At the Crossroads: The Impact of New Irish Science Curricula on First Year Post-Primary Students

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Abstract In Ireland, new science curricula were introduced at primary and early post-primary levels in 2003, in an effort to reverse declining interest and enrolment in science. This paper reports on a national study that explored first year post-primary students' experiences of and attitudes towards school science under these new curricula. Data were gathered from 366 pupils using survey and case study approaches. Findings revealed broadly positive attitudes towards post-primary school science, especially the experimental work that is at the heart of the new curriculum. However, it would appear that students were not conducting open-ended investigations or using information and communications technology [ICT] to any great extent; moreover, there was some evidence of traditional teaching methods being utilised. Pupils were highly critical of previous primary school science experiences, reporting a lack of 'hands-on' activities, didactic methodologies and, for a significant minority, a paucity of any memorable primary science at all. Improvements in curricular implementation are proposed.

Keywords Children's voice • Curriculum • Primary/ post-primary transition • School science.

Introduction

In September 2003, the introduction of a new Junior Cycle Science Syllabus (Department of Education and Science [DES] 2003a) and the Primary Science Curriculum (DES 1999a) heralded major developments in school science in Ireland. The Primary Science Curriculum

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is for all pupils at primary school. It supports learning across a broad range of scientific content, whilst also developing pupils' skills of working scientifically and designing and making (DES 1999a). The Junior Cycle Science Syllabus intends to provide a balanced study of science topics, whilst catering for the full range of student ability in early postprimary years (DES 2003a). Students normally take three years to complete the syllabus, starting in first year and culminating with the Junior Certificate examination at approximately age 15. Post-primary science is not compulsory, however, and in some schools, students can opt out, even on school entry.

Both primary and Junior Cycle science curricula contain many similarities and their aims have much in common (DES 1999a, 2003a). This paper examines the reality for first year post-primary students of this ideal of curriculum continuity and the impact of these new curricula. It complements a parallel study, which focussed on primary children only (Murphy et al. 2011b).

Literature Review

Prior to curricular changes in Ireland, major concerns about school science had been raised. These included the declining uptake of sciences, especially physical sciences, at upper post-primary level and beyond (McNaboe and Condon 2007; Smyth and Hannan 2006) and the potential impact on Ireland's future commercial viability (Task Force on the Physical Sciences 2002). In addition, school science did not seem to be preparing the general student population for life in a technological society. Indeed the Programme for International Student Assessment [PISA] results in 2003 raised concerns about levels of scientific literacy of Irish 15-year-olds, prompting an exhortation to "develop the scientific knowledge of all Junior Cycle students" (Cosgrove et al. 2005, p. xxiv). Against this background, a revised Junior Cycle Science Syllabus (DES 2003a) was devised with an aim of fostering scientific literacy for all, in alignment with a new Primary Science Curriculum (DES 1999a). The former also stated that, as a consequence of studying science "it is hoped that many students will be encouraged to study … science subjects in the Senior Cycle, thus preparing themselves for further study or work in this area." (DES 2003a, p. 3).

A key focus for both curricula is on increasing opportunities for students to learn through inquiry-based approaches. The new curricula are thus in keeping with recommendations made at European level that school science should move away from teacher-focussed, deductive approaches towards more teacher-guided, inquiry-based pedagogies in order to engage student interest (Roccard et al. 2007). Proposals such as this were in turn supported by thinking that inquiry-based science education [IBSE] could be beneficial to students by promoting: debating and cognitive skills (Driver et al. 1985); a sense of ownership and hence interest in science (Novak and Gowin 1984); gains in scientific knowledge, skills and literacy (Hackling et al. 2007); and students' motivation and positive attitudes towards science (e.g. Krogh and Thomsen 2005; Murphy et al. 2011a; also see Minner et al. 2010 for a comprehensive review). Such claims about the impact of IBSE have not been without criticism, however (e.g. Kirschner et al. 2006). Indeed in Ireland it has been predicted that pupils' engagement with inquiry-based approaches may ultimately have little effect on later uptake of science subjects (Matthews 2007), although one study pre-dating current Irish curricula indicated a higher uptake of science in post-primary schools where teachers emphasised practical activities and student participation (Smyth and Hannan 2002, cited in Smyth and Hannan 2006). In order for the effect of curricular developments to be examined, however, it is essential to determine whether curriculum implementation is a reality for students; this issue forms a key focus for the current study.

Irish Junior Cycle and Primary Science Curricula

The revised Junior Cycle Science Syllabus in Ireland (DES 2003a) replaced the one introduced in 1989 (Department of Education [DoE] 1989), in an effort to address a number of the concerns outlined earlier. In the new syllabus, the subjects of biology, chemistry and physics are dealt with using a balanced, outcomes-based approach with an emphasis on acquiring scientific knowledge through investigation (DES 2003b). In contrast, the 1989 syllabus outlined scientific material as a list of content, leading to a view that students were "simply 'observing' or 'learning off' science" (DES 2006, p.3). The enhanced role of practical work in the revised syllabus is underpinned by fundamental change in formal assessment. In this, 35% of students' marks are based on coursework involving a combination of 30 mandatory, prescribed practicals conducted during the 3 years, worth 10%, and up to two open-ended investigations carried out in third year, worth 25% (DES 2003a). The terminal written examination, which attracts the remaining 65% of marks also "rewards the investigative approach and the application of science process skills" (DES 2006, p. 3). The 1989 syllabus, by contrast, was assessed via terminal written examination only, which focussed principally on recall of scientific content knowledge (e.g. DES 2001a, b).

In the revised syllabus, the three subject areas of biology, chemistry and physics receive equal emphasis for students at ordinary and higher level. This balance is evident in syllabus content, in the foci of the 30 mandatory practicals and in the structuring of the terminal written examination (DES 2003b). In contrast, the 1989 syllabus included a core and a choice of five extension topics (physics, chemistry, biology, applied science and local studies), from which ordinary level students choose any three, with higher level students having to take physics, chemistry and biology with one other extension topic (DES 2003b). Allowing students to select optional topics enabled them to place greater emphasis on some areas of scientific content than others, which was thought to favour biology (Eivers et al. 2006).

The new syllabus also advocates stronger links of subject material to examples in everyday life, in an effort to place a greater emphasis on a science-technology-society [STS] approach and scientific literacy than had been the case in the 1989 syllabus (Eivers et al. 2006). However, teacher guidelines state that there is "no explicitly prescribed STS content" and instead suggest exemplars as suitable ways of making relevant links (DES 2006, p. 2). Integration of ICT is also highly advocated as a means of supporting science teaching and learning, including, for example, students' use of simulation and data-logging (DES 2003a, 2006).

