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Science in Primary Schools, Phase 2

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Executive Summary

The formal implementation of the Irish Primary Science Curriculum (Department of Education and Science [DES], 1999a) commenced in September 2003. The National Council for Curriculum and Assessment (NCCA) has commissioned research to examine the effect and extent of this curriculum's implementation. This work forms part of the NCCA's rolling review of the Primary School Curriculum. This report represents the culmination of the second phase of commissioned research, which focuses on students in their first year at post-primary school. These students represent one of the first cohorts to have had the opportunity to study science within both the Primary Science Curriculum and the current Junior Cycle Science Syllabus (DES, 2003a; 2006). This phase of the research considers the impact of past and present experiences of school science on these students. In addition, it considers curricular continuity in primary and post-primary school science as viewed by pupils in the latter stages of primary school and students in their first year at post-primary level. Findings in this report are based on data gathered from a nationwide survey, in which 234 first year post-primary students completed questionnaires, and data gathered from a case study of 8 post-primary schools, in which students were interviewed and asked to complete questionnaires. These data were gathered between February and May 2008. Relevant data gathered from pupils in third to sixth class at primary level during Phase 1 of the commissioned research (Varley, Murphy and Veale, 2008) are also considered in this report.

Findings and recommendations are summarised here.

Summary of Findings

Expectations about post-primary school science

- The vast majority of older primary pupils are looking forward to studying science at post-primary school. Primary pupils in the latter stages of their primary schooling are anticipating post-primary school science that they believe will be interesting and involve conducting experiments in laboratories.

- The majority of students in their first year of studying science at Junior Cycle are enthusiastic about post-primary school science. It appears that their current experiences accord with, or even exceed expectations that were based on the science seen during visits to post-primary school before transfer.

Students' experiences of and attitudes towards school science

- Most first year students have studied aspects of the biology, chemistry and physics components of the Junior Cycle Science Syllabus. Many find the science content at post-primary level to be interesting and informative, though difficult at times. Overall attitudes towards learning about biological and chemical topics are more positive than attitudes towards physics topics. Compared with primary pupils, there appears to be a more negative attitude towards learning about virtually all science topics, however, first years' interest in school science is generally higher than their professed interest in school. Thus it appears that for first years, school science is maintaining a positive image against a backdrop of more limited interest in school.

- First year students are extremely enthusiastic about conducting practical science activities and it appears that they are regularly afforded opportunities to do so at post-primary level. However, the available evidence suggests that these experiences are generally of a prescriptive, teacher-led nature and that few students have conducted open-ended investigations as yet.

- In comparison with primary pupils, first year students appear to be rather unenthusiastic about teacher demonstration of science experiments. However, post-primary students view their teachers' role in explaining science in a generally positive light.

- First years are also positively disposed towards the use of ICT in science; however, it appears that students' actual experiences so far are very limited.

- First year students are very negatively disposed towards reading and writing in science class. These views are more negative than those of their primary counterparts, and are also more negative than students' expressed interest in post-primary school in general. The nature and frequency of writing at post-primary level is not viewed particularly positively by students, especially the "writing up" of work in designated laboratory notebooks.

- First year students are also considering their future study in science. Almost half claim that they would like to study science subjects at Leaving Certificate. Surprisingly, enjoyment of experimental work does not feature as a key reason for continuing scientific study and students focus instead on their interest in the subject and career implications of having scientific qualifications. For those suggesting that they do not wish to study science beyond Junior Certificate, the difficulty of school science is the dominant factor cited.

Students' comparisons of primary and post-primary science

- First year students' generally positive views of post-primary school science contrast strongly with their views about the science they experienced at primary school. The vast majority of first years prefer post-primary school science. This preference is related to several factors but dominant amongst them are: greater frequency of post-primary science in comparison to primary science and in particular, having regular opportunities to conduct experiments at post-primary level. It is of concern that a substantial minority of students indicate that they had no recollection of doing science at primary school, or that science lessons, especially those involving hands-on activities, were extremely rare.

- In relation to this disparity between the ideal curriculum at primary level and that recalled by first year students, further insights were gained. Preparation for post-primary entrance examinations in subjects other than science appeared to have dominated sixth class experiences for a number of students. Some express concern that primary school science did not adequately prepare them for science at post-primary level. In connection with this, the claim that school science is "easy" was especially prevalent amongst sixth class pupils, which potentially indicates a lack of challenge at upper primary level. First years suggest that more hands-on activities and regular timetabling of science at primary level might improve matters.

Summary of recommendations

These recommendations emphasise or supplement those already made on the basis of the research carried out in Phase 1 of this commissioned work (Varley et al., 2008).

- Students entering post-primary school should all have experienced a similar range, depth and type of primary science prior to entry, to ensure that curricular continuity is as effective as possible. To this end, longer term, more in-depth professional development courses should be provided to key individuals within the primary sector. Common goals and expertise could be developed by organising such support for teachers within clusters of schools that would normally feed into the same post-primary school(s).

- Money must be allocated to primary schools for the purchase of science equipment, especially consumables, on a yearly basis. By ring-fencing such funding, the development and expansion of hands-on science at primary level could be supported.

- Primary and post-primary schools in cluster groups should be encouraged to engage in greater liaison about school science. The joint planning of "bridging units" aimed at upper primary pupils and first years at post-primary level would be a potentially fruitful way to facilitate greater curriculum continuity. These units could focus on developing students' skills in areas that appear to be especially limited in both sectors at present, namely pupil-led investigations and the use of ICT in science.

- The Primary Curriculum Support Programme (PCSP) and science advisors from the Second Level Support Service (SLSS) should collaborate to produce and/ or improve on existing materials designed to enhance science curriculum continuity. Such materials could be made available to appropriate teaching staff in upper primary and early post-primary levels through relevant professional publications and support websites.

- Another research study of similar scope to the one reported here should be conducted in a few years' time. This would assess the impact of any ongoing or future initiatives, including those that occur as a consequence of the other recommendations in this report.

SECTION 1:

INTRODUCTION

This second phase of research commissioned by the NCCA focuses principally on students in their first year at post-primary school. As the Primary Science Curriculum is now in its fifth year of implementation, first years in post-primary schools should have engaged with the 1999 Primary Science Curriculum prior to transfer. In addition, these students should also have experience of learning science within the Junior Cycle Science Syllabus (DES, 2003a). This phase of the commissioned research aims to provide information on curriculum continuity. It will also consider the impact of curricular developments in both primary and post-primary sectors on students at the start of their post-primary school careers.

In this opening section of the report a brief overview of some of the issues surrounding early post-primary experiences of school science are considered. Research literature from Irish and selected international contexts is discussed, in relation to the uptake of science at later post-primary and tertiary levels and students' developing attitudes to school science. In addition, literature relating to students' experiences of school science on transfer from primary to post-primary settings is considered.

