The Irish Journal of Education, 2004, *xxxv,* pp. 20-44.

A SURVEY OF MATHEMATICS TEACHERS IN IRELAND

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Teachers of mathematics (n=856) in schools participating in PISA 2003 were administered a questionnaire which asked them about their qualifications and teaching experience, instructional emphasis placed on aspects of Junior Certificate mathematics and PISA mathematics, their general attitudes towards mathematics and calculator usage, and usage of Information and Communication Technologies (ICTs). Results indicate that over 90% of teachers held a Higher Diploma in Education, but that almost 28% studied degree courses which did not include mathematics as a major component. The incidence of ICT usage, by both teachers and students, during mathematics classes is low. Although teachers' reports of instructional activities suggest a low emphasis on transfer of mathematical knowledge to real-life situations, there is tentative evidence, when teachers' responses are compared with those in TIMSS 1995, of a slight decrease in the belief that mathematics is primarily an abstract subject. Teachers' reports of the emphasis given to aspects of the Junior Certificate mathematics syllabus indicate that assessment objectives that are assessed in the Junior Certificate Examination receive higher instructional emphasis than objectives which are not assessed. Some of the areas receiving low emphasis would appear to be important for success in a more literacy-based, contextualized assessment of mathematics such as PISA.

Two contrasting epistemological approaches to mathematics education have been identified: absolutist and relativist (Lyons et al., 2003). Absolutist approaches emphasize an objective, value-free, logical, and consistent discipline (Burton, 1994a). A didactic approach to the teaching of mathematics fits well with this framework. Relativism, in contrast, is characterized by interactions between individuals, societies, and the creation of knowledge, and is seen as subjective, value-laden, and prone to biases (Burton, 1994b). Relativist approaches sit more readily within an instructional approach which emphasizes collaboration and discussion. These contrasting approaches to mathematics education occur within the broader context of the debate on

[1] The authors acknowledge the assistance of Amy Kelly who worked on the development of the teacher questionnaire; David Millar for advice on the weighting of data for analysis; Sarah Zastrutzki for assistance in the preparation of some of the tables; and the PISA national advisory committee for their comments on drafts of this paper.

positivism versus poststructuralism in education (Lyons, Lynch, Close, Sheerin, & Boland, 2003).

Junior Certificate mathematics falls more naturally into the absolutist category and has not been fundamentally revised since the 1960s when elements of 'new mathematics' (which emphasize structure, abstraction, and rigorous presentation) were adopted (Oldham, 2001, 2002). Recently, inservice provision has encouraged and supported teachers to adopt a wider variety of teaching methodologies. Although 'teaching for understanding' is a focus of such training, it is not clear to what extent novel methodologies are used in the classroom. Earlier work (e.g., Commission on the Points System, 1999; Lynch & Lodge, 2002) might lead one to conclude that much instruction in post-primary schools in mathematics and in other subjects is directed at preparing students to do well in public examinations, and tends to be mainly didactic.

Content analyses of mathematics curriculum documents and textbooks carried out as part of the 1995 Third Mathematics and Science Study (TIMSS) indicate some differences in mathematics curriculum and instruction of students in second and third years in post-primary schools (grades 7 and 8) between Ireland and other countries at the time of the study (Schmidt, McKnight, Valverde, Houang, & Wiley, 1997). It should be noted, however, that the TIMSS analyses of textbooks, which described the intended curriculum, relate to an earlier version of the Junior Certificate mathematics syllabus. The revised (2000) syllabus provides much more detail in relation to assessment objectives and topics to be covered.

Findings indicate first, that Irish curriculum guides in place at the time of TIMSS had relatively few statements relating to instructional objectives and fewer guidelines relating to teaching and assessment than other countries. Second, many topics were introduced in Ireland at a lower grade level than the TIMSS median grade level. These included number (exponents and orders of magnitude), measurement (estimation and error), 3-D geometry, patterns, relations and functions, and data representation and analysis. Third, the number of grade levels at which a topic was taught tended to be greater in Ireland than the TIMSS median for several topics, and these again included measurement and aspects of number (estimating computations, exponents, and order of magnitude) and data representation. Fourth, more topics were covered at the higher grade levels in Ireland than in higher-achieving countries such as Korea, Hong Kong, Japan, and the Czech Republic. Higher-achieving countries tended to concentrate on fewer topics at a time and drop more topics at the higher grade levels. The wide range of topics to be covered in the Irish mathematics curriculum is even more daunting when the comparatively short length of the

Irish school year is taken into consideration (see Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996; Oldham, 2001).

More recently, case studies of mathematics instruction have been undertaken in classrooms in 10 Irish post-primary schools (Lyons et al., 2003). Although the results yield rich data, caution should be exercised in generalizing the outcomes due to sample design limitations including sample size. Lyons et al. found a high degree of uniformity in the manner in which mathematics classes were organized and presented. The structure of the majority of lessons comprised teacher demonstration followed by student practice, characterized by a drill-and-practice approach in a highly structured learning environment. (This is consistent with TIMSS 1995, where responses of mathematics teachers in Ireland suggested that mathematics instruction consisted largely of whole-class expository teaching.) Lyons et al. also found that relatively little time was spent explaining lesson aims, and there was some evidence that teachers praised speed rather than understanding. In a comparison of the type and quality of instruction in different tracks (ability groups), instruction in lower tracks was found to be characterized by a slower pace, repetition, and emphasis on basic procedural skills, while instruction in upper tracks was found to be characterized by a fast pace and sense of urgency. The role of teacher expectations in the student-teacher relationship was emphasized by Lyons et al., who observed that expectations of teachers varied according to student gender and social background.

In TIMSS 1995, 50% of students in second year (grade 8) were taught by mathematics teachers who agreed that mathematics was primarily a formal way of presenting the world, and 90% were taught by teachers who agreed that some students have a natural talent for mathematics, while others do not (Beaton et al., 1996). Over 70% of students were taught by teachers who believed that remembering formulae and procedures was very important for success in mathematics. This is the second highest percentage among the countries surveyed. In contrast, just 35% of students were taught by teachers who felt it very important for students to think creatively (third lowest), and 20% by teachers who thought it was very important to understand how mathematics is used in the real world (lowest). In interviews with teachers, Lyons et al. (2003) found views of teachers to be consistent with those found in TIMSS.