Another guiding factor in the design of the revised Junior Cycle Science Syllabus was to align the science encountered by students in early post-primary level with the science they would have experienced within the Primary Science Curriculum (DES 2006). The Primary Science Curriculum, intended for all primary pupils from ages 4-12, (DES 1999a) was itself a considerable development of the relevant section of its precursor, the *Curaclam na Bunscoile* (DoE 1971). Differences between these two primary science curricula have been considered in detail elsewhere (Murphy et al. 2011b); hence the current discussion will focus on comparing current primary and Junior Cycle science curricula. Primary Science Curriculum content is developed in four strands: Living things; Materials; Energy and forces and Environmental awareness and care (DES

1999a). The first three of these link closely, albeit at a more basic level, to material outlined under Biology, Chemistry and Physics respectively in the Junior Cycle Science Syllabus (DES 1999a, 2003a). Aspects of the primary strand Environmental awareness and care have equivalents in Biology, Chemistry or Physics topics at Junior Cycle and thus primary curriculum content is essentially a precursor to material developed further in early post-primary school.

Approaches advocated by both curricula are also very similar, in that there is a focus on enabling learning through practical or 'hands-on' work. Indeed, key scientific skills described in both curricula are similar, for example: observing, investigating, analysing and communicating findings (DES 1999a, 2003a). Primary pupils would be expected to develop these skills, grouped as *working scientifically*, at a more fundamental level than Junior Cycle students (DES 1999a). The Primary Science Curriculum also contains an additional set of skills, grouped under the heading of *designing and making* (DES 1999a) and whilst these are not explicitly followed up in the Junior Cycle Science Syllabus, they form relevant precursors to technological Junior Cycle subjects. Both science curricula strive to move teachers away from didactic modes of teaching, with the Junior Cycle Curriculum guidelines advocating a range of strategies that are "syllabus led rather than textbook led" (DES 2006, p. 11) and the Primary Science Curriculum guidelines specifically stating that "science lessons **should not be workcard or textbook based**" (DES 1999b, p. 27; emphasis in original).

Connections between the two curricula are also seen in the latter's aim of encouraging an awareness of the role of science and technology in society; and also in recognising the value of ICT in promoting learning in science (DES 1999a). One major contrast between the two is that the Primary Science Curriculum is not the subject of any formal, national assessment; procedures are suggested but left to individual schools and teachers to develop (DES 1999a). This last point aside, the links between the new Irish science curricula appear to be strong and should in theory, provide for effective progression and continuity from primary to post-primary level science. This is essential as this period of transition has been seen to be especially problematic.

School Science at Transition from Primary to Post-Primary Level

Experiences in the years surrounding transition from primary to post-primary level appear to be critical in the development of students' attitudes towards school science. Much international research indicates that interest declines in the early post-primary years (Dawson 2000; Francis and Greer 1999; Morrell and Lederman 1998; Osborne et al. 2003), whilst other studies suggest that an erosion in positive attitudes starts within primary level (Jarvis and Pell 2002; Murphy and Beggs 2002). There are also counterclaims that interest in school science across the primary/ post-primary divide is maintained (Logan and Skamp 2008), with pupils developing especially positive views about practical work on transfer (Braund and Driver 2005). Several factors have been suggested to have a negative impact at this important juncture. In the UK, intense preparation for primary national tests in science has been criticised (Collins et al. 2008). Standardised tests for science are not used at transition in Ireland, although the "effort and pressure" of preparation for post-primary entrance assessments in other subjects has been noted (O'Brien 2004, p. 87).

The perceived difficulty of post-primary science in Ireland has been linked to a decline in positive attitudes (Matthews 2007; Smyth and Hannan 2006; Smyth et al. 2004), although pupils in these studies would not have experienced the current Primary Science Curriculum before embarking on post-primary science courses. Discontinuities of teaching and learning at transfer from primary to post-primary school have also been linked to the development of negative attitudes, albeit in studies outside Ireland (Braund et al. 2003; Galton 2002; Jarman 1995,1997). The possible lack of continuity at this point in Ireland is raised, however, by a study of post-primary science teachers, which found that most were unfamiliar with the new Primary Science Curriculum (Eivers et al. 2006). In light of these issues, the first year after transition to post-primary school would appear to be a significant point at which to examine the impact of new curricula on Irish students.

The two most recent PISA studies of 15-year-olds have hinted at positive changes which may relate to curricular reform in Ireland. In the 2006 study, in which science was the major domain, just under half the Irish 15-year-olds claimed they had "fun learning science topics". Interest in learning human biology was high (over 75% of respondents), although fewer than 45% expressed positive views about chemistry and physics (Eivers et al. 2007, p. 26). It was unclear, however, whether attitudes differed between students who were working within the new Junior Cycle Syllabus at the time (about 50% of respondents) or its predecessor. In addition, few participants were likely to have experienced the current Primary Science Curriculum. The most recent PISA study, in 2009, was the first in which all Irish students should have engaged with the current Primary Science Curriculum and, where enrolled, would have experienced Junior Certificate Science under the new syllabus (Perkins et al. 2010). Ireland's drop in the Organisation for Economic Co-operation and Development [OECD] rankings in Literacy and Mathematics performance provoked much comment (e.g. Flynn 2010), however the results in science were encouraging, with OECD rankings climbing from 20th to 18th since PISA 2006. In explanation, it was suggested:

> The introduction of science as a subject in primary schools in 2003-2004 and the implementation of the revised Junior Certificate Syllabus Curriculum at the postprimary level from 2003 onwards may have mitigated the effects of changes in demographics that might otherwise have lowered performance in science in PISA 2009 (Perkins et al. 2010, p. xi).

However, the PISA 2009 report did not aim to examine the degree to which either of these curricula had actually been implemented or experienced by students. It may be relevant to note here that a survey of post-primary teachers after the introduction of the current Junior Cycle Science Syllabus revealed that, in spite of its emphasis on practical work, many post-primary teachers frequently used textbooks, exam papers, workbooks or worksheets for teaching, which would appear to indicate that the spirit of the new curriculum was not being implemented (Eivers et al. 2006). This study did not, however, directly determine the impact of such practices on students.

The current study sets out to review the implementation and impact of primary and post-primary science curricula by seeking the views of post-primary pupils in their first year after transition from primary school. In focussing on the students themselves, this work reinforces a belief on the part of the researchers and others (Logan and Skamp 2008; Murray and Reiss 2005) that students' voices are fundamental to any evaluation of the effectiveness of new curricula. Indeed, the reasons for devising new science curricula in Ireland, discussed above, were predicated on concerns about student engagement with school science and so it would seem to be essential to conduct such work. Specifically, this study aims to address the following:

- What are students' experiences of school science and do these indicate effective implementation of new curricula?

- What are students' attitudes towards the school science they are experiencing?
- What are students' aspirations in relation to the future study of science?

Design and Methods

Data were gathered during 2008 in the second school term, from first years enrolled in Junior Cycle science. The chosen cohort should have had at least 4 years' experience of the Primary Science Curriculum (DES 1999a), and had engaged in at least 18 weeks of study within the Junior Cycle Science Syllabus (DES 2003a). The choice of timing in first year at post-primary level mirrored an approach taken in a UK study of science continuity at transfer (Braund and Driver 2005). A mixed methods approach was taken, gathering data using survey and case study techniques.

