Junior Certificate Science: Results of a survey of teachers conducted in conjunction with PISA 2006

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Introduction

This paper examines the teaching of science to Junior Certificate students in post-primary schools in Ireland. It is based on responses to a questionnaire administered in early 2006 to those teaching Junior Certificate science in schools participating in the 2006 OECD Programme for International Student Assessment (PISA). A summary of the survey, designed for a more general readership, has also been published (Eivers, Shiel & Cheevers, 2006), and is available from Government Publications or at *www.erc.ie/documents/pisa06rjcssreview.pdf*

Although administered as part of PISA, the science teacher questionnaire was Irish-developed and administered only in Ireland. The main purposes of the study were to examine teachers' views on the revised Junior Certificate science syllabus (rJCSS) (introduced in September 2003, and examined for the first time in June 2006), to obtain information on some background characteristics of those teaching Junior Certificate science, and to examine linkages between the PISA science framework and science teaching in Irish schools. In the remainder of this introduction, we provide some background information on PISA, followed by an outline of why the survey of Junior Cycle science teachers was conducted.

An Introduction to PISA

PISA is an assessment of 15-year-olds' knowledge and skills (referred to as 'literacy') in three domains – reading, mathematics and science. Fifteen-year-olds were chosen as the target group for the study because, at this age, compulsory schooling ends in many countries. Thus, PISA attempts to assess how well students are equipped to face the reading, mathematical and scientific demands of their future adult life.

PISA takes place in 3-year cycles, and each cycle looks at one of the three cognitive domains in depth, while also assessing the other two domains. Each cycle is guided by an assessment framework, which defines the areas to be assessed. These detailed definitions inform the development of test items, including the types of item used and the topics covered. The framework upon which the 2006 cycle is based can be downloaded from *http://www.pisa.oecd.org/*. The framework includes sample test items and responses. Although the international element of PISA did not include a science teacher questionnaire, such a questionnaire was developed and administered in Ireland as part of PISA 2006.

Over 250,000 students in 41 countries took part in PISA 2003 (when mathematics was the main skills area assessed). Fifty-five countries are taking part in 2006, suggesting that student numbers will easily exceed 300,000. Science literacy is the focus of the 2006 cycle, and is defined as an individual's:

- scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues;
- understanding of the characteristic features of science as a form of human knowledge and enquiry;
- awareness of how science and technology shape our material, intellectual, and cultural environments; and

- willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen.

The assessment consists of a paper-and-pencil test, containing a mixture of multiple-choice items and items where students need to write their own answers. Some of these require only a very short answer; others require a more in-depth response. As well as test booklets, questionnaires are given to students and to principals. This allows an examination of how student achievement relates to different student and school background characteristics. Test and questionnaire items are jointly developed by participating countries.

Why Teachers Were Surveyed

The uptake of science subjects – particularly physics and chemistry – at Leaving Certificate, has long been a matter for concern, and in October 2000, the Task Force on the Physical Sciences was set up to examine this issue. The Task Force's subsequent report found that there had been a decline in uptake of all three science subjects (i.e., biology, physics and chemistry) between 1990 and 2001 (Task Force on the Physical Sciences, 2002). In physics and chemistry, the declines were from much lower baseline levels than biology. For example, in 1990, while 47% of students studied biology, 16% studied chemistry and 20% studied physics, only 44%, 12% and 16%, respectively, did so in 2001. A significant gender gap in uptake rates was also identified. The gap was widest in single sex schools, where only 80% of girls studied Junior Certificate science, compared to 96% of boys, and only 8% of girls studied Leaving Certificate physics, compared to 25% of boys. The Task Force also reported a decline in the uptake of science at third level, with many science-related courses not being filled to their capacity, and identified a shortage of skilled workers in the areas of science, technology and engineering.

While more recent data provided by the Department of Education and Science (Statistics Section, personal communication) and the Higher Education Authority (2006) indicate a slight increase in uptake of science at second and third levels, there remains a common perception of a science 'crisis' in Ireland. This view, the decline in the uptake of science subjects noted by the Task Force, and the need to update the Junior Certificate science syllabus to reflect scientific advances and changes in the primary school science curriculum all led to the development of the rJCSS. The new syllabus was influenced by the science-technology-society (STS) approach, which involves linking scientific facts to students' everyday lives, thus assisting student understanding of science. The STS approach argues that the ubiquitous nature of science in daily life means that students require relevant science education in order to become responsible citizens. The Primary School Curriculum – revised in 1999 – places the study of science in the context of social, environmental and scientific education, and is also very much based on an STS approach. The adoption of a similar approach by both primary and post-primary syllabi was designed to facilitate a smoother transition for students from primary to post-primary school science.

The structure of the rJCSS is simpler than the earlier syllabus, and is designed to allow equal coverage of the three major science subjects (the core and extensions model of the 1989 syllabus had been criticised for an under-emphasis on physics and chemistry [NCCA, 2006]). Practical work and activities are divided evenly between the three core subjects, and the terminal examination paper consists of three compulsory sections, covering biology, chemistry and physics. These changes are expected to encourage Senior Cycle uptake of physics and chemistry.

The revised syllabus also places greater emphasis on student investigation and practical work, designed to help students develop an understanding of science concepts, as well as acquire the necessary science process skills. For the first time, 35% of a student's marks in the Junior Certificate science examination are based on their performance on two practical elements of the course – Coursework A (10% of total marks), and Coursework B (25% of total marks). Coursework A involves the completion and writing up of 30 specified[1] practical activities, while Coursework B requires students to carry out two scientific investigations from three topics provided by the State Examinations Commission, or a single investigation of their own choosing (subject to meeting certain criteria). The investigative approach is also intended to foster an interest in science amongst students and to increase the uptake of science subjects at Leaving Certificate, and subsequently, at third level.

Another, broader, aim of the rJCSS is that it will promote students' long-term engagement in the scientific society in which they live. In this regard, the rJCSS is theoretically more closely aligned than was its predecessor to scientific literacy as defined by the PISA assessment framework. In fact, the definition of scientific literacy used for the PISA 2000 assessment (OECD, 2000) was cited as part of the rationale for a syllabus revision (Department of Education and Science, 2003, p. 3). Thus, the rJCSS and the PISA views of science recognise the importance of the capacity to use scientific knowledge, of understanding how science can shape our environment, and of using science to draw evidence-based conclusions and make decisions. In addition, the focus in the revised syllabus on conceptual understanding and the development of practical and investigative skills within an STS context is reflected in the three aspects of the PISA science framework: scientific knowledge, scientific processes and scientific areas of applications.

Some hoped-for outcomes of the rJCSS are that Junior Certificate science classes will become more student-centred, and that the introduction of compulsory investigations and practicals will lead to students increasingly becoming active participants in their own learning. However, the move to a more practical approach may account for a perceived increase in workload reported in a recent survey of science teachers (ASTI, 2006). The same group of teachers (mainly 'heads of science' in secondary schools) felt that the employment of laboratory assistants was the change most needed to reduce teacher workload.

Although not specific to the rJCSS, there has been a move towards greater integration of Information and Communication Technologies (ICT) into classroom practice in schools. In relation to science lessons, this is reflected in the increased use of technologies such as datalogging, which can save time spent on gathering data and processing results, thus freeing time to focus on the *meaning* of results.

It remains to be seen how the changes envisaged in the rJCSS (to have student-centred lessons, with a real-life focus) and in the curriculum more generally (greater use of ICT) are reflected in practice. For example, an OECD survey of post-primary schools in 2001 ranked Ireland last of 14 participating countries in teacher usage of ICT (OECD, 2004). More recently, and specific to science teachers, an ASTI survey found that only a

[1] These are generally referred to as the *mandatory* activities. In fact, students are expected to conduct all practical activities included in the syllabus, not just those specified in Coursework A. However, the 30 activities specified in Coursework A must not only be completed, but written up for assessment purposes.

minority of science teachers used ICTs on a regular basis (ASTI, 2006). Thus, it may take sometime before ICTs are as integrated into classroom practice as envisaged in the framing of the syllabus revisions. In a related vein, while the rJCSS attempts to make science more relevant to students' daily lives, and the NCCA's draft teacher guidelines encourage the integration of everyday life into science lessons (NCCA, 2006), it remains to be seen if teachers embrace the STS approach proposed. Indeed, the cross-national TIMSS study in 1995 found that Irish science teachers were less likely than teachers in most countries to believe that understanding how science is used in the real world is very important for success in science (Beaton, Martin, Mullis, Gonzalez, Smith & Kelly, 1996).