In TIMSS, mathematics instruction in Ireland was also characterized by a high frequency of assigning homework, and relatively low use of aids and tools, including computers and calculators (Beaton et al., 1996; Lyons et al., 2003).

The study described in this paper set out to examine the teaching of mathematics in post-primary schools in Ireland based on the responses of mathematics teachers to a questionnaire administered during March 2003 in conjunction with the OECD Programme for International Student Assessment (PISA). The questionnaire, which was administered in Ireland only, was developed for two reasons. First, there was an interest in examining the extent to which teachers in post-primary schools emphasized elements of the PISA mathematics framework (OECD, 2003) in planning for, and teaching, mathematics. Second, there was interest in documenting teachers' views on the implementation of a revised syllabus for Junior Cycle mathematics which was to be examined for the first time in June 2003 (having been introduced in 2000; see DES/NCCA, 2000). The revised mathematics syllabus encourages the use of calculators in mathematics class and permits them in the Junior Certificate mathematics examination. The mathematics curriculum at Junior Cycle, the PISA 2003 mathematics framework, and the performance of Irish students on PISA 2003 mathematics are considered in some detail elsewhere (e.g., Cosgrove, Oldham, & Close, 2005; Cosgrove, Shiel, Sofroniou, Zastrutzki, & Shortt, 2005; OECD, 2003, 2004; Oldham, Close, Shiel, & Cosgrove, 2005) .

Responses to the teacher questionnaire are examined under the following headings: teacher demographics; educational qualifications and training; subjects and programmes taught; classroom activities; use of computers and calculators in the teaching of mathematics; views on the nature of mathematics as a subject; homework and assessment; emphasis placed during instruction on aspects of the Junior Certificate mathematics syllabus; and emphasis placed on aspects of the PISA 2003 mathematics framework.

METHOD

Sample and Response Rates

The defined target population comprised all teachers of mathematics in schools participating in PISA 2003 (both Junior and Senior cycles, full- and part-time), a total of 1,273 teachers in 145 schools.[2] Of these, 856 teachers in 130 schools returned completed questionnaires, yielding a response rate of 67.2%, which is considerably lower than the return rate (91.7%) for the PISA school questionnaire. Hence, caution is required in the interpretation of results since it is possible that non-responding teachers differ in important respects from teachers who responded. The teacher weights, described in the next section, are not designed to control for bias arising from non-response.

[2] Principals were asked to indicate the number of mathematics teachers in the school (full- and part-time) so that the correct number of teacher questionnaires could be dispatched to each; the figure of 1,273 is the sum of these.

Weighting of the Teacher Data

A teacher weight was computed that took school and teacher non-response into account. The weight consists of the product of three components: (i) a school non-response adjustment (the reciprocal of the within-stratum response rate) applied to each explicit sample stratum[3] to account for schools which returned no teacher questionnaires; (ii) a within-school teacher non-response adjustment (the reciprocal of the within-school response rate); and (iii) the school sample weight, which adjusts for differential selection probabilities across sample strata and school non-response in PISA across both explicit and implicit sample strata.[4] Applying this weight to the teacher questionnaire data results in estimates which correspond to the population of all mathematics teachers in post-primary schools in the country, assuming that non-response is random and there are no systematic differences between responding and non-responding teachers.

Match Between Teacher and Student Data

An attempt was made to match teachers anonymously with students through the collection of mathematics class codes on the list of students provided to schools and a question on the teacher questionnaire asking teachers to indicate the class codes of the classes taught. However, owing to the complex nature of the task, a match rate of only 49.0% was achieved. Furthermore, a series of exploratory Pearson chi-square tests comparing matched and unmatched students indicated that students in schools in the small school stratum were significantly under-represented, along with students in Fourth and Fifth year, male students, students in vocational schools, students in designated disadvantaged schools, and students in all boys' schools[5] (in all cases, p .001). The low match rate, together with the differential representation of important sub-groups of the student population, resulted in a decision to take the teacher as the unit of analysis and not to analyse the data disaggregated to the level of students. This means that the responses of teachers cannot be related to student achievements.

[3] There were three strata, based on the number of 15-year olds enrolled: large schools (81 or more students aged 15 years); medium schools (41-80 students); and small schools (1-40 students).

[4] Implicit strata were: school type (secondary, community/comprehensive and vocational) and student gender composition (the percentage of 15-year old females enrolled, split into five categories).

[5] Dependencies among student observations in schools (clustering) suggest that the *p*-values are somewhat conservative.

Other Analysis Issues

For some questions, the rate of missing data exceeds 10 percent. In each case, this is noted in the text since more caution should be applied in interpreting responses to these questions.

To account for the clustered nature of the sample design, standard errors associated with estimates of percentages were computed in WesVar 4.2 (Westat, 2000), using a variance replication method, Balanced Repeated Replication (BRR), or Balanced Half-Samples. The particular variant known as Fay's method was used, which is similar in nature to the jackknife method used in international studies of educational achievement, such as TIMSS (Beaton et al., 1996).

In the questionnaire, respondents were asked which syllabus levels/ programmes they were currently teaching. Some questions asked about a specific programme/syllabus level. To account for the fact that some teachers taught at Junior Cycle only, and some at Senior Cycle only, the responses to such questions presented in the results section apply only to teachers indicating that they were currently teaching a particular programme/syllabus level.

RESULTS

Teacher Demographics

More than half (58.9%) of the sample was female. Almost all teachers (95.6%) were born in Ireland. Teachers reported a mean of 15.9 years teaching mathematics (SE = 0.45; SD = 10.8), and had been teaching in the school they were in at the time of the study for a mean of 13.6 years (SE = 0.48; SD = 10.5). The majority (86.2%) were working full-time.

Teachers' Educational Qualifications and Training

The vast majority (97.0%) of respondents held a bachelor's degree, and just over 80% indicated that it included a component of mathematics (Table 1). Just under 5%, however, said that their degree included mathematics education as a component. About 88% of teachers had a Higher Diploma in Education, and 3 in 10 reported that the course that they took included mathematics, and a similar percentage named mathematics education.[6] Master's and doctoral degrees were less common, with about 1 in 8 holding these qualifications. A comparison of teachers teaching at Junior Cycle and Senior Cycle revealed no appreciable difference in educational qualifications.

[6] It is possible that some teachers interpreted 'maths' to refer to 'maths ed.' here.

