7.4	41.4	49.7
Providing feedback to students about their performance in mathematics	0.8	7.3	55.9	35.9
Teaching students to solve problems in real-life settings	1.2	6.9	59.1	32.9
Engaging students in practical mathematics activities	0.8	11	56.4	31.7
Assessing how students are performing in mathematics	2.2	12.7	54.8	30.3
Preparing students for the revised Junior Certificate mathematics examination	4.1	20.2	49.2	26.4
Catering for students of varying mathematical ability	1.5	15.1	59	24.4
Organising classes so that students can use concrete materials	2.1	18.2	55.9	23.8
Supporting students with learning difficulties in mathematics	2.6	21.3	54.6	21.5
Facilitating students' independence in problem solving/doing mathematics	1.9	16.7	61	20.4
Analysing students' problem-solving strategies	1.9	21.5	58.8	17.8
Engaging students in assessing their own progress/performance in mathematics	2.4	27.4	53.4	16.8

Note. 9.4% to 10.1% of teachers were missing responses on these items.

Overall, teachers indicated high levels of confidence in teaching the 14 aspects. Reported confidence levels were highest for teaching statistics, and geometry and trigonometry, with 50% or more indicating that they were very confident in teaching these topics. Also, between 30% and 50% of teachers reported being very confident in providing feedback to students on their performance, teaching students to solve problems in real-life settings, engaging students in practical mathematics, and assessing students' performance on mathematics.

However, a sizeable minority of teachers reported lower levels of confidence in teaching five of the 14 aspects listed: 20-30% indicated that they were not at all or not too confident in the following: organising classes to facilitate the use of concrete materials (20.3%), analysing students' problem-solving strategies (23.4%), supporting students with learning difficulties (23.9%), preparing students for the revised Junior Certificate examination (24.3%), and engaging students in assessing their own progress or performance (29.8%).

Table 6.6 compares the confidence levels reported by teachers in initial schools with teachers in other schools for the same items shown in the previous table. The categories 'not at all confident' and 'not too confident' have been collapsed, since very few teachers selected the 'not at all confident' category.

Table 6.6. Levels of confidence in teaching 14 aspects of Project Maths: Teachers in initial schools and other schools (junior cycle only)

Aspect of Project Maths	Initial Schools			Other Schools		
	Not at all/Not too confident	Moderately confident	Very confident	Not at all/Not too confident	Moderately confident	Very confident
Teaching statistics	2.0	37.6	60.3	5.0	39.1	55.9
Teaching probability	3.4	40.3	56.4	9.2	41.4	49.4
Teaching geometry and trigonometry	1.3	54.7	44.0	7.5	41.2	51.3
Engaging students in practical mathematics activities	16.4	43.3	40.3	11.7	57.1	31.3
Teaching students to solve problems in real-life settings	11.9	57.0	31.1	7.8	59.2	33.0
Providing feedback to students about their performance in mathematics	11.7	61.5	26.7	8.0	55.6	36.4
Organising classes so that students can use concrete materials	18.5	56.0	25.5	20.5	55.8	23.7
Assessing how students are performing in mathematics	23.3	54.9	21.8	14.4	54.8	30.8
Preparing students for the revised Junior Certificate mathematics examination	28.4	51.6	19.9	24.1	49.1	26.8
Facilitating students' independence in problem solving/doing mathematics	18.3	62.5	19.2	18.6	60.9	20.5
Catering for students of varying mathematical ability	18.7	66.8	14.6	16.5	58.6	24.9
Supporting students with learning difficulties in mathematics	31.2	55.9	12.8	23.5	54.6	21.9
Analysing students' problem-solving strategies	20.5	69.5	10.0	23.6	58.2	18.2
Engaging students in assessing their own progress/performance in mathematics	36.0	55.4	8.6	29.5	53.3	17.3

Note. 9.8% to 10.1% of teachers in other schools were missing responses on these items. Rates of missing data for teachers in initial schools were less than 5%.

Perhaps unexpectedly, more teachers in other schools reported being very confident in teaching eight of these aspects (i.e. with a difference of 5 percentage points or more) compared to teachers in initial schools. These included catering for students of varying ability, providing feedback, supporting students with learning difficulties, and assessing students. Teachers in initial schools reported being more confident than teachers in other schools on just two of the items (again with a difference of 5 percentage points or more), i.e. teaching probability and engaging students in practical activities.

6.4. Perceived Challenges in the Implementation of Project Maths

Teachers indicated the level of challenge for 12 aspects associated with the implementation of Project Maths in their schools. Results for all junior cycle teachers are shown in Table 6.7. Note that we cannot infer from these results which of these are perceived challenges that have been overcome, or that are possible to overcome, and those that might represent significant obstacles in implementation with no obvious solution. For example, while 41.7% cited availability of assessment materials, and 31.6% cited teaching materials, as major challenges, there are some resources at www.projectmaths.ie. Having said this, five of these aspects may be regarded as significant difficulties, since 40% or more of teachers indicated that they were a major challenge. These are the time required to prepare for classes and for group work/investigations, the staggered or phased implementation of Project Maths, the literacy demands of the new courses, the rate of implementation, and available assessment materials. In addition, 31.6% of teachers indicated that available teaching materials such as textbooks were a major challenge, while a similar percentage (29.0%) indicated that funds or resources were a major challenge.

Table 6.7. Perceived challenges in the implementation of Project Maths: All teachers (junior cycle only)

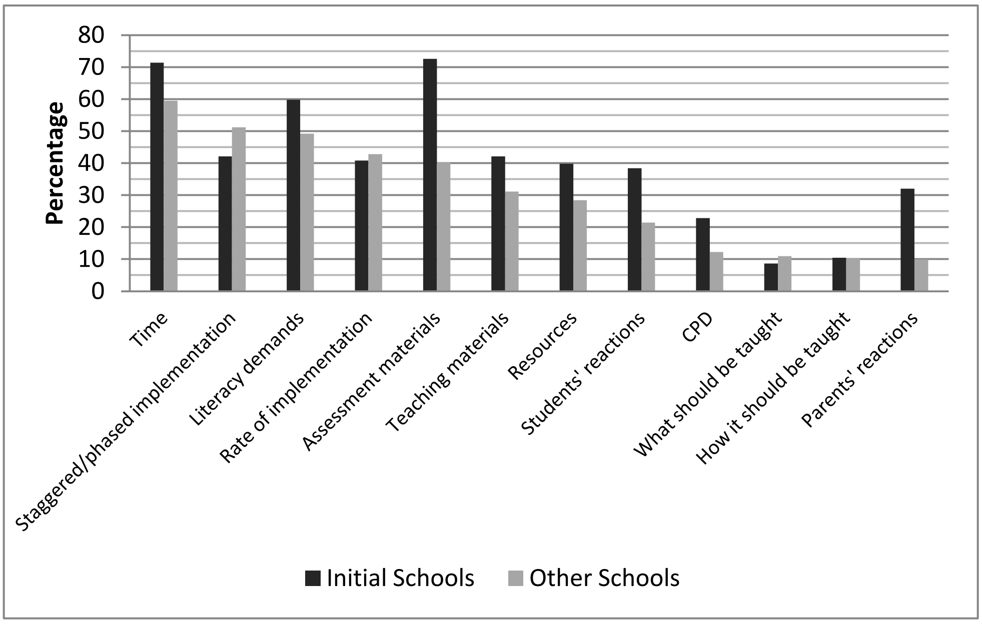
Perceived Challenge	A major challenge	A challenge	Not a challenge
Time, for example to become familiar with coursework, to prepare classes, for group work and investigations	59.8	36.7	3.4
The staggered/phased implementation of Project Maths	51.0	34.5	14.5
Literacy demands of the new courses	49.7	36.1	14.2
The rate of implementation of Project Maths	42.8	44.7	12.5
Assessment materials, for example sample examination papers and guidelines on assessing students' progress	41.7	39.7	18.6
Teaching materials, for example the content and range of textbooks available	31.6	45.8	22.6
Resources, for example funds to buy materials, facilities or equipment	29.0	42.3	28.8
Students' reactions to Project Maths	22.0	45.1	32.9
Continuing Professional Development, for example training opportunities available, content covered	12.6	45.6	41.8
Parents' reactions to Project Maths	10.7	36.2	53.1
How the Project Maths approach relates to my views on what mathematics content should be taught	10.6	39.3	50.1
How the Project Maths approach relates to my views on how mathematics should be taught	10.2	38.5	51.4

Note. 7.1% to 11.4% of teachers were missing responses on these items.