Sampling

Survey

A random sample of 15 schools was drawn from the DES list of post-primary schools (n.d.), which was approximately 2% of all such schools. They were selected to represent a range of schools in Ireland, stratified by: second level school type; recognised disadvantaged status; gender mix and medium of instruction. In each school, one science teacher was asked to complete the teacher questionnaire and administer pupil questionnaires to all first years from one science class.

Case Study

Eight schools were selected in a purposive convenience sample, reflecting different types in the Irish post-primary school system. Where possible, these were linked to case-study schools used in a parallel primary study (Murphy et al. 2011b), and all were in Dublin or neighbouring counties. One science teacher and all students from one science class in each of the eight post-primary schools completed questionnaires identical to those in the survey. In seven of the eight case study schools, the science teacher was asked to select 4-5 students for group interview. In mixed schools, purposive samples of two boys and two girls were chosen. The researchers requested that students selected should be confident in interviews and reflect a range of ability levels. Twenty-nine students were interviewed. One case study school was unable to participate at the interview stage.

Instrument Development and Data Analysis

Student Questionnaire

This was developed following consultation of relevant literature (Dawson 2000; Jarvis and Pell 2002; Kind et al. 2007; Murphy and Beggs 2002; Reid 2003; Stark and Gray 1999; Woodward and Woodward 1998), for use in the context of Irish science curricula. Students were asked to indicate gender and age. Attitudinal data were then collected using a three-point (smiley face) rating scale. Where relevant, items were identical to those in the parallel primary questionnaire (Murphy et al. 2011b), to facilitate later comparison. Items were grouped as: Attitudes to school (6 items); attitudes towards learning about specified school science topics (18 items); attitudes to ways of learning science at school (16 items); and general attitudes to school science (6 items). A number of open questions followed. These asked students to compare their post-primary and primary school science experiences. They were asked in which setting they preferred science, providing reasons. Their views on future study of science were then sought, providing reasoning again. The questionnaire was translated for Irish medium schools, then piloted before implementation. Analysis of grouped items gave alpha values of 0.7 or higher, deemed acceptable as a measure of internal consistency (Kline 1993). Open question responses were analysed to develop coding categories (Glaser and Strauss 1967). Inter-rater reliability analysis was then undertaken with 100 previously uncoded questionnaires. Cohen's Kappa (K) values were all "good" or "excellent", at 0.634 or higher (Robson 2002, p. 342). All data were coded and entered onto SPSS [Statistical Package for the Social Sciences], version 14.0, for further analysis.

Teacher Questionnaire

This merely gathered contextual information such as topic areas covered to date and school details. As this study focussed on pupils, more detailed information on the teachers themselves was not sought. Indeed, a large-scale survey of Junior Certificate science teachers' qualifications and views on implementing the new curriculum had already been carried out prior to this study (Eivers et al. 2006), so the researchers felt it was not necessary to duplicate this work. In addition, the researchers considered that seeking background information about teachers in the current study, which could be linked directly to pupils' remarks, might appear somewhat threatening and could serve as a disincentive to participate. Piloting of the short questionnaire was carried out to ensure acceptable content validity. Data were entered onto SPSS alongside students' data to facilitate analysis.

Group Interviews

A semi-structured interview schedule was designed, aimed at establishing students' experiences and perceptions of school science, both at their current post-primary school and in previous primary school(s). After piloting, interviews were conducted by the researchers. These were taped and transcribed. Responses were read and re-read to establish and refine units of meaning and to identify links, patterns and similarities or differences. Two researchers coded the transcripts to establish inter-rater reliability.

Results

In the survey, responses were received from 234 students in 13 schools, representing a pupil response rate of 88% and school response rate of 87%. Girls made up 42% of respondents and boys 58%, with ages ranging from 12 to 15 years: 75% of students were aged 13. In the case study, 132 questionnaires were returned from the eight case study schools, representing a pupil response rate of 83%. Of the questionnaires returned, 45% were from girls and 55% from boys. The majority (68%) of students were aged 13, in a range of 12-14 years. Students' data from the survey questionnaires, the case study questionnaires and seven group interviews will be considered together and discussed under the following headings:

- Experiences of and attitudes to post-primary school science topics.

- Experiences of and attitudes to post-primary school science teaching methodologies.
- General attitudes to school science.
- Comparisons of post-primary with primary school science.
- Students' views about further study of science.

Experiences of and Attitudes to Post-Primary School Science Topics

Experiences of Post-Primary School Science Topics

Evidence from the teachers' questionnaires in both the survey and case study suggested that most students had already met physics, chemistry and biology topics at post-primary school. It was also apparent from students' interview responses that they had learned about a range of physics, chemistry and biology topics as described in the Junior Cycle Science Syllabus (DES 2003a): "There was a ball and a ring. When you put the ball in the fire it got bigger so it wouldn't go through the ring…it just shows you that heat made it expand," (V)[1]; "We've done a lot of chemistry. Sir showed us how to use the Bunsen burner and we've had to mix different chemicals together," (T); "In biology we go outside to find insects and things" (Z). Students in all seven interview groups gave examples of biological topics that had been studied, with students in six groups describing chemistry topics and five groups mentioning physics topics. Thus it would appear that a relatively balanced approach to the three core areas was being experienced, in accordance with the new curriculum (DES 2003a). In most cases, examples related to experimental work that had been conducted by the students themselves in support of their learning. This approach would accord with the remit of the Junior Cycle Science Syllabus (DES 2003a), or indicate at least that such methods of learning about scientific topics were especially memorable.

Attitudes Towards Learning School Science Topics

Survey students' attitudes towards learning different science topics were ascertained via rating scale responses. Overall, their attitudes to physics topics were not very positive (Table 1). Only two areas, "how machines work and move" and "magnets", were regarded positively by 50% or more respondents. Within chemistry, the vast majority of students showed positive attitudes towards learning about "what happens when you mix things together", with only 9% responding negatively (Table 2). Other aspects of chemistry were less favourably viewed, with only 40-50% of students giving positive responses. In general, survey students' attitudes towards learning about biological topics appeared quite positive (Table 3). The most negatively viewed aspect of biology was learning about "insects, bugs and invertebrates". Case study students' responses to these items on the questionnaire were broadly similar, with only six of the eighteen topics, spread evenly across biology, chemistry and physics, revealing statistically significant differences between case study and survey students (data not shown). In all six subtopics, the case study students held more positive views.

Responses to items were combined to calculate scores for overall attitudes towards physics, chemistry and biology. Related samples t-tests were carried out on the questionnaire responses from both case study and survey students: First year survey students' overall attitudes to learning biology and chemistry were more positive than their overall attitudes to learning about physics, the differences being statistically significant.

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[1] The letters T, U, V, W, X, Yand Z represent the seven case study schools where interviews were conducted.

Table 1 Survey students' attitudes to physics topics

(Figures expressed as percentages)

I enjoy learning about…	Yes	Not sure	No	Total
How machines work and move	56	21	20	97
How we heat our homes	30	35	33	98
Light, mirrors and shadows	40	32	27	99
How sound travels	44	32	21	97
Magnets	50	28	21	99
Electricity, batteries, bulbs and switches	47	29	24	100

N=234; not all totals add up to 100% owing to missing responses.