Table 1
Percentage of Teachers With Various Qualifications, and Percentage of Qualifications Which Included Mathematics or Mathematics Education

	Obtained		Included mathematics		Included maths ed.	
Qualification	Yes	No	Yes	No	Yes	No
Bachelor's Degree	97.0	3.0	82.2	17.8	4.4	95.6
Higher Diploma in Education or equivalent*	88.4	11.6	29.9	30.1	30.3	69.7
Master's Degree	12.1	87.9	4.3	95.7	2.1	97.9
Doctoral Degree	0.6	99.4	0.1	99.9	0.0	100.0
Other relevant qualification	6.3	93.7	1.6	98.4	0.7	99.3

Note. Percentages for the 'mathematics' and 'maths ed.' are not contingent on the 'obtained' column; all are percentages of the total. Total number of respondents = 848.
*For example, a concurrent degree with education portions of that equivalent to a H. Dip. Ed., or a post-graduate teacher training qualification of at least one year's duration.

About 1 in 12 (8.8%) teachers was studying for a formal qualification at the time of the survey. Approximately 4.2% were enrolled in a master's degree programme; 0.7% in a bachelor's degree course, 0.6% in the H. Dip. Ed. (or equivalent), 0.4% in a doctoral degree programme, and 3.8% in another course.

The 833 teachers who responded to a question regarding the major component of their degrees listed an average of 2.01 distinct subject areas.[7] About 71% said that their qualifications were related to the field of mathematics (i.e., mathematics, applied mathematics, statistics, and maths physics). The majority (96.4%) of mathematics or mathematics-related courses were listed simply as 'mathematics'. About 29% of mathematics teachers did not have mathematics as a major component in their degree, while 25%, 15%, 18%, and 13% had studied chemistry, physics, biology, and geography/geology, respectively. One-third listed arts and humanities subjects, 20% business and economics, and 8% computers and technical courses (Table 2).

[7] Some teachers listed subjects in similar fields; e.g., physics and applied physics. These were recoded into a single subject area since the aim was to find out which major disciplines were studied by teachers for their degrees.

Table 2
Number and Percentages of Teachers Identifying Subject Areas as Major Components of Their Qualifications

Subject Area	N	% of Teachers*
Mathematics, Applied Maths, Statistics, Maths Physics	594	71.3
Chemistry / Applied Chemistry	209	25.1
Physics / Applied Physics	127	15.2
Biology / Applied Biology	149	17.9
Geography or Geology	104	12.5
Agricultural Science	13	1.6
Business, Economics, Accountancy	166	19.9
Computers, Engineering, Mechanics, Technical Drawing	68	8.2
Arts / Humanities (other than Mathematics)	281	33.7
Other Subjects	38	4.6
Total number of respondents	833	--

Note. Categories are not mutually exclusive. Data are unweighted.

Since the item on the questionnaire did not distinguish between courses studied during the final year of the degree and other years, it is not possible to infer the precise nature of the courses studied or the major component of the degrees. However, if one assumes that the *first* subject listed is a reasonable proxy for the main component of teachers' degrees, then the main component for 48.1% of respondents was in the field of mathematics, 10.3% in business/economics, 10.0% in arts and humanities, 9.8% in chemistry, 8.3% in biology, and 5.6% in physics.[8]

In the three years preceding the study, 80.5% of teachers had participated in some form of incareer development relating to mathematics or ICTs in education[9]: 66.0% had participated in training courses provided by the Junior

[8] Unlike the data in Table 2, these data are weighted by the teacher weight.

[9] 10.8% of responses are missing for this question. Unfortunately, the wording of the question does not allow one to compute separate estimates of training in ICTs and mathematics. However, the Junior Certificate mathematics support service and Irish Mathematics Teachers Association courses would have comprised mathematics, perhaps including ICTs in the context of mathematics.

Certificate mathematics support services; 19.6% in a course provided by the Irish Mathematics Teachers Association or a course run in an Education Centre; and 17.8% in some other training course. For teachers reporting some training, the average number of hours received over the three years was 12.7 (SD = 12.8; SE = 0.71).

Subjects and Programmes Taught

The subject other than mathematics most commonly taught by responding mathematics teachers was science (at Junior and Senior cycles) (Table 3). Other commonly-taught subjects include computer studies and business studies.

Table 3

Percentage of Teachers Teaching Subjects Other than Mathematics at Junior and Senior Cycle

Subject	Junior and/or Senior Cycle	Junior Cycle	Senior Cycle
Irish	8.8	7.2	6.2
English	8.4	7.3	4.0
Another language	4.3	3.6	3.2
Science	38.9	34.6	20.5
Business Studies	14.4	14.0	8.1
History	4.1	3.4	1.4
Geography	9.7	9.0	4.9
Computer Studies / ICTs	23.9	17.1	14.7
CSPE	13.2	13.2	0.0
Other	29.3*	12.7	20.7*

Note. Categories are not mutually exclusive. 16.3% of responses are missing on this question. Total number of respondents = 725.
*Some of these responses may be referring to Physics, Chemistry or Biology.

Table 4 shows the percentage of teachers reporting at least one year's experience (including the 2002-2003 school year) teaching each mathematics syllabus level/programme for Junior and Senior cycles. Teachers had most experience of teaching Ordinary-level mathematics at both Junior and Senior cycles (Table 5). While over three-quarters had taught Higher-level mathematics at Junior Cycle, just 42% had taught Higher-level mathematics at Senior Cycle. Experience of teaching Ordinary Alternative or Foundation-level mathematics was also generally lower.[10] Experience of teaching mathematics for the Transition Year Programme and Leaving Certificate Applied course was also comparatively low.

Table 4
Average Number of Years Teaching Mathematics at Junior and Senior Cycles, by Level/Programme

Junior Cycle Syllabus	% Reporting one year or more	Average number of years*
Higher	76.7	12.7
Ordinary	90.5	13.0
Foundation	49.6	6.9
Senior Cycle Syllabus/Programme		
Higher	42.4	12.3
Ordinary	85.6	10.2
Foundation (or Ordinary Alternative)	42.7	5.6
Transition Year Programme	39.6	4.0
Leaving Certificate Applied	16.9	3.1

Note. Percentages are not mutually exclusive. Total number of respondents = 842 for Junior Cycle Syllabus; for Senior Cycle Syllabus Programme = 808.
*This is the average number of years for teachers reporting one year or more of experience teaching a particular level/programme.