In contrast, four of the 12 aspects were not considered to represent significant difficulties, with 15% or fewer teachers indicating that CPD, parents' reactions to Project Maths, how Project Maths relates to teachers' beliefs on what should be taught, and how Project Maths relates to teachers' beliefs on how mathematics should be taught, were major challenges.

Figure 6.1 compares the percentages of teachers in initial schools and in other schools who indicated that each of the 12 aspects shown in Table 6.7 is, in their view, a major challenge. Responses diverge considerably between the two groups (by 10 percentage points or more) on eight of the items. In all eight cases, teachers in initial schools were more inclined than teachers in other schools to rate them as a major challenge. These were: the assessment materials available at the time of the survey (72.6% compared with 40.3%), parents' reactions (32.0% vs. 9.7%), students' reactions (38.4% vs. 21.2%), time available (71.4% compared with 59.3%), resources available (39.8% vs. 28.4%), teaching materials (42.1% compared with 31.1%), CPD available or attended (22.8% vs. 12.1%), and the literacy demands of the new courses (59.8% compared with 49.2%).

Figure 6.1. Percentages of teachers in initial schools and other schools indicating that each of 12 aspects of the implementation of Project Maths is 'a major challenge' (junior cycle only)



Across both groups, however, three aspects of the implementation of Project Maths emerged as significant challenges (appearing among the top four in terms of the percentages rated as being a major challenge) (Table 6.8). These were the time available, the phased implementation of Project Maths, and the literacy demands of the new courses. Also, both groups shared the view that the following four aspects of Project Maths posed less of a challenge in its implementation: parents' reactions, CPD available/attended, Project Maths in terms of their own views on what should be taught, and Project Maths in terms of their views on how it should be taught.

Table 6.8. Rankings of 12 aspects of the implementation of Project Maths as 'a major challenge': All teachers, and teachers in initial schools and other schools (junior cycle only)

Perceived Challenge	All %	All Rank	Initial Schools %	Initial Schools Rank	Other Schools %	Other Schools Rank
Time available	59.8	1	71.4	2	59.3	1
Phased implementation	51.0	2	42.5	4	51.4	2
Literacy demands	49.7	3	59.8	3	49.2	3
Rate of implementation	42.8	4	40.8	6	42.9	4
Assessment materials available	41.7	5	72.6	1	40.3	5
Teaching materials	31.6	6	42.1	5	31.1	6
Resources available	29.0	7	39.8	7	28.4	7
Students' reactions	22.0	8	38.4	8	21.2	8
CPD available/attended	12.6	9	22.8	10	12.1	9
Parents' reactions	10.7	10	32.0	9	9.7	12
Project Maths and what should be taught	10.6	11	8.6	12	10.7	10
Project Maths and how it should be taught	10.2	12	10.4	11	10.2	11

Note. 7.1% to 11.4% of teachers were missing responses on these items. Rates of missing data for teachers in initial schools ranged between 3.4% and 9.2%; 7.3% to 11.6% of teachers in other schools were missing responses on these items.

6.5. Teachers' Comments on Project Maths

6.5.1. Analysis of Comments

Teachers were provided with space in the questionnaire to make written comments about their experiences of/views on Project Maths. The question was pitched at a general level (i.e. *please make any further comments on Project Maths in your work as a teacher in the space below, if you wish*). Of all respondents, 34.5% wrote comments. About the same percentages of teachers in initial schools and other schools made written comments (35.7% and 34.7%, respectively).

Responses were split in cases where they pertained to more than one discrete theme or aspect of Project Maths. On average, teachers made 1.65 comments, yielding a total of 757 separate comments or pieces of text. Teachers in initial schools had a slightly higher average number of comments (1.78) than teachers in other schools (1.63).

Comments were subjected to a detailed content analysis, and classified along three dimensions:

1. Overall tone of the comment: positive, negative, or mixed[31].
2. Which part of the education system the comment referred to (junior cycle, senior cycle, or both).
3. The content of the comment itself: eight themes were identified. These are described in detail in the next section. Some of these themes overlap with one another. In addition, 5.6% of comments were classified under 'other' as they did not readily fit under the main themes.

The content analysis was conducted initially by one researcher, and then validated by a second. The content of the comment was discussed by the two researchers and re-classified in a small number of cases. Note that analyses in this section are not weighted. As such, results should be interpreted in a broad and general sense.

[31] Example of a general, positive comment: *I like the concept of Project Maths. I see how children learn from one another;* example of a general, negative comment: *Introducing this change on top of dealing with very large classes is ridiculous;* example of a general, mixed comment: *There is a good understanding of the concepts but it is difficult to prepare the for the junior cert exam.*

6.5.2. Main Themes Emerging

Table 6.8 shows the distribution of comments in terms of their overall tone and the level to which they pertained (junior cycle, senior cycle, or both). A large majority (87%) were negative in tone, and the percentages of negative comments were similar in initial and other schools. A further 8% were mixed in tone, and just 5% were positive. However, it is possible that teachers may have thought it more important to record reservations than to re-assert positive opinions, which other parts of the questionnaire gave them plenty of opportunities to express.

A majority of comments (81%) covered both junior and senior cycles. Teachers in other schools were slightly more inclined than teachers in initial schools to comment on senior cycle or junior cycle separately.

In interpreting the tone of the comments, and indeed their content, we were aware that there was a possibility that those teachers who were negatively disposed towards Project Maths may have been more inclined to make written comments, in which case we could not say that these comprised a representative sample of views. However, a comparison of teachers' agreement/disagreement with the statement 'overall, Project Maths is having a positive impact on students' learning of mathematics' with whether or not they made written comments, indicated that written comments were equally prevalent, whether teachers agreed, didn't know, or disagreed (Table 6.9). As such, written comments do not appear to have come predominantly from teachers who have negative overall views on Project Maths.

Table 6.8. Distribution of teachers' comments on Project Maths by tone and level: Overall, and from teachers in initial schools and other schools

Tone	All comments	Initial Schools comments	Other Schools comments
Positive	4.8	4.4	4.8
Negative	87.3	87.7	87.2
Mixed	8.0	7.9	8.0
Level			
Junior cycle	4.6	0.9	5.3
Senior cycle	14.3	7.9	15.5
Both	81.0	91.2	79.2

Note. Data are unweighted. Percentages are based on a total of 757 comments.

Table 6.9. Cross-tabulation of teachers' overall view on Project Maths with whether or not they made written comments on Project Maths

Comment	'Overall, Project Maths is having a positive impact on students' learning of mathematics'		
	Agree	Don't know	Disagree
No written comment	21.6	48.8	29.6
Written comment	24.9	45.4	29.7
All	22.8	47.5	29.7

Table 6.10 shows the distribution of teacher comments across the themes identified through the content analysis for the sample overall, and separately for teachers in initial schools and in other schools. In two of the eight themes, *syllabus and assessment* and *resources,* there are three sub-themes, since these seemed to reflect related but distinct aspects of the overarching theme.

To a large extent, the distribution of comments across content areas is similar for teachers in initial schools and teachers in other schools, with two exceptions. Other schools were more inclined to make comments on the *phased implementatio*n of Project Maths, while initial schools tended to comment more frequently on *examinations*. These differences can be related to the fact that the initial schools are ahead of the other schools in their experiences of Project Maths.

The four most commonly-occurring themes are *phased implementation, literacy and ability, syllabus,* and *time*. Each of the themes is described in the remainder of this section, with illustrative examples of comments made by the teachers who participated in PISA 2012. Comments are transcribed verbatim in order to retain as much of respondents' original intent as possible.