(biology/physics: $t=-3.16$; $df=217$; $p<0.05$; chemistry/physics: $t=-4.67$; $df=213$; $p<0.05$). First year case study students' attitudes showed statistically significant differences between all three subjects, with chemistry attracting the most positive responses, then biology, then physics (chemistry/biology: $t=-2.60$; $df=128$; $p<0.05$; biology/physics: $t=-2.78$; $df=127$; $p<0.05$; chemistry/physics: $t=-6.68$; $df=128$; $p<0.05$).

Experiences of and Attitudes to Post-Primary School Science Teaching Methodologies

Inquiry-Based Approaches

In the interviews, all students reported conducting experiments themselves and observing their teachers demonstrating experiments. All comments seemed positive: "Sir showed us that some [elements] even react with air. It was exciting." (T). Encouragingly, responses in relation to experiments carried out by the students were generally more in depth than responses relating to teacher demonstrations: "We first got the compass, and put it to the magnet to see which way was North and South. Then you draw dots around it, wherever it points to, and then you draw the lines," (W); "You get to do it. You can see it happening in front of you. If you make a mistake it's yours and the teacher can help you then. It's more interesting than reading or writing." (T). This suggests students' experiences of conducting experiments for themselves were especially memorable. Students in all interviews described practicals of a prescribed nature: "…it's written in the book and we do it" (Z); "He shows us how to do them [experiments] first. And we're able to do it." (X). Only one group described

Table 2 Survey students' attitudes to chemistry topics

(Figures expressed as percentages)

I enjoy learning about…	Yes	Not sure	No	Total
Materials… such as wood, metal and plastic	50	28	19	97
Solids, liquids and gases	43	34	21	98
What happens when you mix things together	72	18	9	99
What happens to things when you heat or cool them	45	29	24	98

N=234; totals do not add up to 100% owing to missing responses

Table 3 Survey students' attitudes to biology topics

(Figures expressed as percentages)

I enjoy learning about…	Yes	Not sure	No	Total
How the human body works	63	23	13	99
How to keep fit and healthy	71	18	9	98
Insects, bugs and invertebrates	34	27	39	100
Animals from around the world	59	24	14	97
Plants and how they grow	42	25	33	100

N=234; not all totals add up to 100% owing to missing responses

what appeared to be a more open-ended investigation: "She said it at the start [try and figure this out for yourselves]…you had to mix them together to see what colour they make" (Y).

Students' responses in the questionnaires revealed very positive views about conducting practical activities, more so than watching teacher demonstrations. For example, 89% of case study students and 88% of survey students indicated that they "enjoy science when I do an experiment with my friends". However, only 43% of case study students and 44% of survey students indicated that they "enjoy science when I do an experiment by myself". Perhaps group work was the norm, which could explain negative attitudes towards the idea of working alone. In comparison, only 36% of case study and survey students agreed that they "enjoy science when I watch my teacher doing an experiment".

It is of more concern however, that in relation to student-conducted experiments, the lowest figures were seen for students' claims to enjoy planning and doing their own experiments (37% in survey and case study). Perhaps such attitudes indicate that students had relatively little experience of student-led investigations: One survey student's comment beside the relevant item, "it would be good" implied that for this first year, such investigations were not within current experience at all. The evidence from case study interviews discussed earlier also implies a dominance of prescribed, teacher-directed practical work over independently-planned pupil investigations.

Other Teaching Methodologies

The group interviews indicated that teacher explanations were a common feature of science lessons, with students in all seven groups describing this form of approach: "Before we'd like start a chapter, she [teacher] might start discussing it…" (W). Although this would appear to be a rather passive methodology, students' attitudes towards teacher explanation were quite positive, with 59% of survey and 63% of case study students claiming to enjoy this. Later open responses on the survey students' questionnaires revealed: "She's [science teacher] the best at explaining!"; "Science in second level is explained. At primary they tell us it's just magic.".

Students in all case study interviews referred to reading in science class, some seeming quite positive: "I bring it [science textbook] home and read it, just ahead of things, because I really like it" (Y). Students in all group interviews suggested that writing up experiments and taking down notes were typical, frequent features of post-primary school science: "One of our copies is an experiment copy, and every time we do an experiment, we write it up… and then our other copy is our notes copy, so if we're learning about something, we'll take down notes." (Z). Views expressed in the interviews about writing were mixed, however no

Table 4 Survey students' attitudes towards reading and writing in science class

(Figures expressed as percentages)

I enjoy science when…	Yes	Not sure	No	Total
I read my science schoolbook	24	27	47	98
I copy from the board	34	27	38	99
I fill in my workbook/ worksheet	30	29	41	100
I write about something I have done in science class	29	26	44	99

N=234; not all totals add up to 100% owing to missing responses

students explicitly stated that writing was enjoyable: "Writing in science is okay, it's not like, fun, but it's you know, it's not boring really" (W). Survey students' responses to statements about reading and writing in school science were very negative (Table 4). However, from the survey data it is unclear the extent to which these methodologies were used. It may be relevant to note, however, that case study students' responses to the equivalent items were similarly negative, with no statistically significant differences between their responses and those of the survey students (data not shown). Overall, these data appear to point to negative or at best ambivalent attitudes towards these formal and commonly experienced modes of learning. Whilst written recording of mandatory practical work is advocated in the curriculum (DES 2006), some examples given by the students imply that there is a frequency of 'writing-up', note-taking and use of textbooks which appears to be against the spirit and recommendations of the new curriculum (DES 2003a, b).

When asked about attitudes to ICT use in science, more than 50% of survey students responded positively to the two relevant items. Such data should be interpreted cautiously, however, as they only measured attitudes, not levels of engagement. In relation to this point, students from five different survey schools wrote comments beside these items, indicating they had "never done" work with ICT in science. It would also appear from the case study interviews that ICT was not commonly utilised as part of learning science. Students in four interviews explicitly mentioned this: "We never get to use the computers" (U). Others indicated that it was the teacher using ICT, rather than the pupils: "She showed us a heart on it [interactive white board]…not the real heart, it was like a picture of a heart and like, all the arteries and all coming out of it (Y)"; "[Teacher] has a laptop and he puts the notes up for us (T)". Thus it would appear that students' apparently positive attitudes towards utilising ICT in science are somewhat aspirational. These findings are of concern, as pupils' use of ICT in science is explicitly recommended in the Junior Cycle Science Syllabus (DES 2003a).