About a quarter of teachers (25.6%) had examined (as assistant or advisor) for the Junior Certificate Examination, and 15.6% for the Leaving Certificate Examination.

Classroom Activities

There is little variation across grades in time spent on various activities in Junior Cycle and Leaving Certificate mathematics classes (Table 5). Administration and dealing with behaviour took up about 8 to 10% of class time; presenting new material about a quarter; explaining mathematical concepts and procedures a further 15% or so. Reviewing homework and practising and solving routine problems took up about 45% of class time. Relatively little

[10] Ordinary Alternative was introduced only in 1990 and replaced by Foundation level in 1995.

emphasis was placed on solving problems in real-life situations (5% at Junior Cycle; 4% at Senior Cycle).

Table 5
Percentage of Mathematics Class Time Spent at Various Activities, by Year Level

Activity	1st/2nd/3rd year	5th/6th year
Administration (e.g., roll call)	4.1	4.0
Reviewing homework	17.7	18.2
Presenting new material	23.8	25.7
Explaining mathematical concepts and procedures (whole class or individuals)	15.0	15.3
Having the students practise routine mathematical operations	15.6	14.7
Having the students solve routine problems	12.6	13.0
Having the students practise transfer of mathematical knowledge to solving problems in real-life situations	4.6	4.1
Dealing with student behaviour	6.0	4.1
Other	0.6	0.9
Total	100	100

Total number of respondents = 663 out of a total of 725 respondents who were teaching Junior Cycle students; and 541 to 584 out of a total of 661 respondents who were teaching Senior Cycle students. The percentages are out of the numbers of teachers teaching the relevant cycle at the time of the survey rather than the grand total of 856.

Use of Computers and Calculators in the Teaching of Mathematics

Over a third (37.8%) of respondents agreed or strongly agreed with the statement 'Computers are an important tool for the effective teaching of mathematics'. However, use was relatively infrequent and the range of software employed was quite narrow. Just over four-fifths (81.6%) said that they never used computers during mathematics classes; 16.2% used computers during some lessons, and 2.2% during most or every lesson.[11] The four most commonly used resources by teachers at both Junior and Senior Cycles were mathematics education websites, word-processing software, spreadsheets/graphing tools, and reference software. Use of programming software was much less frequent (Table 6).

[11] 15.1% of responses are missing on this item.

Table 6
Percentage of Teachers Reporting the Use of Various Software Packages During Mathematics Classes, by Year Level

Software Package	1st/2nd/3rd year	5th/6th year
Drill and practice or tutorial software (e.g., Maths-Master Junior Certificate Multimedia Tutorials; Alge-Blaster)	4.3	1.4
Reference software (e.g., DigiLearn maths solutions to examination papers; Encyclopedia CD-ROMs)	8.0	11.2
Mathematics education websites	16.1	14.1
Symbolic packages (computer algebra systems such as LiveMath)	2.2	1.8
Dynamic geometry packages (e.g., Geometer's Sketchpad)	5.9	2.1
Logo-type programming packages	0.4	0.3
General purpose programming packages (e.g., Basic, C++ or Java)	0.6	0.2
Presentation software (e.g., Microsoft Powerpoint)	8.1	5.7
Word-processing software	5.4	12.0
Spreadsheets and graphing tools (e.g., Microsoft Excel)	12.1	8.5

Note. Percentages are reported as percentages of all teachers rather than of those responding to the question, since 58.1% of teachers did not respond to any part of this question and it is not possible to ascertain whether this was because they omitted the question or whether they did not use any of the software listed. The latter is assumed to be the case for the majority of non-respondents. Total number of respondents is therefore 725 at Junior Cycle and 661 at Senior Cycle, and the 'true' level of missing responses is unknown.

In addition to asking teachers about their use of ICTs, they were asked about their students' use of ICTs. The majority (82.9%) reported that computers were never used by students in mathematics classes; 12.8% reported use in some lessons; and just 4.3% in most or every lesson[12]. The most commonly-used resources at Junior Cycle were spreadsheets/graphing tools, mathematics education websites, word-processing software, and presentation software. At Senior Cycle, mathematics education websites, reference software, and spreadsheets/graphing tools were the most commonly-used resources. In all instances, fewer than 10% of teachers reported use by students of the software resource in question (Table 7).

[12] 13.4% of responses are missing on this item.

Table 7
Percentage of Teachers Reporting that Students Use Various Software Packages During Mathematics Classes, by Year Level

Software Package	1st/2nd/3rd year	5th/6th year
Drill and practice or tutorial software (e.g., Maths-Master Junior Certificate Multimedia Tutorials; Alge-Blaster)	2.8	1.5
Reference software (e.g., DigiLearn maths solutions to examination papers; Encyclopedia CD-ROMs)	1.9	5.7
Mathematics education websites	5.2	6.2
Symbolic packages (computer algebra systems such as LiveMath)	0.3	0.3
Dynamic geometry packages (e.g., Geometer's Sketchpad)	1.5	0.9
Logo-type programming packages	0.3	0.2
General purpose programming packages (e.g., Basic, C++ or Java)	0.3	0.2
Presentation software (e.g., Microsoft Powerpoint)	3.2	2.3
Word-processing software	4.6	2.7
Spreadsheets and graphing tools (e.g., Microsoft Excel)	6.8	4.8

Note. Percentages are reported as percentages of all teachers rather than of those responding to the question, since 58.1% of teachers did not respond to any part of this question and it is not possible to ascertain whether this is because they omitted the question or whether they did not use any of the software listed. The latter is assumed to be the case for the majority of non-respondents. Total number of respondents is therefore 725 at Junior Cycle and 661 at Senior Cycle, and the 'true' level of missing responses is unknown.

When asked whether they thought that calculators should be used by students for mathematics homework, just under half of teachers (48.5%) agreed that this should be the case in First year. However, this increased to 77.0% in Second year, and to 93.8% in Third year. The percentages of teachers who agreed that calculators should be used by students in class in First, Second, and Third years, were 51.7, 79.4, and 94.0, respectively. When asked whether they thought that students should use calculators during the Junior Certificate mathematics examination, 53.6% agreed that unrestricted use was appropriate, 40.2% preferred restricted use, and 6.2% were not in favour of calculators being used in the examination.[13]

[13] The rates of missing responses for these questions range from 13% to 18%.