Table 6.10. Frequencies of teachers' comments on Project Maths by theme: All comments, and comments from teachers in initial schools and other schools

Theme	Sub-Theme	All		Initial Schools		Other Schools	
		%	Rank	%	Rank	%	Rank
Syllabus and Assessment	Syllabus	12.2	3	11.4	3	12.3	3
	Time	9.2	4	6.1	6	9.8	4
	Examinations	8.5	5	20.2	1	6.4	6
Resources	Textbooks	4.4	7	3.5	10	4.5	7
	Professional Development	3.6	8	5.3	7	3.3	8
	Resources in general	3.0	9	4.4	8	2.8	10
Phased implementation		26.8	1	19.3	2	28.2	1
Literacy and Ability		13.1	2	8.8	4	13.9	2
Methodology		2.8	10	1.8	11	3.0	9
Change		2.1	11	4.4	9	1.7	11
Communication		1.3	12	0.9	12	1.2	12
General Comments		7.5	6	7.9	5	7.5	5
Other		5.6	-	6.1	-	5.5	-

Note. Data are unweighted. Percentages are based on a total of 757 comments.

Theme 1 – Syllabus and Assessment

Theme 1a – Syllabus

One-eighth (12.2%) of teachers commented on aspects of the revised syllabus, and 92.4% of these comments were negative in tone. A number of teachers felt the course was too long, with too much content, and reported difficulty in being able to cover the syllabus[32]. Some teachers felt that statistics and probability posed a challenge for students, especially in senior cycle; others felt there was a reduction in level of difficulty in the revised curriculum compared to the one previously in place. This theme overlaps with the *examinations* theme (below) insofar as teachers felt more pressure to cover the entire course with choice removed from the examinations.

[32] It may be borne in mind that, at the time of the survey, most teachers were dealing with the implementation of part of the new syllabus, while maintaining part of the old syllabus (see Table 2.1, Chapter 2).

Examples of comments made on Syllabus:

If the goal was to provide time to allow teachers and students to explore topics in greater depth and detail then project maths will not succeed. The curriculum is too overloaded for this. Some topics have doubled in size. Teachers are intimidated by the amount of new material and methods recommended.

Project maths has some great ideas but unfortunately the department of education has fallen back to its love of content. There is too much content to allow teachers the luxury of exploring concepts/topics in the detail they may want to, especially at leaving cert level. Less content and more time for exploration would produce a more valuable course.

…the course is much longer for leaving cert now as there is a large amount of statistic/probability which is on new junior cert which was not [on the old junior cert.] for them.

There seems to be a reduction in level of difficulty in questions, need to keep a high standard.

Theme 1b – Time

About 9% of teachers' comments mentioned time being an issue for the successful implementation of Project Maths, and again these comments were mostly (92.9%) negative. From the comments received, it can be inferred that teachers were referring both to instructional time, and time outside of teaching hours. Many teachers who commented on time felt they did not have enough time to cover the course. Some teachers reported spending evenings and weekends doing extra work in order to prepare students. They also felt this extra work had resulted in other subjects suffering. These comments also relate to the *syllabus* theme and the view that there is not enough time to cover the amount of content in the new course. Teachers also reported that the lack of time limited the amount of group/practical work that could be implemented.

Examples of comments made on Time:

Time constraints make it more difficult to employ new teaching methodologies.

There is a major problem in Project Maths. Practical work and investigations take up a lot of time. Using it in the classroom can be time consuming also and is not always effective. Preparation for project maths takes up a lot of my time at night and I feel my other subjects have suffered as a result.

There is a serious problem with time. It's well and good devising these experiments but we have NO time to get them done if we want to get course finished. It's ridiculous.

…the course appears to be very long, explorative/investigative methods are 'ideal' but only if the course can be covered in time! I have concerns about this.

Theme 1c – Examinations

Comments that came under the theme of examinations (8.5% of all comments, 93.8% of which were negative in tone) covered the structure, content and layout of examination papers and marking schemes. Comments on examinations were more prevalent among teachers in initial schools compared with teachers in other schools. Teachers were generally unhappy with the removal of question choice from the examination papers. Some even felt it may discourage students from taking the examination at Higher level. Others commented that the removal of choice resulted in them being under too much pressure to cover the course and adequately prepare students. Some felt that the layout and structure of the sample papers and marking schemes lacked clarity. Teachers also voiced dissatisfaction with the lack of availability of sample papers and marking schemes, and were of the view that aspects of the examination (including the marking) were aiding the 'dumbing down' of maths. A few teachers noted a discrepancy between the problem-solving and group work approach of Project Maths and the prescribed nature of the Leaving Certificate examination.

Examples of comments made on Examinations:

I would question the notion of 'no choice' of leaving cert papers - this will discourage some students from pursuing higher level course, instead they will pick a perceived 'easy subject' with choice on paper.

While I agree with the aims of Project Math, the pupils find it very difficult to translate what they learn in class to what is asked in sample exam papers - the jump is too big and the language varies from book to book and paper to paper.

No exam papers for students to practise is going to be a major factor in June, and hence the results. The mock exams gave a marking scheme, giving 6/10 for even attempting a graph - crazy marking scheme, which won't be replicated in marking in June [2012] I'm sure?

Theme 2 – Resources

Theme 2a – Textbooks

A small percentage (4.4%) of comments made by teachers referred to textbooks, all of them negative in tone. Some teachers commented that the textbooks contained content unrelated to Project Maths and/or the syllabus, and/or being of poor quality; others indicated a lack of funds to purchase textbooks. It was also reported that there is a lack of textbooks for certain years and levels: for example, Foundation level; Third Year 'honours' level. A few teachers noted that the style of material covered by the textbooks differed to what was covered in CPD for Project Maths.

Examples of comments made on Textbooks:

From my observation schools continue to use 'old' text books which do not contain the new approaches to maths. When asked why they are using 'old' books the common reply is financial due to lack of money in the school to buy the new books. This is a particular shame especially for children with learning difficulties as most of these aren't even in colour! The weaker students lose out. The stronger students will get by.

The main problems I see are the text books do not have the style of material that was covered at the inservices from project Maths. This is misleading for students and teachers.

There's no book for foundation level maths. Students in our school like the 'This is how to do it' approach.

Theme 2b – Professional Development

The majority of teachers who made comments on professional development (3.6% of all comments concerned this theme, 88.9% of them negative in tone) reported inservice training being of poor quality. However, the fact that a small number of teachers made comments to this effect indicates that teachers' experience of inservice development was largely positive, and negative experiences were relatively isolated. Some teachers reported wanting more inservice and some felt that it did not adequately prepare them to teach Project Maths. Teachers suggested that inservice for junior and leaving cert should have been separated into different days. Teachers also commented on marking schemes being unavailable at the time of inservice. A small proportion of comments were positive in nature. Overall, these comments contrast with data shown in Table 6.2, where 82% of teachers agreed that they found the professional development workshops useful.

Examples of comments made on Professional Development:

The inservice was very poor. It did not prepare you for the course.

Some things done at inservice can be unrealistic to achieve in class.

Inservice was excellent. I have always used problem solving techniques in my teaching of maths - use of maths competencies and quizzes and fun type problems solving. If students enjoy the subject math then it is easy to learn.

In services should be split into two groups for teachers of junior cert and teachers of leaving cert maths. As a teacher of junior cert ord level maths not all inservices are relevant to me.

Theme 2c – Resources in General

A majority of comments under this theme (which comprised 3.0% of all comments, 78.3% negative in tone) concerned funds available to spend on resources. Some teachers commented that their school had limited resources whilst others reported having many resources available. A number of teachers made positive comments on the usefulness and quality of resources.

Examples of comments made on Resources in General:

Lack of resources available to me to use and how to use them means that I cannot try new things.

As a trainee teacher, I feel that project maths and the project maths web site, provides me with an abundance of highly useful resources. Without these resources, I would have a lot less confidence in my ability to teach maths.

Once the implementation process is over we (teachers) really need the Project Maths Development Team to continue their work. The materials they produce are excellent and regardless of teachers views on Project Maths everyone I have talked to comments on the quality, standard and usability of the resources.

Theme 3 – Phased Implementation

Over one-quarter (26.8%) of all comments referred to the *phased nature of the implementation of Project Maths*, with 92.1% of such comments being negative in tone. Comments on implementation were more prevalent among teachers in other schools (28.2%) compared with teachers in initial schools (19.3%).