1.1 Concerns About the Study of Science in Ireland

Concern has been expressed in Ireland about the declining uptake of science subjects both in the later stages of post-primary school and at tertiary level (Task Force on the Physical Sciences, 2002). The proportion of young people taking physics or chemistry at Leaving Certificate level is low and has shown a decline since the 1990s (Smyth and Hannan, 2006). In 2006, only 14% of Leaving Certificate candidates took chemistry, and only 14% took physics. The low uptake of these sciences has had an effect on the numbers of school leavers opting to study for science-related qualifications at third level (McNaboe and Condon, 2007).

In recent years, Ireland's economy has benefited from its ability to attract investment from scientific and technological industries, providing them with a suitably qualified workforce (Task Force on the Physical Sciences, 2002). The decline in uptake of science at later post-primary and tertiary level would therefore appear to be a concern if such economic interests are to be sustained. In an international review of school students' attitudes to science, Osborne and co-workers stated that "there is a clear association between economic performance and the numbers of engineers and scientists produced by a society" (Osborne, Simon and Collins, 2003, p. 1053). The same article noted that Europe lags behind Japan and the US in its number of engineers and scientists per million of the population.

Whether or not young people intend to enter careers in science, another potentially important purpose of studying science at school is to prepare for life in a highly technological society. The Task Force on the Physical Sciences acknowledges that, "in an era of rapid technological change, the goal of 'scientific literacy for all' has become a primary objective of general education" (2002, p. i).

Recent research has raised concerns about the overall levels of scientific literacy amongst Irish post-primary students. The Programme for International Student Assessment (PISA) examines the scientific, mathematical and reading literacy skills of 15-year-olds. In the PISA 2003 assessment of scientific literacy, Irish students were found to rank 13th when compared with participants from 29 other countries within the OECD (Organisation for Economic Co-operation and Development). Whilst this is encouraging, the authors noted a difference in achievement between those students who had studied science at Junior Certificate higher level and those who had not. They recommended that efforts should be made to "develop the scientific knowledge of all Junior Cycle students" (Cosgrove, Shiel, Sofroniou, Zastrutzki and Shortt, 2005, p. xxiv).

In an effort to address concerns relating to subject uptake and scientific literacy, recent curricular changes have been made at primary and early post-primary level. Formal implementation of the Primary Science Curriculum began in September 2003 and this curriculum supports the notion of developing scientific literacy for all: "science education equips children to live in a world that is increasingly scientifically and technologically oriented" (DES, 1999a, p. 6). The current Junior Cycle Science Syllabus, also introduced in September 2003, has the development of scientific literacy in its rationale (DES, 2003a). Additionally, it goes on to state that, as a consequence of studying science at Junior Cycle "it is hoped that many students will be encouraged to study one or more of the science subjects in the Senior Cycle, thus preparing themselves for further study or work in this area." (p. 3).

Relatively little research to date has assessed the impact of these curricula. However, the latest PISA study was carried out in 2006 and thus included Irish students who had studied science within the current Junior Cycle Science Syllabus (DES, 2003a). Ireland ranked 14th out of 30 participating OECD countries in overall science performance, a ranking considered similar to that of the 2003 study. In the light of this result, concern was expressed that the 2003 Junior Cycle Science Syllabus had "not yet led to any discernable improvement in students' science achievement" (Eivers, Shiel and Cunningham, 2007, p. 34). However, it was noted that only about half of the Irish participants had studied science under the 2003 Junior Cycle Science Syllabus, and that some implementation difficulties had been encountered (Eivers, Shiel and Cheevers, 2006). In addition, few students in this study would have experienced the

Primary Science Curriculum (DES, 1999a). Worryingly, the PISA 2006 study also revealed there were no significant differences in achievement between Irish students who had not taken Junior Certificate science and those who had taken Junior Certificate science at ordinary level. Perhaps it is the case that the full impact of the newly-introduced curricula has yet to be realised. One important area in which new curricula could impact on students is in the promotion of positive attitudes to school science. Existing research on this issue will be discussed next.

1.2 Students' Attitudes to School Science

Concern about students' negative attitudes towards science is not new, and indeed, this issue has been investigated extensively for the last forty years (Osborne et al., 2003). Research in the UK, US and Australia has indicated that students' interest in science declines in the early post-primary years, in some cases from the year of entry to post-primary school (Morrell and Lederman, 1998; Francis and Greer, 1999; Dawson, 2000; Osborne et al., 2003). Studies conducted in England and Northern Ireland have even indicated erosion in positive attitudes towards school science that starts within primary level (Jarvis and Pell, 2002; Murphy and Beggs, 2002). Students' experiences of science at primary and early post-primary level may therefore be significant in shaping their attitudes towards science. Attitudes towards science resulting from school experiences are amongst those factors that are influential in determining later subject choices (Smyth and Hannan, 2006).

In Ireland, post-primary students' attitudes to science have been ascertained in a number of studies. The Third International Mathematics and Science Study (TIMSS) included an assessment of students' attitudes to science. First and second years in Irish post-primary schools participated in this study, with 67% of respondents revealing broadly positive attitudes (Beaton, Martin, Mullis, Gonzalez, Smith and Kelly, 1996). Irish post-primary students in transition year, or their first year of Leaving Certificate studies, were amongst the respondents to the international ROSE (Relevance of Science Education) survey (Matthews, 2007). Respondents had completed a course of study in Junior Certificate science the previous year (June 2002). A slight majority of these students expressed positive attitudes towards Junior Certificate Science and the majority claimed that school science was interesting. However, when asked about interest in different science topics, some of the lowest ratings were given to topics that had formed a major part of the Junior Certificate Science Syllabus. Furthermore, the great majority of Irish students in this study stated that they did not want to become scientists, or work in technology (Matthews, 2007).

Irish students' attitudes towards science were also considered within a broader, longitudinal study of experiences in early post-primary school. Initially in first year, interest in science was high, with over 75% of students expressing enthusiasm for the subject, placing it fifth out of thirteen subjects analysed (Smyth, McCoy and Darmody, 2004). Positive attitudes towards science subsequently declined during the first year, although this pattern did not continue into the second year. Declining interest in school science was observed against the background of a generally declining interest in school (Smyth, Dunne, McCoy and Darmody, 2006). As with the TIMSS and ROSE studies, these students had studied science within the old Junior Certificate syllabus. In a more recent PISA study of 15-year-olds, discussed in Section 1.1, about half of the Irish participants had studied within the current Junior Certificate Science Syllabus (DES, 2003a). Just under half of respondents claimed that they had "fun learning science topics". Expressed interest in learning human biology was high (over 75% of respondents), however interest in chemistry and physics topics was much lower, with fewer than 45% of respondents expressing positive views (Eivers et al., 2007, p. 26).