Table 5 Survey students' attitudes to science at school

(Figures expressed as percentages)

What I think about science	Yes	Not sure	No	Total
School science is easy	26	42	30	98
School science is interesting	59	26	15	100
I like science better than other subjects	31	26	42	99
I look forward to science lessons	35	36	29	100

N=234; not all totals add up to 100% owing to missing responses

General Attitudes to School Science

At this juncture, it is relevant to consider students' more general attitudes towards post-primary school science as a means of assessing the overall impact of the individual science experiences. It was encouraging to see that 59% of survey students stated that they found school science interesting (Table 5) and it would be possible to infer that such claims emanated from positive views of content coverage and pedagogies discussed in detail above. Interestingly, students in the Relevance of Science Education [ROSE] project in Ireland gave fewer positive responses to an identical statement "school science is interesting", with only 30% choosing the most positive of *four* available options (Matthews 2007, p. 43). Although students in the ROSE project had studied science under the 1989 Junior Cycle Syllabus, a direct link between the 2003 syllabus and the current students' apparently greater enthusiasm can only be tentative, not least because ROSE students were older and had completed their Junior Certificate studies. Other responses to items about school science in the current survey showed that a minority looked forward to science lessons or found them easy. Despite this, almost a third of survey students claimed to like science better than other subjects, which was encouraging given the wide range of subjects that first years were likely to be studying. Case study responses to these items were essentially similar, with no statistically significant differences between the two cohorts of students (data not shown).

First year survey students' responses were contrasted with those in the parallel primary survey, gathered from upper primary pupils during the same academic year (Murphy et al. 2011b). Collectively, these represented a 'snapshot' of attitudes towards school science for different students at different points in their school careers. Post-primary pupils gave fewer positive responses about school science than their primary counterparts in statements common to the two questionnaires. Post-primary students in this survey thus appeared to be more negatively disposed to school science than primary pupils. Figure 1 is illustrative (Pearson chi-square: χ^2=26.2; *df*=2; p<0.01). First year survey students' general attitudes to school (6 common items) were also less positive than those of primary pupils. Differences were all statistically significant, with the exception of responses to the statement "I'm happy at school". First years appeared to be less enthusiastic about school and school work, did not claim to work as hard and found school to be less interesting than

Fig. 1 Primary and post-primary students' attitudes compared: Interest in school science. (*Figures expressed as percentages. N=1,264*)

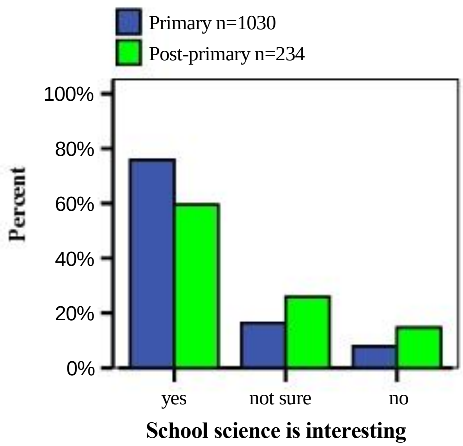
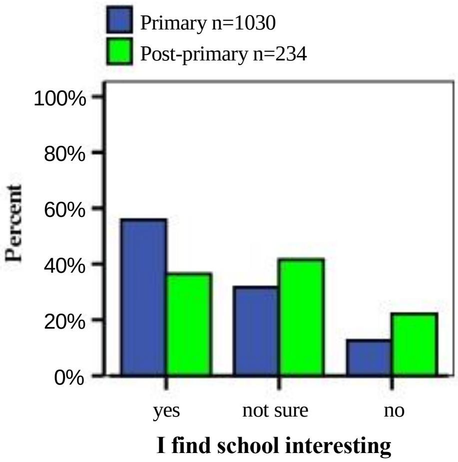


Fig. 2 Primary and post-primary students' attitudes compared: Interest in school. *(Figures expressed as percentages. N=1,264)*



their primary counterparts had stated. Figure 2 is illustrative (Pearson chi-square: χ^2=31.0; *df*=2; *p*<0.01).

The apparently low interest of first year survey students in school science compared to their primary counterparts was surprising, as it conflicted with their generally positive view of post-primary science experiences discussed earlier. Perhaps their apparent disinterest, according to rating scale responses, was merely symptomatic of a general lack of enjoyment of school. To this end, first years' responses to the statements "I find school interesting" and "school science is interesting" were compared. Attitudes towards school science were more positive than their claimed interest in school, the difference being statistically significant (Wilcoxon signed ranks test: *Z*=−5.081; *p*<0.01). This suggests that post-primary students' attitudes to school science were actually quite buoyant, relative to claimed interest in post-primary school.

It was important at this stage to examine past experiences of first years in primary school science, to establish how or whether these had impacted on current perceptions. In addition, it was felt that insights of early post-primary students into the implementation of the Primary Science Curriculum might provide useful information in relation to transition.

Comparisons of Post-Primary with Primary School Science

Previous Experiences of Science in Primary School

The case study interviews were conducted in seven post-primary schools, however students in these groups had come from 17 different primary schools. Therefore comments from the interviews in this section represent experiences from a wider range of primary schools than the number of interview groups.

Encouragingly, students in four of the seven group interviews indicated that they had experienced science in primary school on a regular basis. On the other hand, students in six of the seven interviews indicated that they had rarely or never experienced science in their primary schools: "I can only actually remember doing one experiment. And it wasn't a big one. It was just to see if an orange floated." (W). Perhaps, during their final year in primary school, these students may have focussed on other matters: "I don't think we did many

Table 6 Differences between primary and post-primary science: categories drawn from survey students' open responses

	Frequency	Percent
Post-primary science involves/ is…		
More experiments (general statement)	67	30
More difficult	42	19
Learning more	38	17
More science (rarely/ never at primary)	36	16
More science (general statement)	30	14
More interesting/ makes more sense	20	9
Better experiments	14	6
Doing experiments yourself	11	5
More equipment/ more hi-tech/ chemicals	11	5
More fun	11	5
Wider subject choice	7	3
More dangerous/ exciting	7	3
More note-taking and tests	7	3
Teachers explaining more/ better	5	2
More experiments (never at primary)	3	1
Better facilities	3	1
Primary science involved…		
Bookwork only	3	1

n for question=222. Rare responses (<1% of n) not shown

Responses do not add up to 100% as most responded in multiple categories

experiments in sixth class at all. The teacher just didn't do science really… She was just pretty much just doing everything, getting ready for the entrance exams … and the confirmation and everything" (V).

Survey students' remarks in the open questions concentrated on ways in which they saw post-primary science as an improvement on that experienced at primary level (Table 6). They commented favourably on the increased amount of science at post-primary level. Primary and post-primary curricula differ in the weekly time recommended for science (DES 1999c, 2003a), so this is not so surprising. Of more concern is that 16% of survey students claimed that they had done *no* science at primary school, or such experiences were rare: "in sixth class I didn't do 1 day of science". Analysis revealed that 12 of the 13 post-primary science classes that responded to the survey contained at least one student who volunteered such a claim. Taking interview and survey responses together, these data raise concerns about the differing amounts of primary science that first years in a given post-primary science class may have experienced, perhaps as a consequence of coming from different feeder schools.