Teachers' Views on Mathematics as a Subject

There was a high rate of agreement on two items when teachers were asked to express agreement/disagreement with seven statements about the nature of mathematics as a subject. The vast majority (92.4%) agreed or strongly agreed that some students have a natural talent for mathematics, while others do not. Close to 95% agreed or strongly agreed that more than one representation should be used in teaching a topic. About 64% disagreed or strongly disagreed that mathematics is primarily an abstract subject. Two-thirds (64.7%) agreed that giving students additional practice by themselves was an effective approach to handling students' difficulties with mathematics topics. About three-fifths agreed or strongly agreed that an understanding of how mathematics should be used in the real world was important in order to be good at mathematics in school, while about two-fifths agreed or strongly agreed that mathematics was a difficult subject for most students. About two-thirds (65.7%) agreed or strongly agreed that an understanding of mathematics was important for other subject areas (Table 8).

Table 8
Cross-Classified Percentages of Teachers' Agreement/Disagreement with Seven Statements About the Nature of Mathematics as a Subject

	Strongly agree	Agree	Disagree	Strongly Disagree	Total
Mathematics in primarily an abstract subject	3.1	33.2	51.6	12.1	100
Some students have a natural talent for mathematics and others do not	27.9	64.5	7.3	0.3	100
If students are having difficulty, an effective approach is to give them more practice by themselves during the class	9.2	55.5	30.8	4.5	100
More than one representation (picture, concrete material, symbol set, etc.) should be used in teaching a mathematics topic	34.4	60.0	5.4	0.2	100
To be good at mathematics at school, it is important to understand how mathematics is used in the real world	13.4	46.4	36.8	3.4	100
Mathematics is a difficult subject for most students	3.0	34.3	58.6	4.1	100
A good understanding of mathematics is important for other subjects	7.3	58.4	32.1	2.2	100

Total number of respondents = 823 to 850.

Homework and Assessment

The majority of teachers said that they assigned homework in most or every lesson to Junior Cycle students, with a somewhat lower frequency at Foundation level. Specifically, 98.6% assigned homework in most or every lesson to Higher-level students, 96.8% to Ordinary-level students, and 80.2% to Foundation-level students. Over 70% of teachers gave their students a quiz or test (other than in-house examinations, mock examinations, etc.) at least once a month: 76.3% at Higher level, 81.4% at Ordinary level, and 73.5% at Foundation level. Over 85% of teachers agreed or strongly agreed with three of six statements about homework: that it is an effective way for students to consolidate class work (99.3%); that homework helps to monitor students' progress (96.5%); and that homework is a good way of identifying students' weaknesses (87.6%) (Table 9). Responses of teachers were more divided on the other three statements. Just over half (53.6%) disagreed or strongly disagreed that they often assigned homework which required application of concepts in novel contexts; close to two-thirds disagreed or strongly disagreed that project work was important; and about 60% disagreed or strongly disagreed that the main purpose of homework was to prepare students for the state examinations.

Table 9
Percentages of Teachers Expressing Agreement/Disagreement with Six Statements About Homework

	Strongly agree	Agree	Disagree	Strongly Disagree	Total
Homework is an effective way for students to consolidate what has been covered in class	72.2	27.1	0.6	0.1	100
I often assign homework that requires students to apply knowledge of concepts in novel contexts	5.6	40.8	50.8	2.8	100
Regular homework assignments help to monitor students' progress	42.7	53.8	3.0	0.5	100
Homework is a good way of identifying students' weaknesses	32.3	55.3	11.3	1.1	100
The main purpose of homework is to prepare students for the State Examinations	6.6	33.9	53.2	6.3	100
It is important to assign project work to students	4.7	32.2	57.7	5.4	100

Total number of respondents = 821 to 852.

Emphasis Placed on Aspects of the Junior Certificate Syllabus

Respondents were asked to rate the degree of emphasis they placed on various aspects of the Junior Certificate mathematics syllabus on a 4-point scale with lower values representing a higher emphasis ('a lot' = 1, 'some' = 2, 'a little' = 3, 'none' = 4). In contrast to many of the tables already presented, the means of the instructional content and emphasis ratings, rather than frequencies, are presented in the tables which follow. This approach facilitates comparisons across syllabus levels and topic areas within a single table. The total number of respondents in this and the following section is taken to be 725 rather than 856 since 121 of respondents did not teach mathematics at Junior Cycle at the time of the survey. At Junior Certificate Mathematics Higher level, a high degree of emphasis[14] was placed on applying mathematical knowledge, developing relational understanding (an ability to understand and link mathematics concepts together), and recalling basic facts. The emphasis on developing instrumental understanding (an ability to apply mathematical concepts in specific instances) and developing skills of analysis was moderate to high. Developing creativity, communication skills, and an appreciation of mathematics received moderate to low emphasis, and developing an awareness of the history of mathematics and its role in society the lowest emphasis (Table 10).

The emphasis rating at Ordinary level is similar to Higher level for recall of basic facts. The emphasis on development of instrumental and relational understanding and on application of mathematical knowledge was moderate to high at this level. The emphasis on developing skills of analysis, and in particular creativity and communication skills, was lower at Ordinary than at Higher level, suggesting a more drill-and-practice approach at Ordinary level. At Foundation level, the highest emphasis was placed on recall of basic facts, followed by instrumental and relational understanding. Emphasis on the other aspects was moderate to low, reflecting the differing priorities of the three courses (Table 10).

[14] We use 'high' as shorthand for a mean rating of less than 1.5, 'moderate' for a mean rating of 1.5 to 2.0, 'moderate to low' for a mean rating of 2.1 to 3.0, and 'low' for a mean rating exceeding 3.0.