Most teachers who made comments on implementation disagreed with Project Maths being implemented in a phased manner. Teachers viewed implementation in this way as being unfair on senior cycle students who may not have acquired the knowledge or skills needed for the new course during junior cycle. Teachers generally felt it would have been better to introduce Project Maths initially to first years (and implement it upwards from there).

Examples of comments made on Implementation:

The way in which project maths is being introduced is proving to be a major challenge. If it had been introduced in first year only it would have been more manageable as it would give the students the chance to use the terminology from the beginning.

It is difficult to implement at senior cycle when students have not had the grounding in certain topics at junior cycle. It would have been better to have started in 1st yr only.

The staggered nature of the implementation of Project Maths course is the single most challenging thing I have endured since beginning teaching. It's highly confusing for students and teachers!

Better if introduced for 1st years only. V. good for junior students.

Theme 4 – Literacy and Ability

About one in eight of the comments (13.1%) concerned literacy levels and differences in students' ability more generally. A high proportion (91.8%) of these comments was negative in tone. Some teachers expressed concerns about the use of language in the revised curriculum. Teachers felt that weaker students, students with special needs and non-national students were struggling with comprehension of the material and the wordy nature of some of the questions. They were of the view that Project Maths was a good approach for students of higher ability; however, they felt that some higher-ability mathematics students were now struggling as they also needed good literacy skills in order to read, understand and answer questions. Some teachers perceived a neglect of foundation level in the development of syllabus and CPD materials and resources.

Examples of comments made on Literacy and Ability:

The increased use of language is a big disadvantage, in theory it was a good idea but not in practice.

The language used when phrasing a question poses a major problem for students whose literacy skills would be weak, they can therefore not answer a question they are mathematically capable of doing! This is a major issue! It is something which needs to be addressed if students are to be examined.

Project maths is a good approach for students of good ability and middle of the road students'.

'Total neglect of foundation disgraceful.

Theme 5 – Methodology

These comments relate to teachers' views on the methodologies espoused in Project Maths (2.8% of all comments were under this theme and 61.9% of the comments were negative in tone). Some teachers reported that it was difficult to implement certain methodologies within time and other constraints; other teachers were happy with 'hands-on' approach; and some commented on difficulties in implementing the constructivist approach underlying Project Maths.

Examples of comments made on Methodology:

While the teaching methods advocated with the introduction of Project Maths are very good I frequently had myself reverting back to traditional methods because I'm under a great deal of pressure to get the course covered in the allocated time.

Overall I do think the problem solving aspect of project maths is a very positive step, mixing topics in questions, retaining set procedures to solve questions.

I think the lesson plans given by Project maths are very idealistic. I have found that students are not having the 'eureka' moment. I spent some time with my 1st years on the teaching and learning plan (constructivist approach) for multiplication of fractions which took 2-3 lessons and at the end the students just asked 'why did you not just give us the rule? multiply the top line and multiply the bottom line'. I will not give up but there is more time needed to allow for the discovery learning expected in Project Maths.

Theme 6 – Change

Teachers felt the implementation of Project Maths was a huge change all at once for both teachers and students, particularly those in senior cycle. Many comments under this theme (which comprised 2.1% of all comments, three-quarters of which were negative in tone) indicated that senior cycle students were finding it difficult to adapt to new ways of thinking and new methodologies. Positive comments indicated that teachers welcomed the possibilities offered through Project Maths.

Examples of comments made on Change:

I feel that Project Maths is a very positive development for maths in secondary school. I feel it will really challenge students to think about maths from a broader perspective and change the mentality that maths is one-dimensional - i.e. only one correct answer, method, interpretation. They will learn more also as they will have to be able to explain/defend their answers/method.

At senior cycle students are reluctant to change the way they approach maths and at times find it difficult to work within new methodologies.

I agree with the principles of project maths but the change of content, assessment and teaching methodologies all at once is radical.

Theme 7 – Communication

A small number of comments (1.3%, all negative in tone) concerned communication involving teachers, ranging from informational to consultative. Some of these comments suggested poor communication between teachers and others in the development of Project Maths. Others suggested a lack of information given to teachers and parents on the curriculum changes being made.

Examples of comments made on Communication:

I think parents (and students) are concerned at changes and a lack of information on the curriculum changes, and that little useful public information has been given.

Suggesting that schools were part of 'pilot project' and did little to listen to the comments and suggestions of teachers was a disgrace.

Theme 8 - General Comments

This 'theme' (though not strictly speaking a theme as such) relates to general overall comments about Project Maths. This theme covered 7.5% of comments, 31.6% of which were positive, 54.4% were negative, and 14.0% mixed.

Examples of General Comments made:

I find project maths to be very beneficial in the junior cycle. Students are enthusiastic about it and learn well.

This is a worthwhile initiative, giving students a more practical take on mathematics.

Mathematics is a practical subject. Having innate ability is only a small part of it. Having the interest and confidence to try and work out problems is the key to success. Enjoying homework is very important. Project maths is making a good effort at promoting these gifts.

Whole idea is all over the place. Not impressed by project maths at all.

As a teacher I feel completely let down by the decision makers – education (real education) was very poorly served.

I reserve judgement on Project Maths in terms of it improving mathematical ability. It is more engaging at times for students but I'm not, as yet, convinced of its benefits.

6.6. Key Findings and Conclusions

This chapter presented information on teachers' views on the implementation of Project Maths at junior cycle. Data were collected when the implementation of the new syllabus was in transition, due to its phased design. Comparisons between teachers in initial schools and other schools shows some differences in perceptions about Project Maths. It can be argued that the 'piloting' experience in these initial schools may have brought key issues to the fore, particularly with examination classes, and that these are the issues that need to be addressed in any future evaluation or review of Project Maths.

Close to half of the teachers in our survey (48%) did not know if Project Maths was having a positive impact on students' learning of mathematics (i.e. they responded 'don't know' to the statement 'overall, Project Maths is having a positive impact on students' learning of mathematics'). However, fewer teachers in initial schools indicated that they didn't know (38%), and 45% of these teachers agreed with the statement, compared to 29% in other schools. Overall, these data show that it is too soon for teachers to form an opinion about the impact of Project Maths. Some of the other findings in this chapter (for example, lower levels of confidence with aspects that may be regarded as key to the Project Maths approach, such as problem-solving strategies, differentiated instruction, and student self-assessment) also indicate that any judgements about the success or otherwise of Project Maths will need to be made in the longer term. A counter position for this is that the identification of these issues represents a call for action sooner rather than later.

When asked about their views on specific aspects of Project Maths, teachers were least positive about the phased implementation of Project Maths, new textbooks, clarity of the syllabus learning outcomes, support from the Project Maths Development Team (PMDT), and students' responses to Project Maths. In contrast, teachers generally had positive views on the websites at www.projectmaths.ie and www.ncca.ie/projectmaths, using the syllabus in lesson planning, the Common Introductory Course, the Bridging Framework, and the professional development workshops. They also reported using a greater range of resources in class, and that students now have to do more 'thinking' in class than previously.

Teachers were unsure about some of the specific aspects of Project Maths; in particular, parents' and students' views, resource materials for Strands 1 and 2, the new geometry course, and the Bridging Framework. However, teachers in initial schools were less unsure, and more negative, in their views on students' and parents' responses to Project Maths. On the other hand, teachers in initial schools had more positive views than teachers in non-Project Maths schools on the Common Introductory Course. Teachers in initial schools also indicated that students now have to do more 'thinking' in class to a greater degree than teachers in other schools. That teachers were unsure about students' and parents' views on Project Maths underlines the need for more information from (and for) these two groups. The NCCA is shortly to publish an interim report on Project Maths[33] that will examine students' reactions to the initiative; however, the opinions of parents are not expected to be covered in this review.

Teachers were of the opinion that there had been positive changes in a number of aspects in students' learning, in particular, their understanding of key concepts in statistics and probability, and in geometry and trigonometry, their level of awareness of the relevance of mathematics to other disciplines, their ability to solve real-life problems, and their ability to work collaboratively with one another. Teachers in initial schools perceived significantly greater improvements in five aspects of students' learning. These were their ability to work collaboratively, to explain how they solved problems, to try different strategies, their grasp of fundamental concepts and principles, and the sense of challenge experienced by higher-achieving students. There were no perceived declines in any of the 19 aspects of students' learning that were included in the questionnaire. These early indications of students' learning can be cautiously interpreted as a positive finding.