Data from these studies as a whole appear to show that Irish students in post-primary education hold generally positive views about science. It is not possible to compare data between the studies to say whether overall attitudes to science decline as Irish students progress within post-primary education, nor is it possible to determine whether attitudes have changed, even improved, since the introduction of the Primary Science Curriculum or current Junior Cycle Science Syllabus. At this point it should be noted that many factors can be significant in changing attitudes towards school science, some of which will be discussed next.

1.3 Factors Affecting Students' Attitudes to School Science

Factors that are suggested to cause a decline in positive attitudes towards science are many and complex, but include: intense preparation for primary national tests (in countries where they exist); the perceived difficulty of post-primary school science; teaching approaches; student-related factors and issues arising during the transition from primary to post-primary school. The last of these will be considered in detail in Section 1.4. The remaining issues of particular pertinence to this study are discussed briefly in this section.

National testing in science at primary level currently takes place in some other countries with primary science curricula, including England and Northern Ireland. A recent study of primary teachers in England revealed that test preparation affected the nature of teaching in the final year at primary level, resulting in a reduction in time for practical activities. The consequent, negative impact on older primary pupils' attitudes towards science was raised as a concern (Collins, Reiss and Stobart, 2008). The repetitive nature of revision classes for the science "transfer tests" in Northern Ireland has also been suggested as a factor that may lead to a declining interest in science in later primary years (Murphy and Beggs, 2002). In Ireland, although standardised tests for science are not used at the end of primary school, it is unclear whether the "effort and pressure" associated with preparation for post-primary entrance assessments (O'Brien, 2004, p. 87) has a negative impact on the teaching of other subjects, such as science, in sixth class.

In a review of international literature, it was found that some students perceived post-primary school science to be a difficult subject, and that this led them to be discouraged from further study (Osborne et al., 2003). Findings from the ROSE project, discussed in Section 1.2, also support this view: About 50% of participating Irish students regarded Junior Certificate science as demanding and difficult (Matthews, 2007). A longitudinal study of early post-primary students in Ireland also suggested this. At the end of their first year, students were asked to indicate subjects which they found to be difficult. Science was regarded in this way by 40% of respondents, placing it third after Irish and foreign languages (Smyth et al., 2004). In another study, the lack of science uptake at upper post-primary level was found to be related to its perceived difficulty (Smyth and Hannan, 2006). These studies involving Irish students were conducted prior to the introduction of the current Junior Cycle Science Syllabus, and hence it is not possible to say whether the perceived difficulty of the subject has changed.

Smyth and Hannan's study (2006) also pointed to other factors that might influence the later choices made by post-primary students about scientific study. At lower post-primary level, some of the factors identified were: the effect of "streaming" and ability in general; teachers and teaching methodologies; and, as for the ROSE project, students' perceptions of the usefulness of scientific study

(Smyth and Hannan, 2006). In the cases of streaming and ability, gender appeared as an additional factor: Girls in top and bottom classes in streamed schools were less likely to take biology than those in other class groupings. Male students who chose chemistry, and female students taking any scientific subjects to Leaving Certificate, were found to be disproportionately of higher ability, regardless of streaming. Students who had experienced more "negative interaction" with teachers were less likely to take physics and chemistry subsequently, although a link with lower examination performance by these students was also indicated (p. 313). An earlier study by the same authors showed a higher uptake of science in schools where teachers emphasised practical activities and student participation at both lower and upper post-primary levels (Smyth and Hannan, 2002, cited in Smyth and Hannan, 2006). Although these studies pre-date the introduction of the current science curricula, it is encouraging to note that interactive teaching and in particular, an emphasis on practical activities, are key features of the approaches promoted in both the Primary Science Curriculum (DES, 1999a) and the current Junior Cycle Science Syllabus (DES, 2003a).

1.4 Science at Transfer From Primary to Post-Primary School

Curricular discontinuity encountered by students at the point of transfer from primary to post-primary school is "an entire field of study in its own right", according to O'Brien's report on school transfer in Ireland (2004, p. 9). This section will therefore consider only a few key studies that provide information on students' experiences of science at transfer from primary to post-primary settings.

The contrast between students' expectations and the realities of post-primary science has been suggested as one factor contributing to the development of negative attitudes towards post-primary school science. In a UK study, science lessons observed at post-primary level "typically involved short periods of practical activity followed by extensive periods of writing up experiments" (Galton, 2002, p. 253). In his conclusions, Galton suggested that students' expectations of post-primary science might be unreasonably high, especially given pre-transfer induction, or early post-primary "taster" experiences where students witnessed or participated in science involving "dramatic colour changes, dense smoke, loud noise and peculiar smells." (p. 256). The subsequent disappointment on experiencing actual science lessons at post-primary level, with their emphasis on written work, could therefore contribute to sharply declining interests, a suggestion that has been echoed by others (Braund, Crompton, Driver and Parvin, 2003). In relation to this, a recent survey of Irish post-primary teachers has shown that, even under the current Junior Cycle Science Syllabus, many teachers frequently use textbooks, exam papers and workbooks or worksheets in their teaching (Eivers et al., 2006).

Inappropriately low pitching of content in early post-primary science lessons has also been noted as a problem in the transfer from primary to post-primary settings. For example, research in England and Northern Ireland found that post-primary science teachers did not always appear to take account of students' previous experience and understanding, when deciding what to teach in first year science classes. This was suggested to relate to a lack of information about students' work at primary school, or possibly a distrust of it (Jarman, 1995; 1997; Galton and Hargreaves, 2002; Braund et al., 2003). Even the results of statutory tests in science at primary level were doubted, with students being re-tested on entry to post-primary school (Collins et al., 2008). In Ireland, a study of broader transfer issues revealed that only a minority of post-primary school principals received information from primary schools on transfer students' academic performance. Furthermore, a third of teachers indicated that they had received no information at all about first year students prior to entry. The vast majority of schools in this study used tests in mathematics, English and Irish to assess students pre-entry or on entry to the post-primary setting (Smyth et al., 2004). This study did not examine the transfer of information about students' work in science, perhaps because data were gathered prior to the introduction of the Primary Science Curriculum (DES, 1999a). However, the level of communication in relation to academic matters at the time of transfer would appear to be a concern. In this context, it is worth noting that there is no current national policy relating to the transfer of information between primary and post-primary schools.

Post-primary teachers' familiarity with primary curricula is also pertinent to the discussion of effective pitching of lessons post-transfer. A survey conducted in one Local Education Authority in England showed that less that half the science teachers of first year post-primary students had ever seen primary science curriculum documents (Galton and Pell, 2002). Similarly, a recent study of Irish post-primary teachers, who taught science within the current Junior Cycle Science Syllabus, found that 58% were unfamiliar with the science content and 69% were unfamiliar with the science process skills in the Primary Science Curriculum for fifth and sixth class pupils (Eivers et al., 2006). This is of concern, especially as one session within the in-career development provided on the current Junior Cycle Science Syllabus had focussed on the Primary Science Curriculum. This is discussed in more detail in Section 2.2.2.