Table 10
Mean Level of Emphasis Given to Eight Objectives Relating to Junior Certificate Mathematics, by Syllabus Level

	Higher		Ordinary		Foundation	
Aspect (Junior Cert. Syllabus)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Teaching students to recall basic facts	1.47	(.04)	1.49	(.08)	1.56	(.06)
Teaching instrumental understanding	1.82	(.05)	1.59	(.05)	1.70	(.07)
Developing relational understanding	1.48	(.03)	1.71	(.07)	1.98	(.07)
Developing application of mathematical knowledge	1.34	(.03)	1.76	(.07)	2.20	(.09)
Developing skills of analysis	1.77	(.04)	2.36	(.07)	2.69	(.09)
Developing creativity and communication skills in mathematical thinking	2.30	(.06)	2.61	(.09)	2.90	(.07)
Developing an appreciation of mathematics	2.30	(.05)	2.41	(.09)	2.53	(.09)
Developing an awareness of the history of mathematics and its role in culture and society	3.06	(.06)	3.11	(.09)	3.24	(.07)

Note. Ratings based on a 4-point scale with lower values representing a higher emphasis (‘a lot’ = 1, ‘some’ = 2, ‘a little’ = 3, ‘none’ = 4).

In preparing students for the Junior Certificate Examination, the highest level of emphasis was given to attempting sample questions, both in class and at home, at all syllabus levels (Table 11). High emphasis was also placed on familiarizing students with timing and format. Generally, the level of emphasis on various aspects of examination preparation was highest at Foundation level and lowest at Ordinary level (although the size of the standard errors suggests that, in general, these differences are not statistically significant). Advising students on the appropriate choice of questions was lower, an outcome that may reflect the removal of choice from the Junior Certificate mathematics examination papers from June 2003 (before which the Higher- and Ordinary-level papers, but not the Foundation-level paper, allowed students to choose a subset of the questions presented).

Table 11
Mean Level of Emphasis Given to Four Aspects of Preparation for the Junior Certificate Mathematics Examination, by Syllabus Level

	Higher		Ordinary		Foundation	
Aspect of Preparation	Mean	(SE)	Mean	(SE)	Mean	(SE)
Attempting sample questions from sample examination papers in class	1.31	(.07)	1.21	(.08)	1.08	(.05)
Assigning sample questions from sample examination papers for homework	1.33	(.08)	1.33	(.08)	1.24	(.09)
Familiarising students with the format and timing of the examination	1.57	(.09)	1.49	(.10)	1.27	(.09)
Advising students on appropriate choice of questions in the examination	2.26	(.14)	2.09	(.15)	1.76	(.21)

Note. Ratings based on a 4-point scale with lower values representing a higher emphasis (‘a lot’ = 1, ‘some’ = 2, ‘a little’ = 3, ‘none’ = 4).

Emphasis Placed on Aspects of the PISA Mathematics Assessment

Teachers were asked to indicate the relative emphasis placed on various aspects of the PISA 2003 mathematics framework, using a 4-point scale, with a low value representing a high emphasis. Again, results are presented in terms of mean values. In responding to four aspects relating to the Space & Shape subscale of PISA 2003 mathematics, the skill of representing shapes and patterns received high to moderate emphasis at all syllabus levels; representation

Table 12
Mean Level of Emphasis Given to Four Aspects of the PISA Mathematics Framework Relating to the Topic of Space & Shape, by Junior Certificate Syllabus Level

	Higher		Ordinary		Foundation	
Aspect of PISA Framework	Mean	(SE)	Mean	(SE)	Mean	(SE)
Recognising shapes and patterns	1.89	(.04)	1.79	(.06)	1.79	(.07)
Representing three-dimensional objects in two dimensions	2.48	(.07)	2.49	(.08)	2.74	(.08)
Navigating through space	3.08	(.05)	2.90	(.07)	3.11	(.08)
Navigating through constructions or shapes	3.13	(.06)	3.22	(.08)	3.47	(.07)

Note. Ratings based on a 4-point scale with lower values representing a higher emphasis (‘a lot’ = 1, ‘some’ = 2, ‘a little’ = 3, ‘none’ = 4).

of three-dimensional objects in two dimensions received moderate to low emphasis; and navigating through space, constructions, or shapes received low emphasis (Table 12). Compared with Table 10, there is less evidence of differences across syllabus levels, reflecting, perhaps, a less immediate link between the aspects listed and the Junior Certificate syllabuses.

Skills that received high emphasis at Higher and Ordinary levels relating to Change & Relationships included mathematical modelling of functions and translating representations of Change & Relationships into others. Representing change/relationships in different formats received moderate to high emphasis at Higher level and moderate emphasis at Ordinary level. Recognizing and understanding types of change/relationships received moderate emphasis at Higher level and moderate to low emphasis at Ordinary level. The pattern of emphasis was similar at Foundation level, but the absolute levels of emphasis were lower (Table 13).

Table 13
Mean Level of Emphasis Given to Five Aspects of the PISA Mathematics Framework Relating to the Topic of Change & Relationships, by Junior Certificate Syllabus Level

	Higher		Ordinary		Foundation	
Aspect of PISA Framework	Mean	(SE)	Mean	(SE)	Mean	(SE)
Recognising types of change / relationship	2.23	(.05)	2.62	(.08)	3.02	(.08)
Understanding types of change / relationship	2.32	(.06)	2.75	(.09)	3.08	(.09)
Mathematical modelling of functions	1.49	(.04)	1.74	(.07)	2.30	(.07)
Representing change / relationship in different formats	1.81	(.05)	2.12	(.08)	2.44	(.09)
Translating one representation of change / relationship to another	1.54	(.04)	1.58	(.06)	1.94	(.08)

Note. Ratings based on a 4-point scale with lower values representing a higher emphasis (‘a lot’ = 1, ‘some’ = 2, ‘a little’ = 3, ‘none’ = 4).

The mean emphasis ratings for all six aspects relating to the PISA 2003 Quantity subscale are in the moderate to high range for all syllabus levels, with the exception of representing numbers in various ways, which was accorded moderate emphasis at all levels (Table 14).

Table 14
Mean Level of Emphasis Given to Six Aspects of the PISA Mathematics Framework Relating to the Topic of Quantity, by Junior Certificate Syllabus Level

	Higher		Ordinary		Foundation	
Aspect of PISA Framework	Mean	(SE)	Mean	(SE)	Mean	(SE)
Developing number sense	1.62	(.05)	1.47	(.05)	1.41	(.07)
Demonstrating an understanding of magnitude	1.87	(.05)	1.77	(.06)	1.72	(.09)
Demonstrating an understanding of the meaning of mathematical operations	1.54	(.04)	1.46	(.06)	1.64	(.07)
Developing efficient computational skills	1.61	(.05)	1.57	(.07)	1.63	(.07)
Developing mental arithmetic and estimation skills	1.76	(.05)	1.81	(.06)	1.95	(.07)
Representing numbers in various ways	2.08	(.04)	2.10	(.07)	2.26	(.08)

Note. Ratings based on a 4-point scale with lower values representing a higher emphasis (‘a lot’ = 1, ‘some’ = 2, ‘a little’ = 3, ‘none’ = 4).