Confidence levels were high in teaching the statistics, geometry and trigonometry parts of the revised course. Teachers also reported being relatively confident in providing feedback to students, teaching problem-solving in real-life settings, engaging students in practical mathematics, and assessing students. Confidence levels were lower in facilitating the use of concrete materials, analysing problem-solving strategies, supporting students with learning difficulties, engaging students in assessing their own progress, and preparing students for the revised Junior Certificate examination. In a general sense, teachers' reported levels of confidence appear to be rooted in the more traditional aspects of mathematics, i.e. specific syllabus topics, and are lower in areas that reflect newer concerns in the teaching and learning of mathematics.

We also found, perhaps unexpectedly, that teachers in other schools tended to perceive themselves as 'very confident' to a greater degree than teachers in initial schools on a majority of the 14 aspects of teaching Project Maths that we asked about. Why this is the case is not clear. It could be that participation in Project Maths during its initial phase gave rise to a process of questioning and reflection, and with that, some self-doubt, which did not occur to the same degree in schools that did not participate in the developmental phase of Project Maths.

When asked about the challenges that they perceived in implementing Project Maths in their schools (based on a list of 12 aspects), teachers in both initial schools and other schools indicated that the time available (both inside and outside of mathematics classes), the phased implementation, the rate of implementation, assessment materials available, and the literacy demands of the revised courses presented difficulties, in that at least 40% of teachers in both initial

[33] This report is expected in November 2012.

and other schools rated these as significant challenges. In addition, between 20% and 40% of teachers indicated that teaching materials and resources available and students' reactions to Project Maths were major challenges. Generally, teachers in initial schools were more inclined than teachers in other schools to identify these aspects as major challenges, though particularly so with respect to time, assessment materials, and parents' and students' reactions. Overall, these results indicate that the most significant challenges faced by teachers focus on organisational aspects, with the exception of literacy demands of the revised syllabi.

Just over one-third of teachers (35%) made written comments on Project Maths, and these were categorised into 12 themes/sub-themes, the content of some of which overlapped. The five most common themes identified were *phased implementation, literacy and ability, syllabus, time,* and *examinations.* The content of these mirror the challenges identified by teachers (previous paragraph). A large majority of these comments (87%) were negative in tone, despite the fact that teachers with overall positive and negative views of Project Maths were equally likely as one another to make written comments. However, other parts of the questionnaire gave teachers ample opportunity to indicate positive views on the initiative. In using these results for future planning for mathematics teaching and learning, it would seem important to focus on those that are pedagogical rather than structural or organisational. For example, future CPD should include a focus on the literacy needs of students, the nature of mathematical literacy, and the value of extracting mathematical information from overall context, which is an important (if not essential) part of the process of mathematical modelling.

Teachers were almost unanimous in their view that implementation should not have been done on a phased basis, with a strong preference for starting at First Year, and working upwards from there. There was concern that the current cohort of senior cycle students lacked the foundation skills to tackle the new course. There was also relatively widespread concern about the challenges that the literacy demands of the new course presented to students of lower ability, with special needs, and with another first language. Some teachers commented on the lack of resources for Foundation level. Many teachers were of the view that the revised syllabus was too long and that the removal of choice from the examinations put them under pressure to cover material. The general view here was that the balance between quantity, or breadth, and quality, or depth, had not been achieved. Other themes to emerge were some negative views on textbooks (e.g. no coloured texts for lower-ability students; differences between texts and material covered during CPD for Project Maths), support for the teaching methodologies of Project Maths with an acknowledgement that these were difficult to implement under time and examination-related constraints, the large and radical changes necessitated by Project Maths, and the need for continued support from the PMDT to implement Project Maths.

Taken together, the quantitative and qualitative findings concerning Project Maths indicate that while teachers regard some aspects of the implementation of the initiative as being positive, particularly as they relate to teaching and learning practices (e.g. use of ICTs, small group work), significant challenges remain. Many of the challenges reported by teachers can be related to structural aspects of the education system and the perception that it would have been preferable to implement Project Maths on a non-phased basis.

7. Conclusions and Recommendations

7.1. Introduction

This report is based on a survey of a nationally representative sample of mathematics teachers and mathematics school co-ordinators (a co-ordinator being the staff member with overall responsibility for mathematics in the school). Just over 1,300 teachers in 180 schools took part in the survey, which was implemented as part of Ireland's administration of PISA 2012.

The survey aimed to provide a reliable, representative and up-to-date profile of mathematics teaching and learning in Irish post-primary schools; to obtain quantitative and qualitative information on teachers' views on the implementation of Project Maths; and to make findings available in an accessible format and timely manner.

While achievement data for the students who took part in PISA 2012 will not be available until December 2013, the results in this report aim to paint a picture of mathematics education in Irish post-primary schools at a time of considerable curricular change. When achievement results do become available, it will be possible to link them with the data presented in this report, and to compare the achievements of students in the 23 schools that participated in the initial phase of Project Maths ('initial schools') with other schools. We will also be able to compare students' performance in PISA 2012 with achievements in previous cycles of PISA, in order to examine whether or not the decline in performance levels found in 2009 relative to previous cycles has continued through to 2012. However, it is too early to expect that Project Maths will have had a systematic impact with respect to PISA mathematics achievement, given that its implementation is still underway: it will be 2017 before the first cohort of students studies mathematics under the new curriculum right through post-primary school (from First to Sixth Year).

This chapter does not attempt to provide a summary of main findings; readers are referred instead to the end parts of the previous chapters. Rather, the aim here is to draw findings together in order to make some conclusions and recommendations. Some of the recommendations are aimed at teachers and school principals, while others are aimed in a more general way at the level of the system.

7.2. Conclusions and Recommendations

There are three major aspects of Project Maths that, in our view, run throughout this report:

- the implementation of Project Maths at the same time at both junior and senior cycles within a relatively short timeframe;
- the content of the new curriculum (including what is not included); and
- the assessment and certification of students under the new curriculum.

These may be worth keeping in mind as we draw conclusions under the headings of *implementation and time; grouping, syllabus and assessment; professional development for teachers; literacy; use of tools and resources;* and *parents and other stakeholders.*

Some of our recommendations are made with the expectation that Project Maths will be subject to review and refinement as implementation progresses, and in light of issues raised in this report (see Chapters 1 and 2) and elsewhere.

In reflecting on our recommendations, it should be borne in mind that these arise from the literature review and our survey of teachers. Views of other stakeholders, particularly students and parents, should also be taken into account as the implementation of Project Maths progresses. Empirical data on the mathematics achievement of students studying under the new curriculum will be necessary in order to fully evaluate the efficacy of the Project Maths initiative. The NCCA-commissioned interim report (expected in November 2012) will provide some of this information by describing the achievements and attitudes of students in initial schools and other schools. Also, as noted in Chapter 6, how Project Maths was introduced (at both junior and senior cycles and in the wider context of economic recession) can be expected to impact on any overall views on the initiative.

7.2.1. Implementation and Time

The decision to implement Project Maths at both junior and senior cycles at the same time remains a very unpopular one among teachers, and arguably colours views on the initiative as a whole. Lubienski (2011) noted this in her study, and it emerged again as a major theme in the current survey. It appears that this two-prong implementation strategy has given rise to several secondary problems, some of which are related to a lack of time. The NCCA has pointed out that previous experience with changes made to Junior Certificate mathematics (from 2000) did not result in sustained changes in classroom practice and where change did take place, it tended not to have an impact at Leaving Certificate. It was recognised that, unless the desired change in emphasis in teaching and learning approaches was reflected in a corresponding change in the examinations at both junior and senior cycles, it was unlikely to succeed (NCCA, 2006).

Consistent with the literature review in Chapter 2, teachers in our survey reported considerable time pressures, not only to come to grips with new materials and teaching approaches at both junior and senior cycles, but also to cover a course that they perceived to be too long and too broad. However, the implementation of the new framework for junior cycle (DES, 2012), in which the numbers of subjects taken by students is to be capped, and the numbers of teaching hours for mathematics can be expected to increase, is likely to go some way towards addressing this issue. The perceived lack of availability of textbooks and sample papers that was noted by teachers in our survey and elsewhere (e.g. Lubienski, 2011), could also be traced back to the demands on the system – not only on schools but also the NCCA and the SEC – to adhere to this 'two-prong' approach within a short timeframe.