Lack of communication on academic and curricular matters at the point of transfer is seen as contributing to a repetition of material already experienced at primary school. This in turn can lead to negative attitudes developing early in post-primary school science: "I used to like science but here we started from scratch" (Morrison, 2000, p.47, cited in Braund et al., 2003). Galton's (2002) review of research in the UK found that waning interest in school science appeared to apply to able students more than others, a point also noted in Jarman's (1997) study of post-primary students in Northern Ireland. In Ireland, a study of first year students found that just under 10% reported that their science teacher went "too slowly", although this was stated by students from all ability groups (Smyth et al., 2004, p. 225). The same study showed that others reported difficulty with science and a sense that the teacher's pace was too fast. Issues relating to the difficulty of post-primary school science have been discussed earlier, in Section 1.3. What is clear from the literature discussed, however, is that the appropriate pitching of science lessons on transfer presents problems, which are perhaps exacerbated by inadequate information relating to students' prior experiences.

Arising from extensive studies of transfer in England, potential solutions to the problems that arise have been suggested (Galton, 2002; Galton and Hargreaves, 2002). These sources recommended greater liaison between teachers in primary and post-primary schools. Whilst these studies noted that good general liaison structures existed, they usually involved first-year or liaison tutors at post-primary level and hence focussed on pastoral matters rather than curricular issues. Both sources also described the use of "bridging units" in science, which primary pupils started towards the end of their final year and completed in the first weeks at post-primary level. These were planned with primary and post-primary staff in collaboration and therefore had an additional benefit of fostering better liaison and dialogue on curricular matters. However, the work done in units of this kind was not always accorded high value, either by teachers or the students (Galton, 2002). A further suggestion has been to review teaching methodologies in early post-primary science. Galton argues that early post-primary science practical activities that are often very teacher-directed do not engage students effectively.

The suggestion is that they should be adapted in favour of extended induction programmes that nurture personal development, creativity and the development of students as independent learners and thinkers.

1.5 Concluding Remarks

The introduction of a new Junior Cycle Science Syllabus (DES, 2003a) and the Primary Science Curriculum (DES, 1999a) heralds a period of change in primary and post-primary students' experiences of school science in Ireland. These new curricula have been developed in the light of, and in response to many of the international and national concerns discussed above.

Whilst the introduction of these new curricula has the potential to promote positive attitudes to school science, access to scientific study at post-primary level in Ireland is still not guaranteed. In contrast with many other European countries, not all Irish post-primary schools provide opportunities for students to study the sciences at upper post-primary level, with a "significant minority" failing to offer physical sciences at Leaving Certificate (Smyth and Hannan, 2006, p. 321). Their study noted that in 2002, 79% of schools provided Leaving Certificate physics, 75% chemistry and 12% the combined subject of physics-chemistry. It is unclear whether the schools offering physics-chemistry were additional to those offering the subjects separately. However these data suggest that at least 9% of schools were not providing physics and at least 13% were not providing chemistry studies of any kind at Leaving Certificate level. An earlier finding made by the Task Force on the Physical Sciences, noted that, whilst few Irish students attended schools that did not offer science "over 10% of the total lower post-primary cohort is not enrolled in science", with the non-participation rate in all-girls' schools being 20% (Task Force on the Physical Sciences, 2002, p. iii).

For students in such schools, the impact of changes at primary level is likely to be minimal if their interests, once stimulated, cannot be fostered in a post-primary setting.

The availability of post-primary science at Junior Cycle will be considered further in Section 2 of this report. At this point it should be noted that, although it is not compulsory to study science at Junior Cycle in Ireland, 86% of Junior Certificate candidates took science in 2006. This was the first year in which a proportion of students took the examinations under the aegis of the current syllabus, and the figures represent a slight increase in uptake from 2002, when 84% of Junior Certificate candidates took science (McNaboe and Condon, 2007).

At this stage of curricular change, the NCCA has commissioned research to review the impact of science curricula on pupils[1] at primary school and students in their first year at post-primary school. There are two phases of this commissioned research. The first phase focused on primary pupils' experiences of, and attitudes towards science in primary school (Varley et al., 2008). The second phase of commissioned research focuses on first years at post-primary school and is reported in this document.

The next section of this document, Section 2, presents an overview of the Primary Science Curriculum (DES, 1999a) and compares it with the current Junior Cycle Science Syllabus (DES, 2003a). Section 3 describes the design and structure of the study, whilst Sections 4 and 5 present the findings from the survey and case study. The final section presents conclusions and suggests recommendations.

1 To avoid confusion in this report, the term "pupils" is applied to those attending primary school and the term "students" is applied to those attending post-primary school. Where both categories are discussed together, the term "students" is used.

Section 2:

Science at Primary and Junior Cycle Levels

This section opens with a brief overview of the Primary Science Curriculum. An overview of the Junior Cycle Science Syllabus is then provided, which is followed by a comparison of both curricula.

2.1 The Primary Science Curriculum: Overview

The Primary Science Curriculum (DES, 1999a) is intended for all pupils from junior infants to sixth class. It supports pupils in learning about physical and biological aspects of the world, developing pupils' knowledge and understanding through the skills of *working scientifically* and *designing and making.* Knowledge and understanding for each age group is presented in four **strands:** Living things, Energy and forces, Materials and Environmental awareness and care. Each of these strands is further divided into **strand units** as summarised in Table 2.1:

Table 2.1: Strands and strand units in the Primary Science Curriculum

Strand	**Infants**	**1st and 2nd Classes**	**3rd and 4th Classes**	**5th and 6th Classes**
Living things	Myself Plants and animals	Myself Plants and animals	Human life Plants and animals	Human life Plants and animals
Energy and forces	Light Sound Heat Magnetism and electricity Forces	Light Sound Heat Magnetism and electricity Forces	Light Sound Heat Magnetism and electricity Forces	Light Sound Heat Magnetism and electricity Forces
Materials	Properties and characteristics Materials and change	Properties and characteristics Materials and change	Properties and characteristics Materials and change	Properties and characteristics Materials and change

Environmental awareness and care	Caring for my locality	Caring for my locality	Environmental awareness Science and the environment Caring for the environment	Environmental awareness Science and the environment Caring for the environment

There are a number of scientific skills that the pupils are expected to apply and develop over the course of their eight years in primary school. Table 2.2 summarises these skills. It should be noted that, although the headings for these skills are essentially identical from infants up to sixth class, the detailed descriptions of these skills provided in the curriculum document indicate progression within these skills. Aspects of progression as pupils enter the later stages of their primary careers include: an increasing level of autonomy of application and decisions regarding when, where and how to use these skills; and a shift in emphasis from lower order to higher order thinking within these skills.