In the remainder of this report, results from the survey of science teachers are examined under the following headings: background characteristics; in-career development on the rJCSS; familiarity with the Primary School Science Curriculum; teachers' views on the rJCSS; lesson planning and classroom practice for Junior Certificate science; classroom practice and the PISA framework; and additional comments made by teachers in response to an open-ended question. First, though, we describe how the data were gathered.

Sample, Response Rates and Weights

As the questionnaire for those teaching Junior Certificate science was administered in conjunction with the PISA 2006 assessment in Ireland, survey procedures are related to the procedures used to sample students. Consequently, this section provides a brief description of how Ireland's PISA 2006 student population was sampled, before outlining the sample characteristics and response rates for the teacher questionnaire.

PISA 2006 was administered in Ireland between late March and early April 2006. All 15-year old students (taken as equivalent to those born in 1990) in full-time education in mainstream second-level recognised schools comprised the target population for the main cognitive assessment. A two-stage stratified sample design was used to select students. First, schools were selected, and then students within schools were selected. Explicit and implicit school strata – designed to ensure an adequate representation of a variety of school characteristics – were used. There were three explicit strata based on school size (small [less than 41 students aged 15], medium [41 to 80 such students], and large [81+ students aged 15]). Within these strata, the following implicit strata were applied: school type (secondary, community/comprehensive and vocational) and student gender composition (the percentage of 15-year old females enrolled, split into five categories).

In each explicit stratum, the number of schools selected was based on the number of students in that stratum in the population and the number in the expected sample. The probability of a school being selected was based on the number of 15-year-olds within the school. The greater the number, the greater the probability of selection (often referred to as probability proportional to size, or PPS). To generate a sufficiently large student sample, 165 schools were selected[2], and all of these agreed to participate.

The target population for the teacher questionnaire was limited to teachers in the 165 participating schools. Within such schools, only those who were currently teaching

[2] One selected school, which had closed down, was replaced by a randomly selected replacement school.

Junior Cycle science classes were included in the target population. In total, there were 735 such teachers in the 165 participating schools. Of these, 688 teachers from 163 schools returned completed questionnaires – a response rate of 93.6%.

Before the questionnaire data were analysed, weights were applied to each teacher's responses. Weights are used to ensure that the contributions of certain groups (e.g. teachers working in large schools) are not over- or under-represented in the data and therefore do not bias findings. In calculating weights, the following were considered:

- A school non-response adjustment, to account for schools from which no teacher questionnaires were returned
- A within-school non-response adjustment
- The school sample weight.

All data presented in the remainder of this paper are weighted estimates of respondents' characteristics, and by extension, of population characteristics. Given that all selected schools participated and that there was a high response rate from teachers, the views expressed by those who completed questionnaires may be taken as representative of those teaching Junior Certificate science.

Results

Background Characteristics

Over half (60.3%) of teachers surveyed were female, 38.2% were male, and 1.5% did not indicate their gender. Sixty percent worked in secondary schools, 24% worked in vocational schools, and 16% in community or comprehensive schools, largely reflecting the national distribution of schools by sector. Most of those who taught in single sex boys' schools were male (65% of teachers in such schools) while most teachers in single sex girls' schools and in mixed sex schools were female (74% and 65%, respectively). While 4.2% of respondents were in their first year of teaching, teachers were typically very experienced, averaging almost 17 years as a teacher (Table 1). Male teachers averaged 20 years experience, compared to 14 years amongst female teachers.

Table 1: Number of years teaching experience, by gender

Gender	N	Mean	SD	Min	Max
Female	411	14.4	9.7	1	39
Male	255	20.3	11.4	1	40
All	674	16.8	10.8	1	40

Almost all (96%) had completed an undergraduate degree in which science was a major or a minor component (Table 2). A large majority (84%) of teachers had also completed a Higher Diploma in Education (H. Dip.), while 6% had completed a postgraduate degree with science education as a major component. Of those who had completed a H. Dip., 83.8% had studied science education as a subject in their diploma programme.

Table 2: Percentages of teachers with various qualifications

(N=687)	%
UG degree with science as major subject	91.2
UG degree with science as minor subject	5.4
UG degree with no science subject	1.3
Higher Diploma in Education (or equivalent)	84.3
PG degree with science as major subject	9.7
PG degree with science education as major subject	6.3
PG degree unrelated to science	7.0

As some teachers held multiple qualifications, column percentages sum to more than 100%.

Overall, 85.1% of those surveyed held a postgraduate teaching qualification (one or both of a H. Dip. or a post-graduate degree with science education as a major component). However, this is an underestimate of those with science *teaching* qualifications, as it does not include those whose undergraduate degree was in science education. The percentage with teaching qualifications is likely to be considerably higher.

Chemistry was the subject most commonly studied at undergraduate level (88% of respondents) while biology, physics and mathematics were each studied by over three-quarters of respondents (Table 3). However, only a minority had studied any of these at post-graduate level. At 7%, biology was the most popular subject studied at post-graduate level, while, at 3%, mathematics had the lowest percentage taking the subject. Two percent of respondents had studied geography at undergraduate level, as had just under 2% at post-graduate level. With the exception of undergraduate biology and physics, uptake rates amongst male and female teachers tended to be very similar. However, while 88.4% of female teachers had studied biology as undergraduates, only 67% of males had done so. Conversely, 84.4% of males had studied undergraduate physics, compared to 74.7% of females.

Table 3: Percentages of teachers who studied various aspects of science at undergraduate and post-graduate level

(N=687)	Undergraduate	Postgraduate
Chemistry	88.4	6.7
Mathematics	82.8	2.8
Biology	80.4	7.5
Physics	78.4	5.0
Geography	2.4	1.5

As some teachers held multiple qualifications, column percentages sum to more than 100%.

As shown in Table 4, respondents averaged just over 20 teaching hours per week, of which slightly more than seven hours were allocated to teaching Junior Cycle science classes. On average, less than an hour a week was spent teaching Transition Year science, approximately five hours and 40 minutes was spent on Leaving Certificate science subjects, and over six hours was spent teaching other (non-science) subjects. Within these average times, there was considerable variation. For example, 13% of those surveyed did not teach science at Senior Cycle, while the number of hours spent teaching science to Junior Cycle students ranged from one hour to 21 hours.

Table 4: Weekly teaching contact hours, by subject

Weekly hours teaching …	N	Mean	SD	Min	Max
JC science	667	7.3	3.9	1	21
TY science	644	0.8	1.2	0	9
LC science	629	5.7	3.7	0	19
Other	580	6.2	5.4	0	21.5
Total contact hours	557	20.1	3.4	3	25

Half of all teachers surveyed had taught a Transition Year science module in the three years prior to the survey, while (by definition) all had taught Junior Cycle science (Table 5). The Leaving Certificate physics and chemistry courses had been taught by less than half of teachers, while almost three-quarters (72%) had taught Leaving Certificate biology. Amongst those who answered the relevant questions, 7% had taught the combined chemistry/physics course, while 18% had taught agricultural science. However, more than half of those surveyed skipped items relating to these courses, which are offered in only a small number of schools. Thus, in this instance, percentages based on the total number of respondents (rather than valid responses) may be more meaningful, suggesting that 3% had taught chemistry/physics and 9% agricultural science.

Transition Year science does not have Ordinary or Higher levels, but for all other subjects at least 95% of teachers who taught a subject had taught it at Higher level. In contrast, the percentages who had taught a subject at Ordinary level ranged from 57% (chemistry/physics) to 80% (biology).

Table 5: Percentages of teachers reporting which science subjects they had taught in the last three years and, level at which the subject was taught

	N	% taught in last 3 years (Valid)	% taught in last 3 years (Total)	Of those who taught it, % who taught … Higher level	Ordinary level
Transition Year	671	50.3	49.1	–	–
JC Science	688	100	100	97.8	76.5
LC Chemistry	430	44.3	27.7	99.1	61.6
LC Physics	392	35.9	20.4	99.0	70.8
LC Biology	513	71.8	53.5	97.5	80.0
LC Chemistry/Physics	327	7.2	3.4	95.4	56.9
LC Agricultural Science	346	17.5	8.8	99.0	70.4

There was some variation, by school characteristics, in the subjects taught. For example, 61% of science teachers in girls' schools had taught a Transition Year science module in the previous three years, compared to 45% of teachers in mixed sex schools. Similarly, while 45% of those in designated disadvantaged schools had taught a Transition Year science module, this rose to 53% in non-disadvantaged schools. A higher percentage of those teaching in girls' or mixed sex schools had taught Leaving Certificate biology than those teaching in boys' schools (77% and 76%, versus 51%, respectively). In schools designated as disadvantaged, 38% had taught Leaving Certificate chemistry in the last three years, compared to 47% of those in non-designated schools. However, 42% had taught Leaving Certificate physics, compared to 33% of those in non-designated schools.