Table 15
Mean Level of Emphasis Given to Six Aspects of the PISA Mathematics Framework Relating to the Topic of Uncertainty, by Junior Certificate Syllabus Level

	Higher		Ordinary		Foundation	
Aspect of PISA Framework	Mean	(SE)	Mean	(SE)	Mean	(SE)
Understanding the concepts of variability and uncertainty	2.50	(.06)	2.65	(.09)	2.95	(.09)
Data analysis	1.68	(.04)	1.79	(.06)	2.03	(.07)
Data display	1.83	(.05)	1.72	(.06)	2.06	(.09)
Understanding the concept of simple random sample	2.73	(.05)	2.88	(.10)	3.13	(.09)
Understanding the concepts of probability and inference	3.15	(.06)	3.31	(.09)	3.59	(.06)
Applying the concepts of probability and inference	3.28	(.05)	3.37	(.10)	3.59	(.06)

Note. Ratings based on a 4-point scale with lower values representing a higher emphasis (‘a lot’ = 1, ‘some’ = 2, ‘a little’ = 3, ‘none’ = 4).

In responding to six aspects relating to the PISA Uncertainty subscale, teachers accorded Understanding and applying the concepts of probability and inference low emphasis, particularly at Foundation level. The concepts of variability, uncertainty, and simple random sample received low to moderate ratings. However, data display and analysis received moderate emphasis at Higher and Ordinary levels (and moderate to low emphasis at Foundation level) (Table 15). The pattern of ratings reflects the fact that probability is not on the Junior Certificate course, though statistics (hence, data display and analysis) are.

CONCLUSION

The sample of teachers surveyed in the study described in this paper had substantial teaching experience (a mean of 16 years). Almost all had both a Bachelor's degree (97%) and a Higher Diploma in Education (88%). Seven in ten indicated that their degree included mathematics (or a mathematics-related subject) as a major component. A majority (81%) had also participated in in-career development courses over the three years preceding the survey. Overall, this portrays a relatively highly qualified and motivated teaching body. However, only half of the teachers may be regarded as mathematics subject specialists (if we accept the first subject mentioned by them as the main component of their degree as indicating specialization).

The fact that only a small percentage (4 to 5%) of total time in mathematics classes was devoted to transfer of knowledge to real-life situations suggests that Irish students may be at a disadvantage facing a test such as that administered in PISA, in which practically all problems (97% according to Nohara, 2001) are located in real-life contexts.

While about two-fifths of teachers (38%) agreed that computers were important for teaching mathematics, only a minority used computers, and use was largely confined to websites, spreadsheets, and presentation and word-processing software, and did not involve mathematics-specific software. The low incidence of computer use in schools in Ireland has been highlighted elsewhere (NCCA, 2004), and the barriers to more widespread and integrated use remain a general area of concern.

The revised Junior Certificate mathematics syllabus provides for the appropriate use of calculators, and candidates have had access to calculators during the Junior Certificate Examinations since 2003. The majority of teachers were in favour of the use of calculators but their responses suggest that their introduction should be made gradually at First-year level, with increasing use in Second and Third years. Given that the 1999 Primary School Mathematics Curriculum (DES/NCCA, 1999a, 1999b) specifies use of calculators in Fourth, Fifth, and Sixth classes, lack of access in the early stages of post-primary schooling may be counter-productive for some students.

As previous studies might have led us to expect (Beaton et al., 1996; Lyons et al., 2003), a large majority of teachers (over 90%) in our study agreed that some students have a natural talent for mathematics, while others do not. However, over a third agreed that mathematics was primarily an abstract subject, which may indicate a decrease from TIMSS (in which 50% of students were taught by teachers who agreed that mathematics was primarily an abstract subject) and may reflect the impact of in-career development that has attempted to emphasize teaching for understanding. Just under 60% of teachers agreed that an understanding of mathematics in the real world was important for success in mathematics. This would appear to represent an increase from TIMSS 1995, and again suggests a shift in teachers' attitudes to mathematics as a subject. (However, TIMSS percentages are based on numbers of students, while the percentages here represent the number of teachers, and so are not equivalent.) A large majority of teachers agreed that a variety of representations should be used in teaching a topic, yet the findings of Lyons et al. (2003) indicate that textbooks and blackboards remain predominant instructional media in mathematics classes. However, it is not clear to what extent this is still the case. Curriculum overload and perceived pressure to prepare for examinations may be acting as barriers to allowing teachers to explore and experiment with novel methods and representations.

The relative emphases accorded by teachers to various aspects of the Junior Certificate syllabus confirm previous findings that teachers focus on objectives that are assessed in examinations more than on objectives which are not assessed (e.g., Cosgrove, Shiel et al., 2005). Recall of basic facts received high emphasis at all syllabus levels. Skills of analysis and application were emphasized more at Higher than at Ordinary and Foundation levels. Aspects of mathematics which one would expect to see emphasized within a relativist framework (creativity, appreciation, role of mathematics in society) generally received a low emphasis, reinforcing the view that the learning environments of Irish students are unlikely to equip them with the range of skills emphasized in the PISA mathematics assessment.

Generally, aspects of the PISA 2003 mathematics framework relating to Quantity received moderate to high emphasis. However, students in Ireland performed only at the OECD average on this subscale. While it may be the case that the concepts are familiar, presenting them in novel contexts may pose a significant challenge for students (Close & Oldham, 2005).

Aspects of the Space & Shape subscale generally received a lower emphasis, particularly skills relating to spatial awareness. This is consistent with the overall poor performance of Irish students on this subscale, and reflects a mismatch between the PISA framework and Irish syllabuses in this area. For example, the Higher-level course places considerable emphasis on the development of a sequence of theorems, proofs, some of which may be asked for in examinations. A close consideration of the skills underlying the PISA items on this subscale merits attention.

On the PISA Uncertainty (probability and statistics) aspects, teachers placed moderate emphasis on graphing and displaying data, and low emphasis on probability and inference. Since many of the PISA Uncertainty items dealt with the interpretation of graphed data rather than with more abstract problems relating to probability theory, students in Ireland may have been relatively well-equipped to respond to these items. Indeed, their average performance was significantly above the OECD average, by some 15 points.