Table 2.2: Summary of working scientifically and designing and making skills in the Primary Science Curriculum

Class Groups	**Working Scientifically**	**Designing and Making**
Infants - 6th Class	Questioning Observing Predicting Investigating and experimenting Estimating and measuring Analysing Recording and communicating Evaluating (5th/ 6th only)	Exploring Planning Making Evaluating

It is expected that the knowledge and skills that pupils utilise be "developed and extended" at each class level (DES, 1999a, p.17). It is also worth noting that the curriculum is based on a spiral approach, whereby aspects of the biological and physical environment can be explored at each class level, with an increasingly sophisticated consideration of subject matter.

The Primary Science Curriculum was formally introduced in primary schools from September 2003. Supports for primary teachers in implementing this curriculum have been, and continue to be provided. These have been discussed in detail in Phase 1 of this study (Varley et al., 2008).

2.2 The Junior Cycle Science Syllabus: Overview and comparison with the Primary Science Curriculum

2.2.1 Overview

The current Junior Cycle Science Syllabus was published in 2003 and intends to cater for the full range of student ability, aptitude and achievement in early post-primary years. Students studying for Junior Certificate in science would normally take three years to complete the syllabus, starting in their first year at post-primary school. Students can study science to Higher or Ordinary Level within the same syllabus. This syllabus is based on learning outcomes and signals a shift away from an emphasis on content and towards "hands-on engagement" with practical activities and the development of relevant process skills (DES, 2007, p. 6). It promotes the development of understanding of scientific concepts through a balanced consideration of biology, chemistry and physics topics for all students. Whilst its predecessor also offered all three subjects, students were able to select optional topics, a practice that was perceived to favour biology (Eivers et al., 2006). The 2003 curriculum also emphasises the application of "scientific principles [to students'] everyday lives" (DES, 2007, p. 6). Another guiding factor in the design of the 2003 syllabus was to align the science encountered by students at Junior Cycle with the science they would have experienced within the Primary Science Curriculum (DES, 1999a).

The aims of the Junior Cycle Science Syllabus therefore have much in common with those of the Primary Science Curriculum, as can be seen from the comparison in Table 2.3. In this table, the aims of both curricula have been re-ordered from the original documents to demonstrate links more clearly. Interestingly, the final aim of the Junior Cycle Science Syllabus, which has no explicit antecedent in the Primary Science Curriculum, is that students should "develop a sense of enjoyment in the learning of science" (DES, 2003a, p. 4).

Table 2.3: Comparison of curricular aims

Primary Science Curriculum: Aims equivalent to Junior Cycle	**Junior Cycle Science Syllabus: Stated aims**
The development of scientific and technological knowledge and understanding through the exploration of human, natural and physical aspects of the environment.	Provide a balanced understanding of the physical, biological and chemical dimensions of science.
The development of a scientific approach to problem-solving which emphasises understanding and constructive thinking.	Provide opportunities for observing and evaluating phenomena and processes and for drawing valid deductions and conclusions.
Fostering children's natural curiosity, so encouraging independent enquiry and creative action. Enabling the child to communicate ideas, present work and report findings using a variety of media.	Encourage the development of manipulative, procedural, cognitive, affective and communication skills through practical activities that foster investigation, imagination and creativity.

Helping the child to appreciate the contribution of science and technology to the social, economic, cultural and other dimensions of society. Encourage the child to behave responsibly to protect, improve and cherish the environment and to become involved in the identification, discussion, resolution and avoidance of environmental problems and so promote sustainable development.	Enable students to acquire a body of scientific knowledge…and an understanding of the relevance and applications of science in their personal and social lives. Foster an appreciation of and respect for life and the environment, while at the same time developing awareness of the potential use, misuse and limitations of science, and of health and safety issues relating to science.
No specific equivalent	Develop a sense of enjoyment in the learning of science.

The new syllabus was introduced on an optional basis from September 2003 (DES, 2003b), for examination in the Junior Certificate in 2006 and subsequent years. Approximately 90% of schools in the free education scheme opted in at this point (DES, 2004). All schools that already offered Junior Certificate science were subsequently required to implement the new syllabus from September 2004, with the exception of those which needed to make substantial improvements to their laboratory facilities (DES, 2004). Following additional support, these schools were required to implement the syllabus starting with new entrants in September 2006 (DES, 2006). In consequence, the vast majority of post-primary schools currently offer science within the 2003 syllabus at Junior Cycle. Scientific study at this level is not compulsory, however, and in some schools, students are able to opt out of Junior Cycle science, in some cases at the point of entry to post-primary school. Data relating to students' uptake of Junior Cycle science has been discussed earlier in Section 1.5.

2.2.2 Curriculum supports for Junior Cycle science teachers

Supports were, and continue to be, provided for post-primary teachers in respect of the Junior Cycle Science Syllabus. This report will not discuss these in detail, but highlight the information provided to Junior Cycle teachers about the Primary Science Curriculum, as a means of promoting curricular continuity.

The Junior Science Support Service (JSSS) was set up to assist teachers in implementing the Junior Cycle Science Syllabus (DES, 2003a). Teachers were invited to participate in in-career development, which included six one-day seminars spread out over the first three years of implementation (Eivers et al., 2006). Typical attendance at these seminars comprised 75-80% of existing Junior Cycle teachers. One session focussing on the Primary Science Curriculum was included as part of this seminar series, although the methodologies promoted in the Primary Science Curriculum were briefly addressed in other seminars (A. Walshe, personal communication, May 22nd 2008). In spite of these supports, however, a subsequent survey of Junior Cycle science teachers revealed that 58% were unfamiliar with the scientific content of the Primary Science Curriculum and 69% were unfamiliar with the science processes as outlined for fifth and sixth class (Eivers et al., 2006).

Documentary supports are also available in relation to the Junior Cycle Science Syllabus, including the syllabus document itself (DES, 2003a) and Guidelines for Teachers (DES, 2007). Both of these provide an outline of primary school science, described in a number of sentences in the former document, and two paragraphs in the latter. The information provided in the Guidelines for Teachers on the primary curriculum is general and does not, for example, list the specific areas of the "biological and physical world" that pupils might be expected to have encountered, nor the specific scientific skills that pupils might have developed at primary school (DES, 2007, p.8). Somewhat confusingly, the guidelines also state that "primary science has its roots in nature study and environmental studies" (DES, 2007, p. 8). A post-primary teacher unfamiliar with changes in primary curricula might mistakenly interpret this to mean that there is an emphasis on biological topics within the current Primary Science Curriculum. This is not in fact the case, as the four strands of subject content include two which encompass the physical sciences, namely Energy and forces and Materials (Table 2.1).