In-Career Development on the rJCSS

As part of the introduction of the rJCSS, all schools were invited to participate in an in-career development (ICD) programme. The programme consisted of six one-day seminars over the first three years of the syllabus implementation. Respondents indicated that they had attended an average of 4.3 days of such ICD (Table 6). While almost half (45%) had attended all six ICD days offered, 7% had not attended any. Most of this latter group were not newly qualified teachers (i.e., they did not miss the ICD because they were still in college), and they were teaching the revised syllabus. Thus, a small, but significant minority of teachers were teaching a Junior Certificate science syllabus for which they had not received training. Respondents had also attended an average of 2.3 days related to other aspects of science teaching, although 45% had not attended *any* ICD related to other aspects of teaching science.

Table 6: Number of ICD days attended in the previous three years related to the rJCSS and to other aspects of science teaching

	N	Mean	SD	Min	Max
Revised J. Cert. SS	673	4.3	2.0	0	6
Other aspects of teaching science	581	2.3	2.8	0	30

With the exception of information provided on assessment procedures, most were satisfied with the ICD they had attended related to the revised syllabus (Table 7). Over 80% were satisfied or very satisfied with the usefulness of the handouts and CDs provided on the courses, and with the frequency of the seminars. At least three-quarters of teachers were satisfied or very satisfied with the explanation of new teaching methodologies and the quality of the course content. Only 8% were dissatisfied or very dissatisfied with the usefulness of the Junior Science Support Service's website (*juniorscience.ie)*. However, 13% indicated that they did not know how useful the website was, suggesting that they had never used it). In contrast, over half (55%) were dissatisfied or very dissatisfied with the information provided on assessment procedures.

Table 7: Percentage of teachers reporting various levels of satisfaction with elements of ICD related to the revised syllabus

	N	V. satisfied	Satisfied	Dissatisfied	V. dissatisfied	
CDs	612	32.1	57.4	9.3	1.1	Don't know
Juniorscience.ie website	619	20.0	58.9	6.7	1.0	13.4
Handouts	613	18.8	65.9	14.3	1.1	
Seminar frequency	622	18.4	65.5	15.0	1.1	
Explanation of new teaching methodologies	620	12.7	62.8	21.2	3.4	
Quality of course content	613	12.7	65.4	18.9	3.0	
Information on assessment procedures	617	6.6	38.5	40.2	14.7	

Respondents were asked which, if any, additional topics related to the revised syllabus they would like addressed in ICD. A substantial minority (39.4%) suggested additional topics. The most common type of topic related to general issues about the practical and coursework elements of the syllabus, mentioned by 33% of those who made a comment (13% of all respondents). Typical comments included 'how to proceed with Coursework B', 'hands on with Coursework B', and 'practical work procedures'. Although many of the suggestions in this category were quite vague, the frequency with which Coursework B was mentioned suggests an information gap that has not been filled by ICD. A further 14% of those who made a suggestion wanted ICD specifically dealing with the assessment of Coursework, with most referring specifically to Coursework B.

Eighteen percent of those who suggested additional topics wanted ICD on teaching methods and materials. In particular, science teaching methodologies for mixed ability classes or weaker classes were mentioned, as were datalogging, the use of Information and Communication Technologies, and hands-on training in the use of teaching software. Eleven percent (4% of all respondents) wanted ICD on a specific topic from the syllabus, including electronics/electricity, atomic structure, astronomy, and chemical equations.

Just under 11% of those who suggested a topic referred to marking schemes and guides. These teachers wanted information on how the Coursework element was to be marked, and wanted more detail on the marking scheme for examination papers. Finally, 13% of those who suggested a topic raised a variety of other issues. These included the need for laboratory safety training (particularly on how to deal with disruptive students during practical lessons), advice on how to best prepare laboratories for lessons, and how to deal with the increased practical element in the absence of a laboratory technician.

Familiarity with the Primary School Science Curriculum

Improving the linkage between the primary and post-primary science curricula was one of the reasons behind the revision of the Junior Certificate Science Syllabus. Consequently, a session dealing with the primary school science curriculum was included as part of the initial ICD on the rJCSS. Despite this, teachers' responses indicate a relatively poor knowledge of aspects of the primary science curriculum. Less than 6% described themselves as very familiar with the science content or processes of the current Primary School Curriculum in science for Fifth and Sixth class (Table 8). Fifty-eight percent said that they were unfamiliar with the science content, while 69% described themselves as unfamiliar with science processes in the Primary School Curriculum.

Table 8: Percentage of science teachers reporting various levels of familiarity with aspects of the Primary School Curriculum in science for Fifth and Sixth classes

	N	Very familiar	Somewhat familiar	Unfamiliar
Science content	682	5.8	36.4	57.8
Science processes	670	4.6	26.5	69.0

Views on the rJCSS

Teachers were asked which science syllabus they had implemented with students sitting the Junior Certificate science examination in 2006. Most (72.7%) reported that they had implemented the revised (2003) syllabus, while 19.5% reported that they did not have an examination class in 2006. Thus, 7.8% were implementing the old syllabus with their Junior Certificate examination class, with some types of schools more likely to have adopted the new syllabus than others. For example, of those who had a Junior Certificate examination class in 2006, all teachers working in Vocational schools were implementing the revised syllabus (compared to 85% of those in Secondary schools). Also, while only 79% of those teaching in boys' schools were using the revised syllabus, 90% of teachers in girls' schools and 94% of teachers in mixed schools were doing so.

This section reports the views of all teachers, as even those who had not taught the rJCSS to an examination class were likely to have taught it to First or Second year classes. Where there are notable differences between the views of those who have or who have not taught the syllabus to an examination class, these are highlighted (although, given the small number in the latter category, data must be interpreted with caution).

One of the central tenets of PISA is that it attempts to assess the extent to which students are prepared for adult life. Consequently, teachers were asked how well they felt that the rJCSS prepared students for a number of aspects of adult life. Overall, views were quite positive. Almost all (91%) felt that it equipped students with the skills to understand scientific phenomena encountered in everyday life, either to a great extent or to some extent (Table 9). Fourteen percent of those teaching the rJCSS to Third years selected 'to a great extent', compared to 2% of those not doing so. Over 80% of respondents felt that the rJCSS (at least to some extent) helped students to understand how science is used in the real world, to develop a curiosity about science, and to develop a positive attitude about science. However, just over half felt that it did very little to enable students to critically read a newspaper or magazine article about a scientific experiment, while 11% felt it did not help them to do so at all.

Table 9: Percentages of teachers indicating how well the rJCSS equips students with scientific knowledge/skills they will need for their future lives

	N	To a great extent	To some extent	Very little	Not at all
Understanding how science is used in the real world	659	14.0	71.5	14.0	0.6
Developing a positive attitude about science	662	12.9	71.0	14.5	1.5
Developing a curiosity about science	661	12.1	69.0	17.1	1.8
Understanding scientific phenomena encountered in everyday life	661	11.7	79.0	8.6	0.7
Critically reading a newspaper / magazine article about a scientific experiment	661	3.7	33.9	51.7	10.7

Table 10 shows teacher satisfaction with aspects of the rJCSS, split by the syllabus (pre- or post-2003) that the teacher was using with their Third year classes. Syllabus is unknown for those who did not have a Third year science class at the time of the survey, so teachers in this group are included in the *total* rows. As can be seen, the numbers using the older syllabus are quite small, meaning that conclusions based on their views must be interpreted with considerable caution. That aside, it is clear that satisfaction with the rJCSS is higher amongst those who have implemented it with examination classes than amongst those who have not done so. For example, with the exception of Coursework B, at least 15% of those implementing the rJCSS with their Third year classes indicated that they were very satisfied with the listed aspects of the syllabus. Amongst those teaching the older syllabus, the equivalent percentages ranged only from 3% to 8%.