Students in five of the seven group interviews recalled learning about topics from the Living things strand and three groups mentioned learning about aspects of the Materials strand of the Primary Science Curriculum (DES 1999a). Interviewees only recalled learning about certain topics from the Energy and forces strand. For example, students in four interviews recalled "doing the magnets" (V) and in all interviews, there were students who had made circuits in primary school: "I can just remember lighting up a light bulb" (U). None mentioned topics from the Environmental awareness and care strand. The limited topics remembered could be indicative of the infrequency of primary science lessons. In comparing post-primary with primary school science, survey students enthused about the current wide range of subject coverage and claimed that they were learning more (Table 6). The topics in the Primary Science Curriculum cover at least as broad a range as those in the Junior Cycle Science Syllabus, so such remarks would again appear to suggest limited experiences of science content at primary level.

In terms of case study interviewees' recollections of teaching methodologies, it is encouraging that students in five of the seven interviews reported 'hands-on' activities in primary school: "We got to do it…we got to do the light bulbs" (Y); "I also made a lighthouse with my friend" (T). However, it is difficult to establish the frequencies of such experiences, since students in six of the seven interviews had already stated that they rarely did science in primary school. Students in three interviews recalled watching their teachers demonstrating experiments in primary school: "A teacher would be up at the top of the class and everyone comes up and stands around and watches" (U); "She'd [teacher] like, she'd show us the stuff, and write it on the board and we'd only taking it down" (W). Students in four groups mentioned writing in primary science, "We usually just got a worksheet" (Y), including a worrying comment: "There's a lot more writing than learning involved in primary school" (X). Reading in science class was recalled by students in two groups, "We didn't do that much experiments. We didn't actually do that much science. If we did…we pretty much read from the book" (Z). Students in only three interviews reported using ICT:

> They had kind of microscopes that were kind of connected to the computer so when you put something in, you could see it on the screen of the computer. So like it would be kind of good if they had them in this school (Z)

Students in two interviews specifically mentioned not using ICT in primary school science. For the most part, students' recollections of primary science were not detailed and it was not especially evident that they had engaged with the Primary Science Curriculum in either its content or recommended methodologies to any great extent.

Comparing Students' Attitudes Towards Primary and Post-Primary School Science

In the case study students' questionnaires, 81% indicated that they preferred post-primary to primary science and 79% of the survey students stated the same view. All students in all group interviews stated a preference for post-primary school science, with six interview groups citing increased frequency. Students in five group interviews indicated that they preferred post-primary science since they had more opportunities to conduct experiments: "It's more interactive, you get to do more things than you did in primary school … and we have like, more equipment to do stuff with…"(Y); "We have to test things ourselves-we don't just have to believe the book. We can prove it and I like that" (T). Survey students' reasons for preferring post-primary science (Table 7) mostly referred to practical activities and the fact that students were conducting these themselves. Some survey students also remarked on the differing nature of practical activities at post-primary school, that is, that they took place in laboratories with better equipment and that this was perceived, positively, as being more dangerous.

Some students in the survey responded favourably that post-primary science was more interesting and challenging. Whilst suchremarks are not inthemselvesvery enlightening, students in five of the interviews also claimed challenge as a reason for preferring post-primary science, providing further insight: "It's challenging in a good way. It makes us think. We're not children anymore" (T). The converse of this is that a few students in both survey and case study responses indicated that post-primary science was harder, and this was seen as a negative attribute.

Table 7 Survey students' reasons for preferring post-primary science: Categories drawn from open responses

	Frequency	Percent
More experiments	60	29
More interesting	45	22
More hands-on (students conduct experiments)	26	13
Learn more interesting things	21	10
More frequent/ more time/ didn't do at primary	20	10
More stuff to do (unspecified)	17	8
More fun/ enjoyable	13	5
Just better	11	5
There are laboratories	10	5
More equipment	9	4
More challenging	8	4
Easier than primary	5	2
Wider range of subjects	5	2
More dangerous	4	2
It is better explained	4	2
Enjoy biology	3	1

n for question=204. Missing responses;"don't know"; rare responses (<1% of n) not shown. Responses do not add up to 100% as most responded in multiple categories

Students in five case study interviews maintained post-primary science was more informative:

I think in primary school, you kind of just did the experiments, but you never really did any learning for science. You never really learned much. You just did the experiments, and in this school, you actually have [a] science book and we're like reading and learning things (Z).

Whilst it was encouraging that the vast majority of first years in the current study were enjoying science at post-primary level, it was worrying that many justifications for the overwhelming preference were based on apparent deficiencies in primary science experiences. In this context, interviewees suggested that primary science lessons had lacked progression and continuity: "It was just so repetitive. You just learned the same things as the other years. And it just, you already knew everything" (W); "Sometimes like we went two, 3 weeks without doing science" (V). These remarks conflict directly with the developmental approach to learning envisaged in the Primary Science Curriculum (DES 1999a).

Student Suggestions for Improving Primary Science

Students in the case study interviews went on to make suggestions about how to improve primary science. Students in four case study interviews suggested that pupils should "do more science in primary" (U); students in four groups suggested that if primary science were time-tabled this could lead to more science being taught:

Well if you had like a set date, it would help because like there wasn't really a date where like you'd be doing science… It would just like whenever your teacher decided that she had some spare time to do it [science] (Z).

Interestingly, students in five group interviews suggested that primary science and hence the transition to post-primary could be improved if content were increased: “Because if you did a lot more science last year, you’d, you’d be able to understand it better. And you’d be able to know what you were doing” (V). It has to be borne in mind, however, that students making such statements might not have covered the content as recommended in the Primary Science Curriculum, as earlier evidence suggests. Students in four interviews proposed that having more equipment would improve primary science. In five groups, students said that primary science should prepare for, and link with first year science:

In like sixth class, they’re…pretty much preparing you for first year [post-primary]. And like, they’re all…getting ready for your entrance exams. But you should also be getting ready for science (W).

Back then it was a bit confusing and we didn’t really get it. We should have took down the key words, so it would have make us better in first year now (X).

Look at the secondary school book for first year and look at the curriculum …and sort of incorporate that into like a book for primary school, but like easier definitions (Z).

Comments such as these indicate students’ keen awareness of a disconnection between primary and post-primary science experiences and provide further evidence for an impoverished implementation of the Primary Science Curriculum.

Students’ Views About Further Study of Science

Just under half of students (44% in the survey, 48% in the case study) stated that they intended to study science at Leaving Certificate. The subsequent open question asking for reasons for their response revealed that students felt that science was interesting, fun, enjoyable, useful and even important although few respondents enlarged on these rather general reasons. It is therefore unclear whether these epithets were being used in response to students’ specific experiences of the Junior Cycle curriculum, or were based on broader understandings of science. It is notable, however that few (4% in the survey, 3% in the case study) referred specifically to practical activities as a motivating reason for continuing with science. In comparison, 14% and 19% in the survey and case study respectively, cited career-related reasons. Less than a third of survey students (29%) and case study students (27%) stated that they were not intending to study science at Leaving Certificate level or beyond. The most common reason given was difficulty (12% of survey and 15% of case study respondents).

Many case study interviewees were positively disposed towards the idea of taking a science subject beyond Junior Certificate. Chemistry and biology appeared popular, with students from four and three of the group interviews respectively indicating a preference for studying these subjects further. Students from one of the interview groups indicated a desire to study physics to Leaving Certificate.