Although implementation is already well underway in a wider context of significant financial constraints, any future changes of this nature and scale may benefit from a reflection on the experiences of the implementation of Project Maths from the viewpoints of teachers and students, as well as those responsible for implementation, while at the same time maintaining a sense of realism with respect to time, financial and other constraints. In this sense, Project Maths offers a model for change which can be refined and built on.

1. We recommend that lessons be drawn from the implementation of Project Maths with respect to any future policies or initiatives that entail changes to curriculum and assessment, and particularly with the implementation of the new framework for junior cycle. *(System)*

A second way in which time arises in our consideration of our results is the tension that emerges between implementing new, active teaching approaches within the instructional time that is available. This was identified by teachers in our survey as a major challenge, although there is emerging evidence (discussed in Chapter 2) that, as familiarity with the revised courses increases, teachers' use of time is perceived to be more efficient and effective. In line with the *National Strategy to Improve Literacy and Numeracy Among Young People* (DES, 2011), the Department of Education and Skills sent circulars to schools in 2011 and September 2012 (Circular Numbers

0058/2011 and 0027/2012) asking that every effort be made to provide students with a mathematics class every day, particularly at junior cycle.

2. It is recommended, in addition to the objective to increase the number of mathematics classes to five or more per week as specified in the *National Strategy to Improve Literacy and Numeracy Among Young People* (DES, 2011), that timetabling arrangements for mathematics in post-primary schools are reviewed with a view to establishing whether or not longer single or double class periods would be the most appropriate way in which to deliver the mathematics curriculum. A review of timetabling arrangements should also be accompanied by changes in what is done during the increased time with respect to teaching and learning approaches. *(Schools and System)*

7.2.2. Grouping, Syllabus and Assessment

Ability grouping ('streaming' or 'setting') for mathematics class is very widespread in the Irish post-primary education system, according to the results of our survey. The overall picture points to an issue that is structural or systemic. The consequences of ability grouping have been well-documented elsewhere, with strong national and international evidence pointing to negative consequences for lower-ability bands, with few corresponding gains for higher-ability groups (e.g. Smyth & McCoy, 2011; Smyth, Dunne, Darmody & McCoy, 2007). Research on the use of mixed-ability teaching approaches for mathematics (e.g. Boaler, 2008; Linchevski & Kutscher, 1998) provides promising evidence for the benefits of mixed-ability peer learning outcomes in mathematics (relative to more traditional approaches). However, building up a co-operative learning culture can be difficult to achieve, and easy to dismantle (Boaler, 2009). Teachers in initial schools reported more frequent use of these kinds of approaches than teachers in other schools, which is a positive finding, and is an early indication that some of the challenges presented by Project Maths may be possible to overcome with time.

3. We recommend that a better balance be struck between ability grouping for mathematics classes and the strategic use of mixed-ability teaching approaches. Such teaching approaches can be promoted through dissemination of practices that have been found to be effective in Ireland (for example in initial Project Maths schools), as well as through an examination of practices suggested in international research. *(Schools)*

In our view, the widespread nature of ability grouping for mathematics also points to a need to review the content and length of the syllabus on one hand, and the structure of the mathematics Certificate examinations on the other. This is particularly so if it is an aim of Project Maths to increase the numbers of students studying mathematics at Higher level. However, aiming to increase Higher-level uptake is, in our view, insufficient in the absence of a focus on increasing mathematics standards across all ability levels. The SEC has described the setting of standards for the Leaving Certificate as follows (SEC, personal communication, August 2012):

> The approach taken is sometimes described as a 'college of professionals' approach. In the first instance, a group of people who are deemed to have an expert knowledge of what the students in the target audience ought to be able to achieve in the subject concerned reach a consensus regarding the content standards of the syllabus. This is achieved through the various committees in the National Council for Curriculum and Assessment (NCCA), which are representative of teachers and other subject experts including third level and industry. […] These… are then put into effect as a set of performance standards by the State Examinations Commission (SEC), through the preparation of sample papers [in collaboration with the NCCA and DES] and subsequent examinations.

There is evidence that this approach to standard-setting is not sufficient, as it appears to result in some anomalies. For example, it was found in PISA 2003 that 10.5% of students taking Higher level mathematics for the Junior Certificate had a PISA mathematics score that was at or below Level 2, which is considered to be below a minimal level of competency (Cosgrove et al., 2005). While we would not expect perfect alignment with these two measures of mathematical achievement, it is nonetheless of concern that a small proportion of students taking Higher level mathematics performed at a minimal level on the PISA assessment of mathematics.

Our survey results also recorded a substantial drop in the percentages of students studying higher level mathematics in Fifth Year (31%) compared with Sixth Year (20%). Furthermore, a review of the PISA results for mathematics in 2003 and 2009 suggest a decline in mathematics achievement that is more marked among high achievers than those at the lower end of the achievement distribution. Thus, apart from a potential misalignment between syllabus levels studied and standards associated with the syllabus levels, there is also some evidence that high-achieving students in Ireland are not achieving their full potential in mathematics.

It is likely that some aspects of Recommendations 4, 5 and 6 will occur with the implementation of the new framework for junior cycle. However, it is important that the focus on mathematics is not 'lost' within the wider junior cycle reform agenda.

4. The Junior and Leaving Certificate mathematics examinations should be systematically reviewed in light of the implementation of all five syllabus strands, in 2014 for Leaving Certificate, and 2015 for Junior Certificate, and ideally on an ongoing basis. The review should concentrate on (i) the match between syllabus content (both concepts and skills) and its assessment, with the aim of ensuring that these are in line with one another, (ii) the extent to which senior cycle mathematics builds smoothly and successfully on what is covered during the junior cycle, and (iii) what improvements might be made to delivering the curriculum in classrooms. To support this, consideration should be given to the production of a Chief Examiner's report at both Junior and Leaving Certificate levels on an annual basis in the short to medium term. *(System, with input from Schools)*
5. To ensure continued consistency in the standards associated with the Junior and Leaving Certificate mathematics examinations, ongoing comparisons between examination performance and standardised measures of mathematics achievement, including, but not limited to, PISA mathematics, should be made, and, where appropriate, discrepancies in performance should be identified and examined. The proposed implementation of standardised testing of Second Years under *National Strategy to Improve Literacy and Numeracy Among Young People* (DES, 2011) is a further potential data source with respect to this recommendation. *(System)*
6. Students should receive active encouragement from junior cycle onwards to achieve their potential in mathematics. The decision to take mathematics at Ordinary level should be made with care and consideration not only of students' abilities and interests, but also with respect to their future plans for education and work. The Department of Education and Skills should develop guidelines to help schools allocate students to the most appropriate syllabus level at junior cycle that are based on both needs/interests, and objective evidence, such as performance on a standardised test. Schools should develop a policy to promote take-up of Higher Level mathematics in senior cycle that includes active encouragement and support for students in Fifth Year. *(Schools and System)*

Some of the commentary on Project Maths that was described in Chapter 2 has been critical of aspects of the content of the Project Maths syllabus. In broad terms, this boils down to a perceived over-emphasis on real-life, everyday problem solving, and too little emphasis on more formal or technical mathematics, such as topics covered in calculus, vectors and matrices. Some of the comments from teachers in our survey would support this view. There is a concern that the revised course will not adequately prepare students who wish to enrol in third-level courses with more specialised or applied mathematical content. It was also noted that only about 2.5% of the Leaving Certificate cohort take Applied Mathematics as a Leaving Certificate subject (www.examinations.ie).