Table 10: Percentages of teachers indicating various satisfaction levels with aspects of the revised JCSS, by syllabus used with Junior Certificate examination class

	Syllabus	N	V. Satisfied	Satisfied	Dissatisfied	V. dissatisfied
Mandatory activities (Coursework A)	Old	47	7.9	58.1	30.5	3.4
	Revised	487	20.8	53.3	22.6	3.2
	Total	659	19.5	54.9	22.4	3.3
Range of science topics (content)	Old	47	3.5	78.2	16.7	1.6
	Revised	489	16.6	72.1	10.2	1.0
	Total	660	16.7	71.7	10.4	1.2
Investigative approach to teaching science	Old	45	6.0	61.0	25.6	7.4
	Revised	484	17.0	62.9	16.8	3.3
	Total	653	16.3	62.7	17.8	3.1
Practical work in general	Old	46	5.6	50.6	38.7	5.1
	Revised	485	13.0	45.7	30.7	10.5
	Total	660	13.8	63.6	19.3	3.3
Investigations (Coursework B)	Old	46	5.6	50.6	38.7	5.1
	Revised	485	13.0	45.7	30.7	10.5
	Total	644	12.3	47.9	30.7	9.1

NOTE: The total N includes those who did not have a Junior Certificate science examination class, and therefore, for whom the syllabus being used was unknown.

Further, overall satisfaction levels were reasonably high with most elements of the revised syllabus, excluding Coursework B. For example, approximately three-quarters of all teachers were either satisfied or very satisfied with Coursework A, with the practical work element in general, and with the investigative approach to teaching science. Satisfaction was even higher for the range of topics in the rJCSS, with 88% indicating that they were satisfied or very satisfied with the range. However, only 60% were satisfied or very satisfied with Coursework B.

Based on their experiences of the rJCSS, approximately half of teachers felt that a practical component should be included in assessing each of Leaving Certificate biology, physics and chemistry (Table 11). However, up to one-third indicated that they did not know if such a component should be included. It is likely that this latter category represents a mixture of those who were unsure, and those who felt they did not have sufficient knowledge as they did not teach the subject in question. Examining responses only of those who taught a given subject at Senior Cycle, 62% of biology teachers felt that a practical component should be included in assessing Leaving Certificate biology, while 29% disagreed. Just over half of physics teachers (55%) wanted the inclusion of practicals in Leaving Certificate physics, while one-third felt practicals should not be included in any assessment. Amongst chemistry teachers, 65% felt practicals should be included in assessing chemistry, while 23% disagreed.

Table 11: Percentages of teachers who indicated that a practical component should be included in the assessment of Leaving Certificate chemistry, biology and physics

		N	Yes	No	Don't know
LC chemistry	Chemistry tchrs	210	64.7	23.1	12.2
	All	590	48.1	18.0	33.8
LC biology	Biology tchrs	376	62.0	29.3	8.7
	All	623	55.2	23.5	21.3
LC physics	Physics tchrs	173	55.2	33.5	11.3
	All	589	46.3	18.2	35.5

Teachers were also asked how well they felt the rJCSS prepared students for the various Senior Cycle science courses. Again, there was a high percentage of 'don't know' responses, largely because not all teachers taught a given subject to Leaving Certificate students. Thus, Table 12 reports responses for all teachers and responses for those who have taught a particular subject within the last three years. As can be seen, once 'don't know' responses are excluded, there is a strong degree of similarity between the responses of all teachers and those teaching a specific science subject. Fewer than 6% of teachers felt that Junior Certificate science students were very well prepared for Leaving Certificate physics or Leaving Certificate chemistry. Indeed, just over half felt that students were poorly or very poorly prepared (a percentage that rose to 60% when the views of physics teachers were considered). Attitudes were more positive where biology was considered, with approximately 70% indicating that the rJCSS prepared students well or very well for the Leaving Certificate biology course. Just over half felt that the rJCSS adequately prepared students for the combined physics/chemistry course while just under half of agricultural science teachers felt it adequately prepared students, with 22% characterizing preparation levels for this course as very poor.

Table 12: Percentages of teachers indicating how well they felt the revised Junior Cycle science syllabus prepared students for Senior Cycle science courses

	Teachers	N	V. well	Well	Poorly	V. poorly	Don't know
Biology	Biology	377	11.6	60.9	22.8	4.7	3.5
	All	631	12.4	59.2	23.5	4.8	19.9
Agricultural science	Ag. science	87	8.3	41.6	28.3	21.8	26.6
	All	524	6.9	43.9	31.8	17.4	70.5
Physics/ chemistry	Physic/chem	52	6.8	48.2	35.1	9.9	39.2
	All	513	10.0	50.2	30.6	9.3	67.9
Chemistry	Chemistry	211	5.7	40.6	41.9	11.8	6.6
	All	622	3.9	45.3	41.9	8.9	31.0
Physics	Physics	171	4.9	34.9	48.3	11.9	9.5
	All	618	4.9	45.8	42.3	6.9	37.5

NOTE: 'Don't know' responses are excluded from calculation of other percentages shown.

Currently, 65% of Junior Certificate science marks are allocated to the written examination. Those surveyed were asked what percentage they felt was appropriate. The average percent allocated was 67%, with just over half indicating that between 60% and 70% was appropriate (Table 13). A very small minority (3%) felt that 100% of marks should be allocated to the written examination.

Table 13: Percentages of teachers indicating what percentage of Junior Certificate science marks should be allocated to the written examination

(N=625)	%
Up to 55%	17.5
60%	11.0
65% (current allocation)	30.7
70%	12.2
75%	10.3
76% – 99%	15.5
100%	2.7

Lesson Planning and Classroom Practice

The resources most commonly used to plan Junior Certificate science lessons were student textbooks, used by 86% of teachers to plan a majority of lessons, with only 2% indicating that they hardly ever or never used them to plan lessons (Table 14). The next most commonly used resource was the science syllabus, used by 61% of teachers to plan at least half of their Junior Certificate science lessons. Approximately 23% used audio-visual resources to plan at least half of lessons, while 11% used the internet, and a further 11% used content-based computer software to plan at least half of their lessons.

While 72.4% of those using the older syllabus with Third year classes hardly ever or never used computer-based software to plan their lessons, this fell to 48.3% when those teaching the rJCSS were considered. Also, while just over half (53.9%) of those using the older syllabus hardly ever or never used the internet to plan lessons, this fell to 40.2% for those using the revised syllabus. However, the numbers teaching the pre-2003 syllabus were very small, so all findings must be interpreted with caution.

Table 14: Percentages of teachers indicating the frequency with which they used various resources to plan Junior Cycle science lessons

	N	Most or all	50-90%	10-49%	Hardly ever or never
Student textbooks	663	40.6	45.4	12.3	1.6
Science syllabus	658	27.2	33.5	27.9	11.4
Audio-visual resources	650	5.6	17.5	53.1	23.8
Content-based computer software	650	2.1	9.5	37.3	51.1
Information from the internet	648	1.6	9.8	46.8	41.8

A significant minority of respondents (16.4%) added to the list of planning resources. Almost one-third of these used additional academic sources, such as books, science journals and teachers' own knowledge and material. A further 16% used resources that fostered an STS approach (e.g. newspaper articles and everyday examples of science phenomena). Almost 14% of those who listed an additional planning resource indicated that they used some form of an interactive or 'fun' element in planning lessons, such as discussion, role-play, games and puzzles. Other planning resources listed included additional equipment (such as models, posters, charts and 3-D aids), handouts, worksheets or sample test papers, ICD material and datalogging. A small number stated that they planned lessons using practical work. However, it was unclear if this referred to using the outcomes of previous practical lessons to plan subsequent lessons or if preparing equipment for a practical lesson was viewed as part of lesson planning.

Unlike the resources used in planning lessons (which tend to be somewhat similar across grade levels), the resources used during a lesson can vary considerably, depending on the grade level in question. For this reason, questions relating to classroom practice asked respondents to limit their answers to their Third year classes. This allowed for a more accurate picture of practice at a particular grade level, but unfortunately, it meant that teachers who had not taught Third year students did not answer the questions.

As with planning lessons, the resource most commonly used in Third year science lessons was student textbooks – used in a majority of lessons by 80% of teachers (Table 15). Past or sample exam papers were also widely used in science lessons with Third year students. Fourteen percent of teachers indicated that they used them in most or all lessons, while a further 45% used exam papers in over half of lessons. Forty-five percent of science teachers used workbooks and worksheets in at least half of lessons, compared to the less than 8% where content-based computer software or information from the internet was concerned. The resources least frequently used were specialised hardware (such as datalogger), and newspaper or magazine articles about science – hardly ever or never used by at least three-quarters of Third year science teachers.

There were few differences in the responses of those teaching the older and the revised syllabi. However, while 45% of those teaching the revised syllabus to Third years used workbooks or worksheets in at least half of lessons, only 30% of those using the older syllabus did so.