Discussion and Conclusions

Experiences of Curriculum Implementation at Post-Primary Level and its Impact

Scientific Subject Content

Interview responses included a range of topics covered within biology, chemistry and physics from the Junior Cycle Science Curriculum (DES 2003a). The clearest descriptions of these involved examples where students had seen or participated in a practical activity to support their learning. Such exemplars indicate that a balanced approach to curriculum content is being adopted, in line with the intentions of the new curriculum (DES 2003a). In addition, the approaches described lend support to the idea that students are acquiring scientific knowledge through investigation, as recommended. In spite of the balance of topics covered, however, case study students' overall attitudes to learning scientific subjects revealed a differing enthusiasm for chemistry, biology, and physics at a statistically significant level, with chemistry being most positively regarded. Interestingly, in case study interviews, the subject that students most commonly wanted to study at Leaving Certificate was chemistry. Survey students' overall attitudes to biology and chemistry were also more positive than attitudes to physics, at a statistically significant level. Students' interest in biological topics is perhaps not surprising and mirrors other findings with older pupils (Eivers et al. 2007). This study, however, paints a new and encouraging picture of interest in chemistry, in contrast with extant Irish data (Eivers et al. 2007; McNaboe and Condon 2007). Significantly, the current research is the first of its kind in which all students were working within the new Junior Cycle Science Syllabus. Before claiming the new syllabus as a success in engaging students with chemistry, and a concern in relation to physics however, a note of caution should be sounded: Curriculum content is likely to be just one of many factors which might impact on students' attitudes to learning about different science topics, a point emphasised in the conclusions of the ROSE project in Ireland (Matthews 2007).

In terms of other school factors, for example, it is possible that a bias in subject qualifications of the pupils' teachers in the current study existed which might have had some bearing on pupils' subject enthusiasms, rather than the new curriculum as such. However, data on teachers' qualifications were not gathered for reasons discussed earlier, so it is not possible to examine this idea. It may be relevant to note here that an earlier study revealed that 96% of Junior Certificate science teachers had science qualifications at undergraduate level, with the vast majority having at least some background in biology, chemistry and physics at that level (Eivers et al. 2006).

At this point, it should be noted that there is a key aspect of the Junior Cycle Science Curriculum which was not apparent in any of the data collected in the current study. There were no references made by students in either interviews or questionnaire responses to content or approaches relating to an STS focus in science lessons. Whilst no explicit questions at interview examined this issue, the lack of any such data would indicate that little, if any attention is being directed towards this key curricular aim (DES 2003a).
Perhaps it is the case that teachers are making connections to the everyday world, but that students are failing to recall these readily. Equally, it may be possible that teachers believe that the nature of science, including STS, is implicit when students conduct experiments, and so does not need further coverage. In either case, it would appear that such strategies are not impacting on students. Perhaps more explicit ways of teaching about the nature of science and its role in society might be adopted; these have been shown to be both beneficial and motivating for students (e.g. McComas 1998).

Inquiry-Based Approaches

This study provides ample evidence that aspects of this central feature of the new Junior Cycle Science Syllabus are being addressed. Specifically, students appear to be engaging in inquiry-based science on a regular basis, via a combination of teacher demonstrations and directed practical work conducted by the students themselves. The detailed descriptions given by interview students appear to accord with a curriculum aim to "make biological, chemical and physical phenomena more real through actual experience" (DES 2003a, p.6). Survey and case study data also indicated that the vast majority of students held positive views about doing experiments.

In contrast, few students claimed to enjoy planning and doing their own experiments. The authors believe that such remarks may indicate an absence of such approaches rather than students' actual experiences. This view was borne out by interview data, where experiments described were almost exclusively prescriptive, contrary to syllabus recommendations to "foster investigation, imagination and creativity" (DES 2003a, p. 4). This mirrors similar concerns about practical approaches in a primary/ post-primary transition study in Australia (Logan and Skamp 2008). Perhaps post-primary science teachers are not engaging first years in independent inquiry because they are leaving open-ended work until the third year coursework investigations (DES 2006). However, if students are afforded few opportunities to develop independent inquiry skills in first year, then the authors contend that students will be ill-prepared for later assessments. There could be other negative consequences: A UK study suggested that early post-primary science activities that were highly prescribed ultimately led to disillusionment (Galton 2002).

Use of ICT in Science

According to interviews, a proportion of first years in the case study were not using ICT in science lessons, although some of their teachers were. The questionnaire did not aim to determine frequency of ICT use, however some survey students volunteered that they had never used ICT in science. Such evidence conflicts with the general promotion of ICT within the Junior Cycle Science Syllabus. However, curriculum guidance is not always supportive of this aim; for example, students must use laboratory notebooks and a printed pro forma for recording key components of coursework, both of which would appear to mitigate against the use of ICT (DES 2006). This may be one reason why students' use of ICT was limited and handwritten report-writing appeared common. Whatever the reasons are for poor ICT use, they should be identified and overcome: A UK study showed that appropriate use is strongly associated with enhanced student achievement and motivation in science at post-primary level (BECTA 2003).

Reading and Writing in Science Class

In this study there was a prevalence of descriptions of note-taking and recording experiments in "hard-back copies" (U) by the interviewees, which serve to confirm the findings of an earlier study of Irish science teachers' practices under the new curriculum (Eivers et al. 2006). It is perhaps unfortunate that the formal use of "laboratory notebooks" is embedded in the new curriculum (DES 2006, p.32), albeit just for mandatory practicals. Perhaps, in consequence, science teachers are adopting this format whenever recording is required. The case study interviews also indicated that some science lessons were heavily reliant on textbooks and reading "chapters and stuff" (Z). Such approaches appear to contradict a firm recommendation in curricular guidance that teaching strategies should be "syllabus led rather than textbook led" (DES 2006, p. 11). Survey students were very negatively disposed towards reading and writing in science, more so than their claimed interest in school (Wilcoxon signed ranks test: All statistically significant at $p<0.01$). This pattern was matched in case study questionnaire responses, although the case study interviewees indicated fairly ambivalent attitudes. The current study found no evidence of students utilising more creative or interactive methods of communicating, in spite of such alternatives being suggested in the guidelines (DES 2006). The deleterious impact of these routine and rather traditional approaches cannot be ignored as they are flagged as key contributors to sharply declining interest in school science (Braund et al. 2003).

General Attitudes Towards Post-Primary Science

Overall, most survey and case study students expressed positive views about post-primary school science. The evidence suggests that, where approaches in the new Junior Cycle Science Syllabus are being implemented, these are having a positive impact. These findings accord with work carried out in Australia (Logan and Skamp 2008). It may also be the case that for first years at least, science at post-primary level is still somewhat exciting and new and is therefore viewed in a fairly positive light, in spite of relatively low levels of general interest in school. In contrast, a US study of students from upper primary to upper post-primary levels revealed that interest in school science declined sharply compared with interest in school (Morrell and Lederman 1998). In the current context, it would be worth exploring whether positive attitudes towards science are maintained, or decline later in post-primary school, as research from elsewhere suggests (Dawson 2000; Francis and Greer 1999; Osborne et al. 2003).