The JSSS has created a support website which, amongst other things, provides links to the Primary Science Curriculum documents (DES, 1999a;b). In addition, a six page overview of the scientific subject content for fifth and sixth class pupils is available as a downloadable document (JSSS, 2008). This summarises content from the Primary Science Curriculum strands Living things, Materials and Energy and forces. Unfortunately, it provides no information about subject content within the strand Environmental awareness and care. In relation to scientific skills, the opening paragraph makes reference to "activities related to these topics", leaving the reader to infer scientific skills from the subsequent descriptions of scientific content alone, for example "explore and investigate how people move" (JSSS, 2008, p. 1). A significant omission of this summary therefore, is that it does not provide separate information on the scientific skills in the Primary Science Curriculum and hence does not signal the major part which the development of scientific skills has to play in primary experiences. Short of reading and analysing the Primary Science Curriculum itself, it appears that Junior Cycle teachers' documentary supports lack key information that would help to promote effective curriculum continuity.

The links between the two curricula will now be discussed in relation to their coverage of knowledge and understanding (Section 2.2.3) and scientific skill development (Section 2.2.4).

2.2.3 Comparison of Subject Knowledge Content Areas

Knowledge and understanding at Junior Cycle is presented as three components: biology, chemistry and physics. Each of these is further divided into **main topics** and **subtopics**. The components and main topics are presented in Table 2.4.

It can be seen from a comparison of Tables 2.1 and 2.4 that there are many similarities between the types of scientific content envisaged at primary and early post-primary level. The Junior Cycle Science Syllabus acknowledges this fact (DES, 2003a). Elements of the Living things strand from the primary curriculum would be apparent in the biology topics at post-primary level, Materials content links to chemistry topics and Energy and forces strand units link with physics topics. Aspects of the primary strand Environmental awareness and care have equivalents in biology, chemistry and physics, but are not presented as a separate component at post-primary level.

Table 2.4: Summary of components and main topics in the Junior Cycle Science Syllabus

Com-ponent	**Main Topics**		
Biology	Section 1A Food Digestion Enzymes Aerobic respiration Circulatory system Excretion	Section 1B Skeletal system Muscular system Sensory system Reproductive system Genetics	Section 1C Living things The microscope Plant structure Transport in plants Photosynthesis Reproduction and germination of plants Ecology Microbiology & biotechnology

Chem-istry	Section 2A Materials Mixtures Classification of substances, elements and compounds Metals Non-metals Mixtures and com-pounds Water and solutions Acids and bases	Section 2B Air and oxygen Carbon dioxide Hardness of water and water treatment Electrolysis of water Acids and bases	Section 2C Basic atomic structure Bonding Rusting and cor-rosion Metals Hydrocarbons, acid rain
Physics	Section 3A Measurement in science Density and flotation Force and moments Pressure Work and power Energy Energy conversion	Section 3B Heat Heat transfer Light Reflection of light; Refraction of light Sound Reflection of sound; Hearing	Section 3C Magnetism Static electricity Current electricity; Voltage Electric circuits Electricity in the home Electronics

The breadth and depth of understanding in the content areas is greater at post-primary level than at primary and thus represents a progression from the material that pupils should have experienced in primary school. Some overlaps exist in the earlier points of each topic or sub-topic in the post-primary syllabus, however, when compared with the curriculum for fifth and sixth class at primary level. Examples of this include: "structure, function and care of teeth" (DES, 1999a, p. 83), compared with "identify molars, premolars, canines and incisors and describe their functions" (DES, 2003a, p. 11); and "recognise that materials can be in solid, liquid or gas form" (DES, 1999a, p. 88) compared with "name the three states of matter and know their characteristics" (DES, 2003a, p. 19). It should be noted however that the Primary Science Curriculum presents pupils' learning of scientific subject content phrased as enabling objectives, whilst the Junior Cycle Science Syllabus presents subject content areas in terms of learning outcomes (DES, 1999a; 2003a).

2.2.4 Comparison of scientific skills

Practical activities are seen as a central feature of the Junior Cycle Science Syllabus, emphasising the "practical experience of science for each individual student" (DES, 2003a, p. 3). Indeed, the assessment of science in the Junior Certificate involves the presentation of coursework related to practical activities conducted during the three years of study, which are discussed in more detail later in this section. These practical activities, highlighted in the syllabus, are noted to represent "a minimum of practical work" (DES, 2003a, p. 8) recommended during the three years of study.

There is a strong emphasis on the development of students' scientific skills in both curricula. According to the Teacher Guidelines for the Junior Certificate Science Syllabus, a key purpose of hands-on experiences at primary level is to enable pupils to encounter objects and events "in reality before they become the subject of thought and mental manipulation" (DES, 2007, p 8). At Junior Cycle, the curriculum envisages that students would build upon the skills acquired at primary level, however it suggests that such skills be developed "through the systematic approach to investigations" (DES, 2007, p. 7). Thus a more formal approach to practical activities at post-primary level is envisaged.

The skills that students might typically acquire and develop during practical activities are described on pages 6-7 of the Junior Cycle Science Syllabus (DES, 2003a) and are summarised in Table 2.5. In Table 2.5, these have been re-organised from the syllabus document for ease of comparison with the skills of *working scientifically* in the Primary Science Curriculum, also shown in Table 2.5.

Table 2.5: Comparison of scientific skills in the Primary Science Curriculum and Junior Cycle Science Syllabus	
Primary Science Curriculum	**Junior Cycle Science Syllabus**
Questioning Observing Predicting Investigating and experimenting Estimating and measuring Analysing Sorting & classifying Recognising patterns Interpreting Recording and communicating Evaluating (5th /6th class only)	Questioning (in description of investigations) Observing Examining Describing Identifying (e.g. animals and plants) Test a theory/ confirm a hypothesis (in description of experiments) Investigating Testing Preparing (e.g. solutions) Measuring Calculating Analysing Classifying Identifying (e.g. patterns) Recording Graphing or tabulating Presenting in a variety of forms Problem solving (in description of investigations)

It should be noted at this point that the skills associated with *designing and making* at primary level (Table 2.2) do not have equivalents in the Junior Cycle Science Syllabus. The skills fostered at primary level in this area are instead extended and developed in a variety of subjects that students might study at post-primary level. These include: Technology; Home Economics; Art, Craft and Design; Materials Technology (wood); and Metalwork. A consideration of curriculum continuity of the Primary Science Curriculum with these subjects is not within the scope of the current study and will not be discussed here.

In relation to the skills presented in Table 2.5, it would appear that the skills of *working scientifically* that pupils encounter at primary school are re-encountered and further developed at post-primary level. The majority of these skills are itemised explicitly in the Junior Cycle Science Syllabus. However, skills equivalent to the primary curriculum skills of questioning, predicting and evaluating only appear in the descriptions of specific types of practical activities and in the guidelines for conducting investigations as part of Coursework B, discussed later in this section (DES, 2007). The two main types of practical activities envisaged in the Junior Cycle Science Syllabus are considered next.