Table 15: Percentages of teachers indicating the frequency with which they used various resources in Third year science lessons

	N	Most or all	50-90%	10-49%	Hardly ever or never
Student textbooks	567	44.2	35.6	15.9	4.2
Past / sample exam papers	565	14.1	44.9	38.5	2.6
Workbook / worksheets	565	10.2	35.2	46.4	8.2
Information from the Internet	557	0.5	6.5	30.5	62.4
Content-based computer software	554	0.5	7.3	27.2	65.0
Newspaper / magazine articles about science	559	0.2	2.1	22.8	75.0
Specialised hardware (e.g., datalogger)	548	0.1	1.9	16.8	81.1

Approximately one-third of respondents indicated that in most or all of their Third year science lessons they related scientific concepts to examples in the real world, while a further 46% indicated that this occurred in a majority of such lessons (Table 16). Most teachers also regularly used examples of technological applications to show how science is relevant to society, or reported regularly using a physical model to help students understand a science topic. A majority of teachers indicated that in over half of their lessons, students performed experiments by following instructions, and drew conclusions from an experiment they had conducted. However, between 5% and 6% of teachers indicated that these activities hardly ever or never happened. Forty-seven percent of teachers indicated that in over half of their lessons students spend time in a lab doing practical experiments. In comparison, 24% indicated that at least half of their lessons involved the teacher conducting experiments as a demonstration, while 20% indicated that this hardly ever or never happened.

Table 16: Percentages of teachers indicating how often listed activities occurred in their Third year science lessons

	N	Most or all	50-90%	10-49%	Hardly ever or never
Tchr relates scientific concepts to examples in the real world	564	32.5	45.5	21.7	0.3
Students draw conclusions from an experiment they have conducted	563	21.3	43.7	29.8	5.3
Students do experiments by following instructions	561	16.5	39.5	37.8	6.2
Tchr uses examples of technological application to show how science is relevant to society	559	10.4	29.6	43.6	16.4
Tchr uses a physical model to help students understand a science topic	560	10.2	31.4	46.9	11.5
Students spend time in a lab doing practical experiments	561	9.2	38.0	49.6	3.2
Tchr does experiments as demonstrations	558	6.0	18.4	55.4	20.2
Students design an experiment to answer a scientific question	560	1.8	7.9	43.5	46.8
Students read articles about science in sources other than their usual textbooks	557	0.6	3.1	24.4	71.9

Students designing an experiment to answer a scientific question was less common, with almost half of teachers indicating that this hardly ever or never happened. Of the nine listed activities, the one least likely to occur in a Third year science lesson was students reading articles about science in sources other than their usual textbooks. This never or hardly ever happened in 72% of teachers' classrooms, while only 4% indicated that it happened in more than 50% of lessons.

Those teaching Third year students were also asked to indicate the extent (if any) to which a variety of factors impeded their effectiveness in teaching science to those students. As can be seen from Table 17, lack of technical support was far more likely than any other factor presented to be described as a major impediment. Seventy-one percent of teachers felt that lack of technical support impeded their teaching of science to Third year students to a great extent, while a further 18% felt it impeded them to some extent. Almost three-quarters felt that insufficient class time impeded them to at least some extent, while 62% cited insufficient laboratory time as an impediment. At least half of those who responded also felt that their effectiveness in teaching science to Third years was impeded to a great or to some extent by lack of computer software, lack of computer hardware, and insufficient laboratory equipment. However, less than one-in-ten felt that poor quality textbooks impeded their teaching to a great extent.

Eight percent of respondents (35 teachers) indicated other factors that impeded their teaching of science to Third years. Of these, 35.8% felt that a shortage of time to prepare, set up and clean up after practical lessons impeded their teaching of science, while 24%

cited student-related issues (e.g., discipline problems in the laboratory, lack of student interest, student aptitude). Lack of internet access, or broadband internet was mentioned by 15%, while 12.8% complained about elements of the revised syllabus, including the release date for Coursework B, an increased workload, and the use of overly technical language. Other impediments listed included a lack of audio-visual resources, poor laboratory design, health and safety issues and that some teachers lack skills relating to elements of the syllabus and to the use of computers.

Table 17: Percentages of teachers indicating the extent to which a variety of factors impeded their teaching of science to Third year students

	N	A great extent	Some extent	V. little	Not at all
Lack of technical support	567	70.6	17.6	3.8	7.9
Insufficient laboratory time	558	36.4	25.2	20.1	18.4
Insufficient class time	564	32.1	41.2	18.1	8.6
Insufficient laboratory space	561	29.7	25.9	23.0	21.4
Lack of computer software	558	22.2	27.5	30.3	20.0
Lack of computer hardware	559	22.1	28.2	26.9	22.7
Insufficient laboratory equipment	564	19.7	32.9	29.3	18.1
Lack of audio-visual equipment	562	16.5	26.3	34.5	22.7
Poor quality of textbook content	563	7.1	30.2	39.3	23.4
Other	35	70.8	29.2	0.0	0.0

To support the introduction of the rJCSS, schools were provided with a grant of €3,500 for each Junior Cycle science laboratory in the school. In addition, schools which had not had a major capital upgrading since 1995 could apply for an enhanced grant to meet identified needs. On average, schools received a total grant of approximately €18,000. Given this, it is not surprising that those teaching the rJCSS were less likely than those teaching the older syllabus to feel impeded by lack of laboratory equipment. Half (52.0%) of those teaching the rJCSS felt that insufficient laboratory equipment impeded their effectiveness, compared to 68% of those teaching the pre-2003 syllabus. In contrast, while 38.1% of those teaching the pre-2003 syllabus felt that a lack of computer software was, at least to some extent, impeding their effectiveness, this rose to 50.2% when those teaching the revised syllabus were considered.

Those who had taught both the rJCSS and the earlier (1989) syllabus were asked to indicate the extent to which the implementation of the former resulted in changes in certain elements of their Third year science lessons. Almost all (94%) felt that the amount of preparation required for science lessons had increased, while 86% felt that student involvement in practical work had also increased (Table 18). Eighty-seven percent thought that their own use of investigative approaches to teach science had increased and that students' use of investigative approaches had increased. Just over 60% believed that the content of the revised syllabus was more relevant to students' everyday lives than the content of the old syllabus, while only 3% felt that the content was less relevant. Sixty-eight percent found an increase in collaborative group work and discussion involving students and over half (51.6%) of teachers who had taught both syllabi felt that there was at least some increase in students' abilities to apply science processes.

However, approximately half believed that the revised syllabus had not led to any change in students' understanding of science concepts, in students' interest in learning science, or in the emphasis on preparing students for the written examination. Fifty-seven percent of teachers felt that the revised syllabus had not led to any change in their own use of ICTs in science classes, while almost 70% noticed no change in student use of ICTs.

Table 18: Percentages of teachers indicating the extent to which implementation of the revised JCSS resulted in changes in certain elements of their Third year science lessons

	N	Major Increase	Some Increase	No change	Some Decrease	Major Decrease
Amount of work tchr must do to prepare for science lessons	433	65.3	29.0	5.5	0.2	0.0
Student practical work	433	42.7	43.3	13.6	0.5	0.0
Use of investigative approaches by students	429	24.3	62.7	13.0	0.0	0.0
Tchr use of investigative approaches to teach science	430	20.8	66.0	12.4	0.7	0.0
Collaborative group work/discussion involving students	431	9.8	58.3	29.6	1.8	0.7
Use of ICTs (e.g., computer software) by tchrs in science classes	432	7.8	33.5	56.9	1.2	0.5
Relevance of content to students' everyday lives	429	5.3	55.4	35.9	3.2	0.1
Students' interest in learning science	433	5.3	38.0	53.3	3.0	0.5
Emphasis on preparing students for the written JC examination	433	4.7	14.7	52.9	23.7	4.0
Students' ability to apply science processes	431	4.3	47.3	42.7	4.8	0.9
Use of ICTs (e.g., computer software) by students in science classes	430	3.0	24.8	69.8	1.9	0.5
Students' understanding of science concepts	431	2.8	38.1	50.5	7.8	0.8

Classroom Practice and the PISA Framework

All respondents were asked to indicate how much emphasis they placed on developing particular skills in their Third year science students (the skills chosen had been identified in the PISA science framework as important life skills). Over 80% of teachers reported placing either some or a lot of emphasis on interpreting scientific evidence and drawing conclusions, on explaining conclusions reached and the scientific evidence on which they are based, and on applying scientific knowledge to a given situation (Table 19). Over 70% placed either some or a lot of emphasis on justifying the acceptance or rejection of conclusions, and on developing their students' skills in describing and explaining scientific phenomena and predicting changes. Sixty-four percent felt that they placed at least some emphasis on identifying suitable keywords to search for scientific information on a given topic. Almost 60% placed at least some emphasis on distinguishing between scientific and non-scientific explanations and just over half (56%) placed some to a lot of emphasis on distinguishing between questions that can be answered using a scientific approach and those that cannot.