7. We recommend that an overall priority in moving forward is to obtain further clarity with respect to the purposes of mathematics education at post-primary level. The review process proposed under recommendation 4 should be extended to reconsider the content and skills underlying the revised mathematics syllabus with a view to ascertaining the appropriateness of the balance between everyday and formal mathematics. The review should gather information on the mathematical demands of some of the most popular third-level courses to determine whether a better match between post-primary and third-level mathematics is possible or desirable; it should also consider what third-level institutions are doing in order to adapt to the changes at post-primary level in order to improve delivery of their courses. The review will need to consider the place of Applied Mathematics within post-primary mathematics education in general. *(System, with input from Schools)*

7.2.3. Professional Development for Teachers

Our findings indicate that somewhere between 15% and 32% of teachers who currently teach mathematics may lack the appropriate qualifications to do so effectively. This issue has already been flagged by researchers at the University of Limerick (Uí Ríordáin & Hannigan, 2009), though results of a recent Teaching Council survey of teachers suggest that the problem may not be as widespread as suggested in the UL report (DES press release, September 29, 2011). The results of our survey are closer to the Teaching Council survey than to those in the UL report.

As noted in Chapter 2, a welcome development is the commencement of a new Professional Diploma in Mathematics for Teaching which is funded by the Department of Education and Skills. The course is expected to run each year over three years, and already, the figures point to its need, with almost two teachers (750) applying for every one place on the course (390) (DES press release, September 22, 2012). It is also noteworthy that consecutive teacher education is to be extended from one to two years from 2014 in light of the Literacy and Numeracy Strategy (DES, 2011).

Our survey also found that high numbers of teachers were of the view that their initial teacher training/third-level studies did not adequately prepare them for some aspects of their work as mathematics teachers, particularly in the areas of the mathematics assessment and mathematics teaching methods; literacy also emerged as an aspect of the teaching and learning of mathematics in need of more attention (see also the next section). It is reasonable to argue that substantial support is required to make the changes to teaching and learning suggested by Project Maths. There is plenty of evidence that supports the importance of high-quality teacher education (e.g., Gilleece et al., 2009; Smyth & McCoy, 2011). Some of the reported difficulties in attending formal continuing professional development (CPD) courses could be circumvented through the provision of flexible online courses. Another important trend in CPD is the engagement of teachers in professional development activities within their schools e.g., they identify an issue and then seek to find solutions (e.g., Gilleece et al., 2009).

8. Future CPD opportunities should include a focus on mathematics teaching methods, the assessment for and of mathematics, mathematical literacy, and the importance of extracting mathematical information from context as part of the overall process of mathematical modelling. As many as possible of these should be offered in the form of flexible online resources and training modules. *(System and Schools)*
9. Teachers of mathematics should be encouraged to identify gaps in their professional development and/or understanding of mathematics teaching, learning and assessments, and schools should seek to support them in addressing these gaps. *(Schools, with input from System)*

7.2.4. Literacy

A major theme to emerge in this study, more so, perhaps than in existing research and commentary on Project Maths, concerns the perceived literacy demands of the revised mathematics syllabus, which challenges teachers and students alike. Teachers' concerns for students focused on those with lower achievement, learning difficulties, and/or a first language other than English or Irish. In general, teachers felt that middle- to high-ability students would be able to manage the revised syllabus. Some drew attention to the fact that there is a lack of resource materials for students studying Foundation level mathematics, though it was noted in Chapter 2 that while the revised junior cycle curriculum now no longer includes a Foundation Level syllabus, the Junior Certificate Foundation Level examination has been retained.

10. It is recommended that increases in the amount of instructional time as described in *National Strategy to Improve Literacy and Numeracy Among Young People* (DES, 2011) be accompanied by a strategic approach to organising mathematics instruction within the allocated time that incorporates teaching mathematical literacy (i.e., the language and procedures of mathematics and mathematical problems; communicating mathematical thinking and ideas) to students who need it. Mathematics teachers should have primary responsibility for this. *(Schools)*
11. The DES/NCCA should clarify the role and purpose of Foundation level mathematics at both junior and senior cycles, and review its provision of guidance and materials specifically as they relate to students with lower levels of literacy. *(System)*

7.2.5. Use of Tools and Resources in Delivering Project Maths

Our survey found that teachers tended to use textbooks to a considerable degree in planning and conducting their teaching and learning activities; they also commented, consistent with previous research reported in Chapter 2, that appropriate textbook resources were lacking. The NCCA recommends against the over-reliance on textbooks as teaching and learning resources, and the Project Maths website (www.projectmaths.ie) includes a range of teaching resources, including handbooks, learning plans, student CDs, example questions and tasks, and reference books and websites. However, information on how these resources might be used in an integrated way is lacking.

12. It is recommended that the DES/NCCA further clarify how the resources available to teachers and students may be used with one another and in conjunction with textbook resources. Some re-organisation of these resources may be required to achieve this. *(System)*

Teachers in Project Maths initial schools reported markedly higher usage of ICT resources during mathematics classes, particularly software, both general and mathematics-specific. It was noted in

Chapter 2 that some of the CPD emphasised the use of ICTs in teaching and learning, and it is very encouraging that teachers in initial schools appear to have incorporated these tools into their classroom practices quickly, and in a manner that can only be described as widespread. However, we do not know which tools and practices are associated with more and less effective teaching and learning approaches.

13. It is recommended that the use of ICTs in teaching mathematics be examined carefully with a view to identifying those tools and strategies that are most effective in achieving teaching and learning goals, and that these are worked into the suite of resources available to all mathematics teachers. *(System and Schools)*

7.2.6. Parents and Other Stakeholders

We noted that the views of parents on Project Maths were absent from existing research and commentary on Project Maths. The fact that teachers, particularly those in the initial schools, were of the view that a large minority of parents and students may not be happy with aspects of Project Maths, is a potential cause for concern. There are only limited resources for parents at present. The NCCA's website includes information for parents under Project Maths FAQs[34]; there are also introductory courses for parents (e.g. www.careerguidance.ie), though these are not available on a widespread basis. It may well be that many parents do not yet have an informed opinion on Project Maths, and/or are unsure about its content and objectives, and how best to support their children's mathematics learning. Media coverage of the initiative, some of it negative, may be an influence here.

There is also the potential for more collaboration between the post-primary and third-level sectors with respect to achieving the objectives of Project Maths, particularly in the promotion of interest in mathematics and an awareness of the importance of mathematics across a range of third-level disciplines. There are already some instances of this which could be built on further. For example, Engineers Ireland's STEPS programme, established in 2000, works in partnership with the DES to encourage positive attitudes towards science, technology, engineering and mathematics (STEM) disciplines, and increase awareness about these disciplines (see www.steps.ie).

14. We recommend that a campaign be implemented for parents, as one of the key stakeholders in education, whereby: (i) they are informed about Project Maths – its aims and objectives; (ii) they have an opportunity to voice their opinions about Project Maths, and have these opinions heard; (iii) they are encouraged to play an active role in their children's mathematics education through the promotion and dissemination of practical tips and examples; and (iv) schools encourage and facilitate parental involvement in their children's mathematics education in ways that suit local needs. *(System and Schools)*
15. It is recommended that the DES develops a strategy to mobilise and utilise support from the third-level education sector in order to further develop the aims and objectives of Project Maths, particularly in fostering an interest in and awareness of the importance of mathematics, and in the provision of clear, relevant information on the mathematics content and skills requirements of various STEM disciplines. *(System)*

[34] http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Project_Maths/Information_on_Project_Maths/Parents_info_note.pdf.

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Technical Appendix

This Appendix contains technical background information on the analysis procedures used to report results. It is likely to be of relevance to readers with an interest in the analysis methodologies underlying the results.

A.1. Sample Design, Response Rates and Computation of Sampling Weights

Like any large-scale educational assessment, it is important that the sampled schools, teachers and students are representative of their respective populations. Schools were sampled first, with probability proportional to size (with larger schools having a higher likelihood of being sampled). Prior to sampling, schools were grouped by the enrolment size of PISA-eligible (15-year-old) students and school sector (community/comprehensive, secondary, and vocational). Small schools had 40 or fewer PISA students enrolled; medium ones had 41-80 students enrolled, and large schools had 81 or more students enrolled. In addition, all 23 schools that participated in the initial stage of Project Maths were included in the sample. This resulted in ten strata or clusters of schools:

- Size 41-80 / Community/Comprehensive
- Size > 80 / Community/Comprehensive
- Size <=40 / Secondary
- Size 41-80 / Secondary
- Size > 80 / Secondary
- Size <=40 / Vocational
- Size 41-80 / Vocational
- Size > 80 / Vocational
- Project Maths initial schools.