Practical activities

The Junior Cycle Science Syllabus makes a distinction between *investigations*, in which students find out "information about a particular object, process or event in a manner that is not pre-determined in either procedure or outcome" (DES, 2003a, p. 6), and *experiments* in which the student "follows a prescribed procedure in order to test a theory, to confirm a hypothesis or to discover something that is unknown" (p. 7). These two approaches appear to mirror the range of types of hands-on work envisaged at primary level, that is, "open investigations", "teacher-directed" approaches and "closed activities" (DES, 1999b, pp. 54-55).

The increased emphasis on practical activities conducted by students in the Junior Cycle Science Syllabus is also supported by changes to the assessments. For the first time, a component of students' assessment at Junior Certificate level includes course work related to practical activities. A total of 35% of students' overall marks are allocated to this coursework, which is further subdivided as follows:

- **Coursework A:** Students are awarded a pro-rata mark for completion of 30 mandatory practical activities specified in the

Junior Cycle Science Syllabus (DES, 2003a). Students from first year onwards would be expected to conduct these. The Teacher Guidelines specify that "students are required to complete reports on these activities" and that these should "follow the format described [in the teacher guidelines]" (DES, 2007, p. 62). A "laboratory notebook" is suggested as a means of maintaining these records (DES, 2003a, p. 32). Coursework A is worth 10% of the overall marks.

- **Coursework B:** Students in their third year carry out and report on **either** two scientific investigations chosen from three topics provided by the State Examinations Commission, **or** on a single investigation of their own choosing. Guidance is provided to teachers about the criteria for supporting students' appropriate selection of the latter (DES, 2007). "Handwritten reports" of these investigations are submitted to the State Examinations Commission for assessment, using the pro forma booklet(s) supplied (DES, 2007, p. 68). Coursework B is worth 25% of the overall marks.

Somewhat surprisingly, the guidelines in relation to both of these coursework elements (DES, 2007, pp. 62-68) do not mention the use of ICT either as a part of conducting assessed practical activities or as a feature of report-writing. Indeed, the guidelines for Coursework B state that handwritten reports should be submitted, which would appear to discourage the use of ICT. This anomaly is unfortunate, given that some attention is paid to promoting the use of ICT elsewhere in the guidelines. It is worth noting, however, that the NCCA is currently in the process of developing a framework for ICT in curriculum and assessment, which may clarify this issue.

2.3 Concluding Remarks

In comparing the science curricula at primary level and Junior Cycle, it would appear that there are many commonalities of experience envisaged for students within the two school settings, whilst a development or progression of experiences would also be inherent in the documents. The Primary Science Curriculum therefore presents an opportunity to prepare pupils for their future study of science at post-primary level, and, conversely, the Junior Cycle Science Syllabus allows teachers to build on students' earlier experiences at primary school. However, the extent to which this curriculum continuity has been recognised by primary and post-primary teachers, who are perhaps more focussed on coming to terms with the implementation of their respective science curricula, remains to be seen.

The reality for students, of this ideal of curriculum continuity, is a key focus of the research conducted in this study. The next section provides an in-depth account of the aims of this study and details of data gathering and analytical methods employed.

Section 3: Design and Methods

This section describes the rationale for the design of the study and the strategies and research instruments employed in collecting data in the post-primary schools. Details of the strategies and research instruments employed for collecting data from primary school pupils have been provided in an earlier publication (Varley et al., 2008). Information is provided in this section in relation to the strategies used and sampling approaches taken in the post-primary schools. This is followed by an account of the development and piloting of research instruments, including details of the analytical methods employed subsequent to data collection.

This study focussed almost exclusively on collecting data from young people. It therefore sought to continue and extend the emphasis placed on gathering children's views as an essential part of reviewing curriculum implementation (NCCA, 2005). In so doing, the study also accorded with goals set out in the National Children's Strategy, that "children should have a voice in matters which affect them" and that "their lives will benefit from evaluation, research and information on their needs, rights and the effectiveness of services" (Office of the Minister for Children, 2000, p. 11). It was felt that first year post-primary students should be enabled to comment on their perceptions of, and developing attitudes towards school science and would "provide reliable responses if questioned about events that are meaningful to their lives" (Scott, 2000, p. 99).

This study aimed to examine and compare the attitudes and perceptions of post-primary students towards school science with those of primary pupils. This evidence would provide insights on curriculum continuity. The study therefore set out to consider the following questions:

- What are older primary pupils' conceptions of and attitudes towards post-primary science?

- What are first year post-primary students' attitudes towards science in post-primary school?
- How are primary and post-primary science experiences viewed by first year post-primary students?
- Are there any differences in attitudes towards school science that can be seen in students from third class up to first year post-primary level?
- What are first year post-primary students' aspirations in relation to future study of, or involvement in science?

3.1 Research Strategies

A **survey** was chosen as a means of gathering information from students in a range of post-primary schools countrywide. It provided an opportunity to find out students' experiences of and attitudes towards many aspects of school science from a representative proportion of Irish post-primary school first year students. Data gathered on such a scale allowed for subsequent quantitative analysis, including a consideration of student responses according to a range of variables. It was decided that students from first year only would be asked to participate in this aspect of the study. These students would have had several years' experience of science within the Primary Science Curriculum (DES, 1999a) on which to reflect. In addition, these students would have experienced at least two terms of study at post-primary level, within the current Junior Cycle Science Syllabus (DES, 2003a). The survey used two different questionnaires as instruments for collecting data: a student questionnaire and a brief teacher questionnaire (Appendix A). The survey was conducted during April and May 2008.

A **case study** of a small sample of post-primary schools was designed to add depth to and triangulate with the findings of the student survey. The case study provided opportunities to find out more detailed information about the ways that students respond to science in their classrooms, and their views regarding their previous experiences at primary school. The results discussed in this report relate to students who were interviewed in small groups in the period from February to May 2008. Data from the case study schools were gathered from students using group interviews. Consent was obtained for students to participate (Appendix B). Their science teachers also completed a brief contextual questionnaire, which was identical to that used for teachers in the survey (Appendix A). In the case study, students in the class from which the interview group was drawn were also asked to complete a questionnaire, which was identical to that used in the survey (Appendix A). Table 3.1 summarises the research design and research instruments used for the two strategies employed.

Table 3.1: Summary of research design

Strategy	Research Instruments	Schools	Classes	Students
Survey (first years)	Student Questionnaire	15	15[a]	265[a]
	Teacher Questionnaire	15	15	n/a
Case study of post-primary schools (first year)[b]	Group Interview	7	7	29
	Student Questionnaire	8	8	160[a]
	Teacher Questionnaire	8	8	n/a

a Numbers indicate classes/ students given questionnaires to complete, not numbers returned.

b Further details of the schools and their participation in each aspect of the case study are provided in Appendix C.