Table 19: Percentages of teachers indicating how much emphasis they place on developing particular skills in their Third year science students

	N	A lot	Some	A little	None
Interpreting scientific evidence and drawing conclusions	593	40.4	46.0	10.6	3.0
Explaining conclusions and the scientific evidence on which they are based	592	40.2	43.1	13.2	3.5
Applying scientific knowledge to a given situation	593	32.8	50.9	14.1	2.3
Describing or explaining scientific phenomena and predicting changes	586	28.4	50.5	17.4	3.7
Justifying the acceptance or rejection of conclusions	591	23.8	48.6	20.9	6.7
Identifying suitable keywords to search for scientific information on a given topic	590	21.2	43.2	24.3	11.4
Distinguishing between scientific and non-scientific explanations	589	17.7	40.4	31.0	11.0
Distinguishing between questions that can be answered using a scientific approach and those that cannot	590	10.8	44.9	27.3	17.1

Additional Comments on the rJCSS

At the end of the questionnaire, teachers were asked if they wished to make any additional comments about issues raised in the questionnaire or about Junior Cycle science in general. An unusually large percentage (55%) did so, with just over half of these making comments on more than one theme or topic. The topics raised are summarised in Table 20, and explained in more detail below.

Table 20: Summary of additional comments made by respondents

	N	% of all respondents	% of those who commented
Criticisms of syllabus content / style / depth	121	17.6	32.5
Need for a lab technician	110	15.9	29.4
Lack of time	97	14.2	26.2
Need for additional resources	60	8.7	16.1
Positive comment on syllabus content / style / ICD	56	8.2	15.1
Timing of Coursework B	54	7.9	14.5
How marks are obtained	50	7.3	13.6
Logistic/implementation problems with rJCSS	47	6.8	12.6
rJCSS and weaker students	34	4.9	9.0
Health & safety issues	11	1.7	3.1
Other	34	4.9	9.0

Percentages sum to more than 100% as some respondents made multiple comments.

Criticisms of Syllabus Content / Style / Depth

Almost one-third of those who added a comment (18% of all respondents) criticised the content, style or clarity of the revised syllabus. Complaints included a lack of clarity about the depth with which topics needed to be covered – with a number wondering if they were expected to teach definitions – and an over-emphasis on learning facts, with no time to examine concepts. Many raised specific issues related to the practical work element of the syllabus. For example, there was a perception that too much time had to be spent writing up experiments, while ignoring how well students actually carried out the experiments. Thus, it was felt that writing skills, rather than the ability to conduct an experiment, were rewarded. A small number complained about the style of language used in the syllabus and textbooks, suggesting that it was difficult for weaker students to understand.

Many felt that there were too many mandatory activities, while a small number indicated that the mandatory activities selected were poor exemplars. Some complained that although there were officially 30 mandatory activities, in practice, many more activities had to be completed. Generally, there was a feeling that in attempting to complete all the mandatory activities within the allocated time, discussion and analysis had been replaced by rushed conducting and write up of activities.

Some views were contradictory. For example, some respondents felt that there should be fewer topics on the syllabus, with more in-depth coverage of those retained. However, others commented that while the approach adopted was generally positive, they felt that students were missing a foundation in some of the basics of science, suggesting that some important topics were missing. Other comments in this general category included perceived weaknesses in the coverage of particular areas (each of physics, chemistry and biology were mentioned as 'losing out' in the revised syllabus), and the widening of the gap between the requirements of Junior Certificate science and the requirements of Leaving Certificate science subjects. Leaving Certificate biology was mentioned as needing a more practical orientation, while the (possible) lack of the need to learn definitions was seen as an obstacle to Leaving Certificate physics and chemistry.

"The information content of the course has been reduced, creating problems at Leaving Certificate. [It would be] better to shorten the syllabus and give more details"

"The revised syllabus is big on activities but short on science"

"The investigative approach is the way forward but you also need to create a foundation in the basics of science"

"Losing touch with basic skills like drawing a graph"

"I am also extremely concerned about how these students will cope with the even greater jump into L.C. physics than they had with the old course. The two don't seem to apply to each other"

"JCSS is very good on the process of doing science. JCSS is seriously lacking in important content, e.g., global ecological issues, knowledge of the universe"

"Most of the mandatory practicals are not discovery-based"

Laboratory Technicians

A large percentage (29% of those who offered a comment, or 16% of all respondents) raised the issue of laboratory technicians. Consequently, this topic is treated separately to the more general category of additional resources. There were no contradictory comments on this topic. All those who raised the issue felt that laboratory technicians were needed to help teachers implement the syllabus properly. There was a consensus that the revised syllabus had greatly increased the amount of laboratory-based work required, without any concomitant reduction in contact teaching hours. Aside from an increase in laboratory classes, respondents also felt there had been increases in the time needed to prepare laboratories for lessons, to clear up after lessons, and to engage in laboratory management and stock control. They felt that laboratory assistants were needed to help them manage some or all of the above, as well as assisting with supervision when a large number of students were conducting experiments. A small number suggested that while the practical orientation of the revised syllabus was a very good idea, it was unlikely to be effective without the employment of laboratory assistants.

> *"A great course if you had a lab tech and proper ICT resources in a lab"*
>
> *"Need more technical support to be able to get away from class demos only"*
>
> *"With all the equipments and practical work we now have to carry out, and the new demands on equipment, a lab technician is a necessity"*

Time Demands

Although many of those who raised the need for a laboratory technician indicated that part of the reason was a shortage of time, a further 26% of those who made comments (14% of all teachers) independently mentioned shortage of time as a problem. Many of the comments referred to an increase in teacher workload as a consequence of the revised syllabus, while others felt that the course was too long to cover in the time allocated. Others specifically mentioned time constraints related to the practical elements of the course, usually suggesting that an additional double lesson per week was needed to do the course justice.

> *"No time has been allocated to teachers for preparation for all this work and clearing up after, ordering equipment/materials, logging/correcting/keeping records of mandatory experiments and Coursework B"*
>
> *"Preparation is huge – worksheets for investigations should be prepared by the Department for all teachers"*
>
> *"While I welcome the increased student participation in investigative practical work, there has been a huge increase in my workload, free classes and lunchtime are spent preparing for practical classes"*
>
> *"Five classes per week in my view are required to comfortably complete the course timewise – 2 doubles and 1 single"*

Resource Needs

Sixteen percent of those who wrote comments (9% of all teachers) discussed the need for more resources. In particular, the need for increased access to school laboratories was cited as a problem. Many felt that it was difficult to complete practicals and the associated preparation and cleaning work in the time they were allocated. Specific resources mentioned as lacking were data projectors, dataloggers, and computers. Some pointed out that not only did they not have such equipment, but that their laboratory could not accommodate them were they available. While most wanted additional physical resources, a small number mentioned the need for additional human resources (other than laboratory technicians). These included the need for smaller class sizes for practical lessons (implying that more teachers were needed) and the need for a science co-ordinator in each school.

"My modern new lab has 'no room' for a computer or other audio visual equipment"

"Access to lab only once a week a problem"

"All schools need lab technicians urgently for H & S reasons"

"Use of IT limited by pressure on computer room. Labs given computer room rejects!"

"JC science looks like a good idea but with lack of training and resources it will eventually become a subject taught from the textbook and done by experimental rote. You don't get much when you're cheap!"

Positive Aspects of the Syllabus

Fifteen percent of those who wrote additional comments (8% of all teachers) wrote positively about the revised syllabus or of their experiences teaching it, although many added a negative qualification. For example, while some felt that the students enjoyed the practical element, they also felt their (the teacher's) workload had increased. Others felt the revised course was more interesting, but too long or too difficult to fit into the timetabled hours. Some felt that the course was generally good, but that time was required to sort out logistic issues and to establish the best methodologies, while a small number felt that the revised syllabus it made it easier to get a good grade. Many commented on the high quality of the ICD provided, although again, this was sometimes coupled with a negative comment about the timing or quantity of ICD. One teacher commented that the introduction of Coursework B had fostered collaboration between teachers in the school.