The relative emphasis placed on aspects of Change & Relationships was moderate to high at Higher and Ordinary levels, but low at Foundation level. This is broadly consistent with Irish students' performance on this subscale (which was significantly, but not substantially, above the OECD average), but it should be noted that the items comprising the Change & Relationships subscale did not readily map onto a particular topic area of the Junior Certificate syllabus (Cosgrove, Shiel et al., 2005). This is at odds with the OECD (2003) position that this subscale is similar to school algebra and functions, and suggests that the validity of the scale requires closer scrutiny. Again, the mismatch may reflect the rather formal approach to algebra and functions in the Irish syllabus and textbooks, and the lack of emphasis on some teaching/learning approaches that have become familiar elsewhere in this area.

While our data provide some insights into mathematics education in Ireland, and are consistent with analyses of PISA and the Junior Certificate (Close & Oldham, 2005; Cosgrove, Shiel et al., 2005) and with the findings of recent classroom-based research (Lyons et al., 2003) and of TIMSS 1995 (Schmidt et al., 1997), they leave many questions unanswered. Qualitative research methods might be usefully employed to gather supplementary information on teachers' views of the PISA test items and how these relate (or do not) to the Junior Certificate. Consideration might be given to the extent to which PISA concepts and skills are covered during Senior Cycle and Transition Year. Indeed, the Transition Year might provide an opportunity to experiment with real-life, cross-curricular approaches to the teaching of mathematics, which it is claimed can enhance students' engagement with, and understanding of, mathematics concepts as applied to real-life problems (see e.g., McCloughlin, 2005).

REFERENCES

Beaton, A.E., Mullis, V.S., Martin, M.O., Gonzalez, E.J., Kelly, D.L., & Smith, T.A. (1996). *Mathematics achievement in the middle-school years: IEA's Third International Mathematics and Science Study.* Chestnut Hill MA: TIMSS International Study Center, Boston College.

Burton, L. (1994a). Clashing epistemologies of mathematics education: Can we see the 'wood' for the 'trees'? *Curriculum Studies, 2,* 203-219.

Burton, L. (1994b). Differential performance assessment in mathematics at the end of compulsory schooling: A European comparison. In L. Burton (Ed.), *Who counts? Assessing mathematics in Europe* (pp. 1-21). London: Trentham Books.

Close, S., & Oldham, E.E. (2005). Junior Cycle mathematics examinations and the PISA mathematics framework. In S. Close, T. Dooley, & D. Corcoran (Eds.), *Proceedings of the First National Conference of Research in Mathematics Education* (pp. 174-192). Dublin: St Patrick's College.

Commission on the Points System. (1999). *Final report and recommendations.* Dublin: Stationery Office.

Cosgrove, J., Oldham, E.E., & Close, S. (2005). Assessment of mathematics in PISA 2003: Achievements of Irish 15-Year-Olds in an international context. In S. Close, T. Dooley, & D. Corcoran, (Eds.), *Proceedings of the First National Conference of Research in Mathematics Education* (pp. 193-208). Dublin: St Patrick's College.

Cosgrove, J., Shiel, G., Sofroniou, N., Zastrutzki, S., & Shortt, F. (2005). *Education for life: The achievements of 15-year olds in Ireland in the second cycle of PISA.* Dublin: Educational Research Centre.

DES/NCCA (Department of Education and Science/National Council for Curriculum and Assessment). (1999a). *Primary school mathematics curriculum. Content.* Dublin: Stationery Office.

DES/NCCA (Department of Education and Science/National Council for Curriculum and Assessment). (1999b). *Primary school mathematics curriculum. Teacher guidelines*. Dublin: Stationery Office.

DES/NCCA (Department of Education and Science/National Council for Curriculum and Assessment). (2000). *Mathematics syllabus: Higher, Ordinary, and Foundation level.* Dublin: Stationery Office.

Lynch, K., & Lodge, A. (2002). Equality and power in schools. London: Routledge Falmer.

Lyons, M., Lynch, K., Close, S., Sheerin, E., & Boland, P. (2003). *Inside classrooms: The teaching and learning of mathematics in social context.* Dublin: Institute of Public Administration.

McCloughlin, T. (2005). Timeo danaos: An integrated mathematics and science programme for Transition Year. In S. Close, T. Dooley, & D. Corcoran (Eds.), *Proceedings of the First National Conference of Research in Mathematics Education* (pp. 209-219). Dublin: St Patrick's College.

NCCA (National Council for Curriculum and Assessment). (2004). *Curriculum assessment and ICT in the Irish context: A discussion paper.* Dublin: Author.

NCCA (National Council for Curriculum and Assessment). (2005). *Review of mathematics in post-primary education: A discussion paper.* Dublin: Author.

Nohara, D. (2001). *A comparison of the National Assessment of Educational Progress (NAEP), the Third International Mathematics and Science Study Repeat (TIMSS-R), and the Programme for International Student Assessment (PISA).* Washington DC: National Center for Education Statistics.

OECD (Organisation for Economic Co-operation and Development). (2003). *The PISA 2003 assessment framework: Mathematics, reading, science and problem solving knowledge and skills.* Paris: Author.

OECD (Organisation for Economic Co-operation and Development). (2004). *Learning for tomorrow's world: First results from PISA 2003*. Paris: Author.

Oldham, E. E. (2001). The culture of mathematics education in the Republic of Ireland: Keeping the faith? *Irish Educational Studies, 20*, 266-277.

Oldham, E. E. (2002). The performance of Irish students in mathematical literacy in the Programme for International Student Assessment (PISA). *Irish Journal of Education, 33,* 31-52.

Oldham, E.E., Close, S., Shiel, G., & Cosgrove, J. (2005). *The OECD Programme for International Student Assessment: Interpreting the performance of Irish 15-year olds in mathematics.* Paper presented at the European Educational Research Association Annual Conference, University College Dublin.

Schmidt, W.H., McKnight, C.C., Valverde, G.A., Houang, R.T., & Wiley, D.E. (1997). *Many visions, many aims. Volume I: A cross-national investigation of curricular intentions in school mathematics.* Dordrecht, NL: Kluwer.

Westat. (2000). *WesVar complex samples 4.2.* Rockville MD: Author.