The data from this study may lend some credence to the idea suggested in the PISA 2009 report (Perkins et al. 2010) that the new curriculum at Junior Cycle level has impacted positively on students in terms of their attainment. This connection can only be suggested tentatively, not least because students in the current study were from a different cohort and year group than those in PISA 2009; however, the link between motivation and achievement under this new curriculum would merit further research.

Experiences of Curriculum Implementation at Primary Level and its Impact

It is a major concern that these students' views of their primary science experiences are comparatively bleak. In the survey, some 16% of students chose to state that primary experiences had been absent or rare, a claim also made by some interview students. Case study and survey data also indicated that some students had infrequent opportunities to engage in practicals at primary level. These findings conflict with Primary Science Curriculum guidance, especially its emphasis on 'hands-on' approaches (DES 1999a, b).

Some interviewees suggested that one reason for the apparent lack of engagement with science at upper primary level was due to preparations for post-primary entrance examinations in other subjects. Such comments may indicate a more substantial problem which needs further exploration: General studies of school transfer in Ireland have raised concerns both about the emphasis on preparation for post-primary assessments and their widespread use (O'Brien 2004; Smyth et al. 2004).

In light of such experiences it was not surprising to find that an overwhelming majority of students preferred post-primary to primary science. The principal reason given was that students were afforded opportunities to conduct more experiments at post-primary level and that significantly, they were being allowed to conduct these for themselves. A similar outcome was noted in a previous UK study of science at transfer (Braund and Driver 2005). Students in the case study interviews proposed improvements for primary science, such as regular time-tabling, providing more equipment and enabling pupils to engage in practical activities. They also suggested that primary school should try to prepare primary pupils for post-primary school science. This is a particularly disconcerting indicator of the perceived discontinuity between primary and post-primary science, as it contrasts sharply with curricular intentions (DES 1999a, 2003a).

The researchers acknowledge that these students may have presented overly negative and critical views of primary science in a bid to distance themselves from primary school in general. Equally, the sheer novelty of post-primary school science may have eclipsed formerly positive views about primary science, of the type commonly found in our parallel primary study (Murphy et al. 2011b). Nevertheless, it would seem that some of those students who are forming positive attitudes towards post-primary science now are doing so in spite of, rather than because of their experiences of primary science.

Students' Views About Further Study of Science

Just under half of survey and case study students indicated that they would like to study science for Leaving Certificate, with a substantial minority linking this decision with chosen careers. The likely relationship of such views with future enrolment should not be discounted simply because these students are young; a large-scale longitudinal study in the US showed that pupils who expected to have a science-related career at age 13 were more likely to obtain college level science qualifications than those who did not (Tai et al. 2006). It is hard to say from the current research whether decisions about further study are directly linked to students' current engagement with school science. In particular, experimental work featured infrequently in their reasons for future scientific study, even though the evidence suggests that it is highly motivating for students now. This would appear to add some weight to remarks in the conclusion of the ROSE project in Ireland, made prior to the introduction of the new Junior Cycle Science Syllabus, that increasing the emphasis on practical work would not necessarily yield gains in terms of students' later study choices (Matthews 2007).

In the questionnaires, about a third of survey and case study students claimed that school science was not easy, with 12% and 14% of respective cohorts indicating that science was, or would be, too difficult to continue. The perceived difficulty of post-primary science and associated lack of uptake at upper post-primary level has been highlighted in earlier Irish studies (Matthews 2007; Smyth et al. 2004; Smyth and Hannan 2006). Current figures are, however, a little lower than those reported previously and encouragingly, this study is the first in which all respondents worked within the new Junior Cycle Science Syllabus (DES 2003a).

However, the current study also reveals that students appear to be entering post-primary school with widely varying experiences of primary science, and presumably diverse levels of attainment and skill. Thus, the continuity of learning intended by the introduction of new science curricula is being undermined by the reality of implementation at primary level. This could explain why some students find science difficult at post-primary level.

Recommendations

The positive message from this study is that certain key aspects of the new Junior Cycle Science Syllabus are being implemented, and that, in the case of practical work in particular, this is having a positive impact on most students. However, there is also evidence, or rather a lack of it, indicating a neglect of certain areas recommended in the new syllabus, namely the use of student-led, open-ended investigations, the use of ICT and the adoption of STS links and approaches. The reasons for this could not be fully examined in this study, which focussed on students rather than teachers and schools, but steps need to be taken to remedy these problems. This might be in the form of specific funding, development of additional resources and the support of science teachers themselves through professional development. Indeed, since this study was conducted, progress has been made in relation to resource development, for example through the work of the Junior Science Support

Service (JSSS 2009) and it would be hoped that such materials are having a positive impact. Institutions involved in initial teacher education should also be considering how best to equip new cohorts of Junior Cycle science teachers to tackle these specific approaches. The study also provides evidence that in some classrooms, there is an emphasis on fairly traditional, and somewhat negatively viewed modes of teaching when practicals are not taking place. This includes the writing of notes, formal recording of experiments and reliance on textbooks. Moving science teachers away from such approaches may be a more difficult task, especially if such practices have led to examination success in the past. Equally, there may be a reluctance to experiment with more interactive or student-centred approaches when, for example, teacher guidelines on coursework submissions insist on handwritten, formal report-writing (DES 2006). In this instance, although professional development would be useful, changes at systemic level would also be essential, to value and even perhaps insist on some alternative modes of reporting assessed coursework, such as posters, oral presentations or the use of multimedia.

The lack of continuity and progression between primary and post-primary science must also be addressed. An explicit way to achieve this could be by bringing primary and post-primary schools together to devise ‘bridging units’, an approach which has been successful elsewhere (Galton 2002; Braund and Hames 2005). These could focus on developing independent inquiry skills, creativity, STS links and use of ICT, which would also serve to address weaknesses apparent in the implementation of the Junior Cycle Science Syllabus. The authors warn however, that such activities should be phase-appropriate and not, for example, involve primary children rehearsing for the Junior Cycle Science Syllabus. In setting up such programmes, in-depth professional development would also need to be provided for teachers in both phases. A large-scale US study, for example, found that it was only after approximately 80 hours' professional development that teachers “reported using inquiry-based teaching practices significantly more frequently” (Supovitz and Turner 2000, p. 973). To date, such levels of support have not been widely available in Ireland.

The research reported here presents a ‘snapshot’ of curricular implementation in Ireland. Curricula discussed here are in their early years: Subsequent research should assess the long-term impact of early scientific experiences at school and monitor further developments in curricular implementation. It must be remembered that both new curricula were developed to effect positive change in relation to all pupils' experiences of school science. The beginnings of such change are evident, however primary and post-primary schools must take students' perceptions of the current picture seriously and work to address ongoing weaknesses of curricular implementation. Thus it appears that the teachers, as well as their students, are at an important crossroads.

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