"Wish I was learning this course as a student - love it and love teaching it"

"<u>Quantity</u> of inservice poor, <u>quality</u> of inservice excellent!"

"I like the new J. science syllabus, especially the hands on approach by students, but a lot of prep work is required to have practicals set up & equipment ready for class"

"Attractive course. Students enjoy investigative approach. Seriously hampered by issues around laboratory"

"I feel the JCSS is a great improvement on its predecessor. I think it gives students a more <u>practical</u> experience of science and as a result they see science as being more fun and exciting, as well as challenging but approachable"

Timing of Coursework B

Approximately 15% of those who made comments raised issues about the timing of Coursework B. All felt that the timing of the release of Coursework B titles was poor, and many felt that the time allowed in which to complete them was too limited. A particular point of concern was that the delay in sending schools the Coursework B titles meant that it had to be completed at the same time as mock examinations, mid-term break and Easter holidays. This was perceived to be a time when students' minds were focussed elsewhere. Some felt that while there appeared to be adequate time for students to complete Coursework B, no account was taken of the quite limited laboratory access in many schools. Many suggested that Coursework B should be distributed before Christmas, while some suggested it should be done in Second year. Others noted that projects for some other examination subjects also had to be completed at around the same time, causing unnecessary stress to students.

"Lateness of part B titles, prior to JC mocks, defies belief. Instructions on exact format details on completion of projects is a disgrace"

"Too many time demands Mar/Apr. Trying to monitor exam preparation and focus on write up of practicals coursework"

"With regard to the timing of the release of Coursework B – the titles are released at a time when Mock Exams, Mid-term breaks and Easter Holidays leave a very narrow time frame to complete the experiments. Therefore the students are somewhat rushed and do not have the time to take a full investigative approach to the topics at hand"

"My 3rd years have CPSE, religion, science and possibly art and construction projects all to do around the time of the pre-examinations. The Department should spread out their workload over 2nd and 3rd year better"

How Marks are Obtained

Almost 14% of those who made an additional comment (7% of all teachers) referred to structure of the marking scheme for Junior Certificate science, to how marks were obtained in practice, and to how the examination papers were designed. A number were unhappy that there seemed to be no choice on the paper. Some felt this disadvantaged weaker students while others felt that it made it harder to achieve a high grade. There were mixed views about the appropriateness of the marks allocated to Coursework. As noted earlier, most teachers were satisfied with the principle of allocating a considerable percentage of marks to the practical element of the course. However, some were dissatisfied with *how* the marks were distributed between the two types of Coursework. For example, some felt that 25% was too much for a few weeks work (Coursework B), or that 10% did not reflect the amount of work demanded by Coursework A.

Many also expressed doubts about how well the marks assigned to Coursework would reflect a student's capabilities. While a few raised the issue of Coursework being graded by teachers with little or no experience in grading such work, most were worried that Coursework was not necessarily students' work. For example, some felt that parents would help their children, while others felt that some teachers would do most of the work for students. Consequently, some felt that the marks assigned to Coursework should be reduced, while others felt that the State Examinations Commission should incorporate a practical element into the examination – with equipment supplied and activities supervised by personnel from the Examinations Commission.

"The lack of choice in the final exam mitigates (sic) against students achieving A grades and simply serves to make the process of correcting easier and less cumbersome"

"I don't think Coursework B will be a true test of the pupil's ability and therefore 25% is far too high a mark. In reality, the teacher will do the planning, buy the equipment, tell the student what to do and write it up because the majority of students are unable to do so"

"I think Coursework B is going to be easier for students coming from homes where parents have a scientific background and I wonder how fair this is"

"I feel that the project work in Coursework B is open to abuse/cheating and should not be"

"Get rid of coursework: its rarely student's own"

"I strongly feel that the students should be inspected (externally) on-site doing science investigations. Coursework A is in danger of becoming a form-filling exercise. Students can get full marks for copying out experiments without having done them"

Logistical / Implementation Issues

Thirteen percent of those who made comments (7% of all teachers) referred to logistical problems with the implementation of the revised syllabus (excluding the late release of Coursework B titles). Some referred to an inadequate amount of ICD, with others pointing out that there did not appear to be supplementary ICD for those who missed the original series (for example, those on career breaks). While most felt that the ICD offered was of good quality, some felt it presumed access to certain laboratory equipment and ICT resources, while others complained that it did not supply answers to basic questions. For example, a few indicated that they did not know how to deal with students who had missed some of the mandatory experiments, or with students who had lost their lab copies.

There were also complaints about the late availability (or unavailability) of aids such as sample completed investigations, sample exam papers and teacher guidelines, while one respondent felt that the new textbooks were rushed publications and were not a good reflection of the syllabus. A number of teachers also criticised the question style on the sample papers that were made available, indicating that some students found them off-putting or hard to understand.

"Having an inservice on "sequence of teaching" new course when the first three years are over seems a bit strange!!"

"Samples of completed investigations highlighting [the] correct method of approach etc. would be useful for students"

"More guidance needed with new Project"

"The course is now 3 years in operation & the first group are being examined in June yet no guidelines for the revised syllabus have been published"

The Revised Syllabus and Weaker Students

Nine percent of teachers who made additional comments (5% of all respondents) referred to how the revised syllabus affected weaker students. However, views were evenly divided between those who felt weaker students were in a better position than before and those who felt that the new syllabus put them at an even greater disadvantage. Those who felt that weaker students benefited singled out the practical element for praise. Some felt that the marks assigned for the practical element made it easier for weaker students to obtain marks. Others felt that it made it easier to engage weaker students, or that it rewarded students for the ability to *do* something, rather than just write about it.

In contrast, others criticised the organisation of Coursework, because marks were assigned for writing up experiments, not for being able to conduct them properly or being able to explain verbally what they had done. Some also mentioned the volume of material that had to be covered as being somewhat confusing or overwhelming for weaker students.

> *"[students with a learning difficulty] … can do the experiment and discuss what has happened but cannot write about it. No marks are awarded for actually <u>doing</u> the experiment, all the marks are given for <u>writing</u> it up. Once again these students are penalised for what they don't know and not rewarded for what they do know and what they can do practically"*
>
> *"The previous Ord. Level papers were much more 'doable' by weak students who enjoyed answering them. I'm told the difficulty is to ensure that they don't do too well on the written paper as they will already have maybe 30% sitting down to do the written paper"*
>
> *"I find the new Junior Cycle much better for those students who do not do so well in written exams. It allows their lab work to make a difference to their result"*

Health and Safety Issues

Three percent of comments related to health and safety issues. All indicated that they had not received any health and safety training associated with the introduction of the revised syllabus[3]. Some indicated that a large group of students simultaneously performing experiments in a laboratory was a considerably higher risk setting than a teacher performing a demonstration. In particular, some mentioned fears about the behaviour of disruptive students and weaker students, who were either unwilling or unable to follow instructions. One respondent also felt that science teachers should be consulted when new laboratories were being designed, as many designs did not deal adequately with space and health and safety issues.

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[3] Health and safety training was integrated into ICD related to the introduction of the revised syllabus, rather than included as a separate module.

"I am very worried that in our current climate, lab work is almost impossible on my own with no help. I am very nervous of accidents and student injury"

"It appears no one thought of the safety aspects of the practicals when done by a class of 28 students – some of whom are not able to read"

"Without a lab technician, unruly kids place restrictions on practical work"

Other Comments

A large number of teachers (5% of all respondents) made additional comments that did not fall into any of the categories shown in Table 20. Such comments included those who did not see much difference between the revised and older syllabus, or who indicated that they had always used the investigative approach. Others thought that there had been considerable change and suggested that it would take time for teachers to become comfortable using the investigative approach or the new methodologies. A small number of responses related to science's position in the post-primary school timetable, including the view that science should be a core subject, and that insufficient time was allocated to science as a subject.

A number of additional comments could be classified as broad, negative statements about the capabilities of current students. These included a perceived deterioration in mathematical skills, in attitudes to learning (and to learning science in particular) and in willingness to engage in an independent style of learning.

Conclusions and Discussion

Thus far, this paper has described aspects of science teaching at Junior Cycle, described teacher views on the rJCSS, and examined how the PISA assessment framework is reflected in teaching practices. In this section, we discuss the implications of our findings. It was not possible to link teacher responses directly to student performance on PISA scientific literacy as, at the time of writing, data collection was ongoing in some countries. Therefore, only broad linkages between PISA scientific literacy and teacher responses are possible. The data do, however, provide considerable information about the implementation of the rJCSS.