Within each cluster, schools were sorted by the percentage of students whose families are eligible for a medical card (split into quartiles), and the percentage of female students enrolled (also split into quartiles).

Once schools were sampled, students were sampled at random within each school. However, the focus of this section is a description of the sample of teachers and mathematics school co-ordinators, so the remainder discusses these respondents, rather than the students that participated.

The sample of mathematics teachers was defined as *all teachers of mathematics in the school.* Therefore this included mathematics teachers of both junior and senior cycles, although the teacher questionnaire focused on junior cycle in some sections, since the majority of PISA students were in junior cycle at the time of the assessment. At the beginning of the administration of PISA, school principals were asked to provide the ERC with the total number of mathematics teachers in the school, and the numbers of questionnaires were sent out were based on this information. However, it emerged that, in 32 of the 183 participating schools, more teachers returned questionnaires than expected (i.e. the total number of returns was more than the expected number of mathematics teachers). In these schools, the total number of mathematics teachers was adjusted to equal the total number of returns, or else the response rate would have exceeded 100% for those schools.

It is estimated, therefore, that there were 1645 mathematics teachers in participating schools. Of these, 1321 returned a questionnaire, which constitutes an acceptable response rate of 80.3%. On average, 7.2 questionnaires were returned per school, and school-level teacher response rates ranged from 7% to 100%.

In all analyses of the teacher questionnaire, data are weighted by a teacher weight. This consists of four components, and ensures that the reported results are representative of the population of mathematics teachers in Ireland. The first component, the school base weight, is the reciprocal of the schools' probability of selection. The second, school non-response adjustment, is an adjustment that is applied to account for the fact that two of the 185 sampled schools did not participate. The third component is an adjustment to take the over-sampling of initial schools into account; if this were not done, initial schools would contribute disproportionately to estimates for the sample as a whole. The fourth component is a teacher non-response adjustment. Since each mathematics teacher has a selection probability of 1, it is necessary only to compute the non-response adjustment, which is the number of returned questionnaires divided by the number of expected questionnaires. In summary, the teacher weight = school base weight * school non-response adjustment * oversampling adjustment for initial schools * teacher non-response adjustment. For analyses in this report, the normalised teacher weight is used; that is, the population weight adjusted in order to return the same N as the number of respondents. The normalised rather than the population weight is used in order to avoid artificially inflating the power of analyses.

The sample of mathematics school co-ordinators (and hence the computation of the weights) is more straightforward than that of mathematics teachers, since there was only one co-ordinator per school. In total, 171 co-ordinators returned a questionnaire, which constitutes a highly satisfactory response rate of 93.4%. The mathematics school co-ordinator weight was computed as the school base weight * co-ordinator non-response adjustment. As with the analyses of the teacher questionnaire data, the normalised school co-ordinator weight is used in all analyses in this report.

A.2. Correcting for Uncertainty in Means and Comparisons of Means

We surveyed a sample of mathematics teachers rather than the whole population of mathematics teachers, estimates are prone to uncertainty due to sampling error. The precision of these estimates is measured using the standard error, which is an estimate of the degree to which a statistic, such as a mean, may be expected to vary about the true (but unknown) population mean. Assuming a normal distribution, a 95% confidence interval can be created around a mean using the following formula: Statistic ± 1.96 standard errors. The confidence interval is the range in which we would expect the population estimate to fall 95% of the time, if we were to use many repeated samples. For example, the mean perceived change in students' interest in mathematics shown in Chapter 6, Table 6.4 of this report is 0.338, with a standard error of 0.023. Therefore, it can be stated with 95% confidence that the population mean for perceived changes in students' interest in mathematics lies within the range of 0.293 to 0.383.

To correct for the uncertainty or error due to sampling, we have used SPSS® macros developed by the Australian Council for Educational Research (ACER). The standard errors were computed in a way that took into account the complex, two-stage, stratified sample design. The macros incorporate sampling error into estimates of standard errors by a technique known as variance estimation replication. This technique involves repeatedly calculating estimates for N subgroups of the sample and then computing the variance among these replicate estimates. The particular method of variance estimation used was Jackknife N. Variance estimation replication is generally used with multistage stratified sample designs, and usually has two units (in this case, schools) in each variance stratum. In the case of the teacher data, there were 90 variance strata, and there were 85 such strata for the mathematics co-ordinator data. Using the particular Jackknife method, half of the sample is weighted by 0, and the other half is weighted by 2. For more information on this and related techniques, see Brick, Morganstein, and Valliant (2000); the PISA data analysis manual (second edition) also provides a good overview of the rationale and implementation of this family of methods (OECD, 2009).

A.3. Constructing Questionnaire Scales from Responses to Individual Questions

In Chapter 5 of this report, we presented results relating to four scales which we constructed on the basis of teachers' responses to individual items on the teacher questionnaire. Each scale has an overall mean of 0 and a standard deviation of 1. These scales were created using principal components analysis in SPSS® (see, e.g. Hutcheson & Sofroniou, 1999), initially through exploring the characteristics of the item batteries as a whole, then establishing which items 'fit together' best with each other. Table A1 shows the factor loadings and reliabilities for two scales concerning general views on mathematics (fixed views of mathematics and constructivist/applied views of mathematics; see also Tables 5.1 and 5.2), while Table A2 shows the factor loadings and reliabilities for two scales concerning views on ability grouping (support for ability grouping and awareness of potential negative effects of ability grouping). It should be noted that the scale reliability for the fixed view scale (.42) is low, while the reliability for the constructivist/applied view scale is acceptable (.69) (Table A.1); scale reliabilities for the two scales on ability grouping are acceptable to good (.81 for the support for ability grouping scale and .68 for the potential negatives of ability grouping scale; Table A.2) (see DeVellis, 1991).

Table A.1. Factor loadings and scale reliabilities for the two scales concerning general views on mathematics

Items on fixed views of mathematics scale	Factor Loading	Items on constructivist/applied views of mathematics scale	Factor Loading
Some students have a natural talent for mathematics and others do not	.414	There are different ways to solve most mathematical problems	.520
If students are having difficulty, an effective approach is to give them more practice by themselves during the class	.347	More than one representation (picture, concrete material, symbols, etc.) should be used in teaching a mathematics topic	.587
Mathematics is a difficult subject for most students	.496	Solving mathematics problems often involves hypothesising, estimating, testing and modifying findings	.587
Few new discoveries in mathematics are being made	.609	Modelling real-world problems is essential to teaching mathematics	.730
Mathematics is primarily an abstract subject	.525	To be good at mathematics at school, it is important for students to understand how mathematics is used in the real world	.711
Learning mathematics mainly involves memorising	.613	A good understanding of mathematics is important for learning in other subject areas	.609
Scale reliability (Cronbach's alpha)	.419	Scale reliability (Cronbach's alpha)	.691

Table A.2. Factor loadings and scale reliabilities for the two scales concerning views on ability grouping

Items on support for ability grouping scale	Factor Loading	Items on potential negatives of ability grouping scale	Factor Loading
Allocating students to mathematics classes based on some measure of academic ability is, overall, a good practice	.764	Class-based ability grouping for mathematics has a negative impact on some students' self-esteem	.661
Class-based ability grouping for mathematics facilitates a more focused teaching approach	.743	Class-based ability grouping for mathematics slows the pace of learning of lower-achieving students	.696
Class-based ability grouping for mathematics accelerates the pace of learning for all students	.703	Class-based ability grouping results in lower expectations by teachers of the mathematical abilities of lower-achieving students	.772
Class-based ability grouping is not particularly beneficial for teaching and learning mathematics*	.623	Class-based ability grouping for mathematics benefits higher-achieving students more than lower-achieving students	.727
Mixed-ability teaching in mathematics is beneficial to lower-achieving students	.585		
Mixed-ability teaching in mathematics 'drags down' the performance of higher achievers	.540		
It is possible to teach the mathematics curriculum in mixed-ability settings without compromising on the quality of learning	.615		
The best way to teach the mathematics curriculum effectively is in class-based ability grouped settings	.712		
Scale reliability (Cronbach's alpha)	.810	Scale reliability (Cronbach's alpha)	.679

*Item was reverse coded for the scale

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