Given the very high school- and teacher-level response rates, it is reasonable to believe that the views expressed by respondents are representative of those teaching Junior Certificate science classes. The data suggest that most of those teaching Junior Certificate science are experienced teachers and that almost all have studied science at third level. In terms of gender and teaching experience, the teachers surveyed are similar to those who participated in TIMSS in 1995 (Beaton et al., 1996), although the percentage of female teachers has risen slightly since then (from 54% to 60%). Most of those surveyed had experience of teaching both the rJCSS and its predecessor, and were able to comment meaningfully on the effects of syllabus change.

The rJCSS can be examined in two ways – the syllabus as intended in theory, and how it has been implemented in practice. Our data indicate that while many support the syllabus as theoretically constructed, there are difficulties with its implementation. For example, there were complaints about a lack of published teacher guidelines[4], of sample completed investigations and about the delay in issuing sample exam papers. There was also widespread dissatisfaction with the information given on assessment procedures.

Some of these issues can be resolved easily for the 2007 examination cohort. For example, it was never intended that teachers be provided with sample investigations. Instead, general support in this area was provided by the Junior Science Support Service. In a related vein, a small number of teachers wanted generic forms such as worksheets for investigations to be developed centrally and made available to all teachers. In fact, such worksheets are available on the *juniorscience.ie* website. However, many teachers have never used the website, and even those who have used it may have had difficulty finding the worksheets. Improved communication would help to resolve both of these issues.

Some other implementation difficulties also seem easily remedied. For example, earlier distribution of Coursework B titles would allow students more time to complete them, also solving problems with limited laboratory access and clashes with project work for other subjects. Similarly, 'catch-up' ICD for those who missed the original sessions seems a relatively simple logistical problem to overcome, and is scheduled as part of the work of the Junior Science Support Service for the 2006/07 school year.

The lack of laboratory assistance was another factor widely perceived as hampering the implementation of the syllabus (and was also cited as a significant problem in a recent ASTI survey of teachers in a 'head of science' role [ASTI, 2006]). Many teachers felt that the rJCSS had significantly increased their laboratory workload without any decrease in their class contact hours. This, they felt, gave them little time to prepare and clean up after practical lessons. Others raised fears about supervision and safety issues when large numbers of students – particularly disruptive or low-achieving students – were performing experiments. Others felt that while the revised syllabus appears to advocate a more interactive approach, this was difficult for one teacher to manage with of a large group of students. The employment of technical assistants was one of the recommendations of the Task Force on the Physical Sciences (2002). It remains a relevant recommendation.

A number of teachers also complained about the lack of any health and safety training to accompany the rJCSS. The Junior Science Support Service adopted an integrated approach to health and safety training. Thus, rather than providing a separate module on health and safety, such issues were integrated into other modules. Our data suggest this model of training needs some modification if teachers are to feel fully briefed on the relevant issues.

Textbooks can influence the implementation of a syllabus, particularly if, as we found, teachers use them far more commonly than other resources when planning lessons. However, 37% of teachers described poor quality textbooks as an impediment to teaching science. This suggests that textbook publishers and authors, in consultation with subject and curriculum experts, need to devote greater attention to ensuring that textbooks adequately reflect and support the aims, objectives and content of the syllabus.

[4] At the time of writing, only draft guidelines (NCCA, 2006) were available on the NCCA website.

Implementation issues aside, the rJCSS was intended to differ from its predecessor in a number of ways, including reduced length, increased emphases on scientific investigation, on applying scientific processes, and on understanding the scientific concepts involved. It is also intended to provide a better match with the contents of the primary school science syllabus, and to reduce the focus on the terminal written examination paper. Thus, a notable difference between the rJCSS and its predecessor is that only 65% of a student's final mark is derived from the written examination. While the percentage of marks that should be allocated to practical work is often a contentious issue, our data show that most teachers are largely in agreement with the changes introduced. Indeed, less than 3% felt that all marks should be derived from the written paper.

It is harder to assess if the new syllabus does indeed create a seamless flow between science at primary and post-primary levels. While an introduction to the primary school science syllabus was included as part of the in-career development (ICD) programme for the rJCSS, it does not seem to have fostered an understanding of the primary syllabus among most survey respondents. A majority of teachers (all teaching *Junior Cycle* students) described themselves as unfamiliar with the science content and processes in primary school science. It would seem important to address this issue if teachers are to create a smooth transition across the two syllabi for students.

Amongst the hoped-for benefits of the rJCSS were increased uptake rates of science subjects at Senior Cycle and at third level, and a better balance between biology and the physical sciences (Task Force on the Physical Sciences, 2002). While most of those teaching Leaving Certificate biology felt that the rJCSS provided adequate preparation for that course, only a minority of those teaching Leaving Certificate physics and chemistry felt that students were adequately prepared for their courses. Possibly, the rJCSS has not achieved a balance between the three core science subjects. However, since most teachers were satisfied that the it helped students to understand how science is used in the real world, and to develop a positive attitude about science, it may be that changes are required at Senior, not Junior, Cycle in order to produce better linkages between the two levels. It is too early to establish definitively if uptake at Senior Cycle will increase, but the perception of a lack of preparedness for chemistry and physics suggests it may not.

Teachers seemed to appreciate the increased emphasis on scientific investigation, albeit with caveats about implementation. Self-reports of behaviour also suggest that the revised syllabus has led to major increases in student use of investigative approaches, and in the lesson time allocated to practical work. There were also significant increases in the use of investigative teaching approaches and in collaborative group work. However, while the rJCSS was perceived to be more relevant than the older syllabus to students' everyday lives, most did not feel that this had led to an increase in student interest levels or to student understanding of scientific concepts.

Theoretically, the rJCSS is more closely aligned than was its predecessor to the PISA framework for scientific literacy. Teacher responses also suggest that, at some levels, there has been a greater alignment between classroom practice and scientific literacy as conceptualised in PISA. As already noted, there has been a reported increase in the use of investigative approaches and a perception that the course is more relevant to students' everyday lives. A comparison of TIMSS data with those of the present survey provides some evidence that these perceptions are reflected in practice. For example, in 1995, teachers in Ireland were less likely than were teachers in most other countries to rate student understanding of how science is used in the real world as important (Beaton, et al., 1996). In contrast, the present survey found that most teachers reported using real world examples in most lessons.

Further, most teachers reported that they placed considerable emphasis on some of the key elements of the PISA science framework. For example, one-third of teachers felt that they placed a lot of emphasis on interpreting scientific evidence, on drawing and explaining conclusions and on applying scientific knowledge. However, this does not appear to be directly attributable to the rJCSS, as those teaching the pre-2003 and the revised syllabi reported no major differences in the emphases given. An important element of PISA scientific literacy is that students should be able to evaluate if claims are scientifically sound. Such claims need not necessarily be major scientific theories, but everyday claims such as those made in advertisements or newspapers. However, most teachers felt that the rJCSS would have little effect on students' ability to read critically a newspaper or magazine article about a scientific experiment. Also, teacher reports indicate that distinguishing between scientific and non-scientific explanations and between questions that can or cannot be answered using a scientific approach were the two aspects of the framework that received least emphasis in Junior Cycle science classes. PISA 2006 (and its predecessors) includes a small number of items that ask students if specified questions can be answered using a scientific approach. Previously, Irish students have performed reasonably well on such items, despite apparently limited exposure to the underlying concepts during science lessons. It remains to be seen what effect, if any, the rJCSS will have on how students perform on such items in the future.

Finally, the rJCSS represents a closer alignment with the *concept* of scientific literacy, as defined in the PISA framework. However, in terms of *content*, some of the topics covered may be less familiar to those studying the revised syllabus than they would be to those who studied the older syllabus. For example, PISA 2006 contains four major categories covering knowledge of science (Physical Systems, Living Systems, Technology Systems, and Earth and Space Systems). The last category – Earth and Space Systems – receives considerably less coverage in the revised syllabus than in the pre-2003 syllabus.

Overall, our data suggest that the revised syllabus has achieved some, but not all, of its aims. There appears to have been a shift to a more practical method of teaching science, but this change has been hampered by some implementation difficulties. In theory at least, the revised syllabus at Junior Cycle is more closely linked than was its predecessor to scientific literacy as defined by the PISA framework. Thus, it will be interesting to discover if this theoretical alignment leads to improved PISA science performance by students in Ireland, or if the removal of some content areas from the syllabus leads to a deterioration in Ireland's relative position.

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