3.2 SAMPLING

3.2.1 Student survey

A random sample of schools was drawn from the most recent DES list of post-primary schools, for participation in the survey (DES, n.d.). The sample was stratified by: different school types within the post-primary sector; recognised disadvantaged status; gender mix and medium of instruction. Schools were telephoned and invited to participate in the survey, which commenced in April 2008. Each school was asked to administer the questionnaire to all students from *one class only* of first years taking science within the Junior Cycle. In this way, 265 students were invited to participate in the survey. Their science teachers were also asked to complete a brief contextual questionnaire. A guidance sheet and letter of explanation about the research accompanied each set of questionnaires sent (Appendices A and B). Where schools indicated during initial contact that they could not participate, a school of similar profile was selected at random from the original sample frame.

It was not possible to stratify the random sample to include a representative proportion of special schools, as the database used did not specify this information. No special schools appeared in the random sample. However, it should be noted that the contextual questionnaire asked teachers to identify the number of pupils in their class with special needs and seven of the responding mainstream schools had some pupils in this category.

3.2.2 Case study

Schools

From the outset of the study, schools that reflected different types in the Irish post-primary school system were approached. A further criterion in selecting the schools for inclusion in the post-primary study was that, where possible, these should be ones that took pupils from one or more of the case-study primary schools used in Phase 1 of this research (Varley et al., 2008). Ultimately, eight post-primary case study schools agreed to participate, which collectively represented schools that:

- Teach through the medium of English or Irish (Gaelscoil);
- Have a designated disadvantaged status or not;
- Have some students with English as a second language, or not;
- Are single sex or mixed;
- Are secondary, comprehensive or community schools;
- Stream children for science in first year or not;
- Teach science as a compulsory subject to Junior Certificate, or allow students to opt out.

The profiles of the schools participating in the case study are further described in Appendix C. Of the eight post-primary case study schools, six took pupils from primary schools that participated in the Phase 1 case study, representing links with five of the case study primary schools. The two post-primary schools which did not take pupils from primary schools in Phase 1 were recruited to increase the representation of girls' only schools and Gaelscoileanna within the case study.

Group interview students

Groups of students from seven of the eight case study schools were interviewed. Each group comprised four or five students from one first year class at a given post-primary school. All these students were currently studying science within the Junior Cycle Science Syllabus. In each case the teacher selected the students to be interviewed.

Where possible, students who had previously attended one of the case study primary schools within Phase 1 were selected. In the mixed schools, purposive samples of two boys and two girls were chosen. The researchers asked that the students selected should be confident in an interview situation, but also reflect a range of ability levels within that class, taking the other stated criteria into account. All of the students interviewed volunteered to take part in the group interviews and were informed about the purpose of the interviews. Students' oral assent to participate was obtained before the interviews began. Written consent from their parents or guardians had also been obtained (Appendix B).

3.3 Instrument Development, Piloting and Data Analysis

3.3.1 Student questionnaire

Instrument development

The student questionnaire was designed in a format that, based on piloting, was felt to be readable and relatively quick and easy for students to complete (Appendix A). The initial section elicited information about the gender, age and the class of the student. Other contextual information regarding each class of students was elicited via a short teacher questionnaire (Appendix A).

The main part of the student questionnaire elicited responses via a three-point (smiley face) Likert scale format. The format and wording of this part of the questionnaire was designed to be as similar as possible to that used with primary pupils in Phase 1 of this study (Varley et al., 2008). This would allow valid comparisons to be made between the data collected in both phases of the study. These Likert items sought attitudinal data and were grouped in five broad categories under the following headings (Appendix A):

- Six items on attitudes to school: "What I think about school";
- Eighteen items on attitudes towards learning about specified school science topics: "I enjoy learning about…";
- Sixteen items on attitudes to ways of learning science in the classroom: "I enjoy science when…";
- Six items on attitudes to school science: "What I think about science"; grouped with
- Four items on students' perceptions of the nature of science: "What I think about science".

Students were then asked to respond briefly to several open questions. These asked students to reflect on and compare their current post-primary experience of science with their experiences of science at primary school. Students were asked to decide in which setting they preferred science and to provide reasons for their choice. Students were also asked about their future aspirations in relation to the study of science, providing reasoning again (Appendix A). A drawing option was not offered in the post-primary questionnaire, as it was felt that students at this level would be capable of answering all open questions in written form.

These questionnaires were developed following consultation of a range of literature (Dawson, 2000; Jarvis and Pell, 2002; Kind, Jones and Barmby, 2007; Murphy and Beggs, 2002; Reid, 2003; Stark and Gray, 1999; Woodward and Woodward, 1998). The Likert items were essentially identical to those used in the questionnaire for the primary school study (Varley et al., 2008). In developing these during Phase 1 of the study, attention had been paid to the wording of the Likert items so that science content areas appearing in both the Primary Science Curriculum (DES, 1999a) and the Junior Cycle Science Syllabus (DES, 2003a) were described in student-friendly terms. In addition, the 16 items prefaced by the phrase, "I enjoy science when ..." were chosen to reflect methodologies likely to have been experienced by students in learning science at either type of school.

Piloting

Rigorous piloting of the questionnaire for primary pupils had been undertaken previously (Varley et al., 2008). The adapted version of the questionnaire for post-primary students was piloted in two of the post-primary case-study schools. The medium of instruction of one of these schools was English, the other Irish. Questionnaires were piloted in focus groups with students from first year. Adjustments to instruments and re-piloting were undertaken to ensure acceptable content validity. A larger-scale pilot of the final version of the questionnaire allowed reliability analysis to be conducted. Grouped Likert items gave alpha values of 0.67 or higher (Cohen, Manion and Morrison, 2000), which was deemed acceptable.

The final version of the Likert items on the questionnaire was essentially identical to that used in the primary phase of this study, with the following differences:

- "I enjoy learning about insects and mini-beasts" was changed in the post-primary questionnaire to read "I enjoy learning about insects, bugs and invertebrates", as some post-primary students were unfamiliar with the term "mini-beasts";
- "I am looking forward to learning science in post-primary school" was deleted and two items were incorporated at this point in the questionnaire: "I would like to study science subjects for my leaving certificate"; and "I like science at second level better than the science I did at primary school"; and

- A small box for further, optional comments was provided by the side of all the Likert items relating to school science, as, during piloting, some post-primary students had expressed a desire to explain some of their Likert item responses.

Data analysis

Data from the closed response and Likert scale items on the student questionnaires were coded and entered onto SPSS (Statistical Package for the Social Sciences), version 14.0. Where relevant to the data analysis, the Likert scale responses were analysed on SPSS using non-parametric tests.

The open question responses were analysed by two members of the research team using the constant comparative method for developing categories (Glaser and Strauss, 1967). Categories emerging from the responses were coded, discussed and re-coded until no new categories emerged from the data. At this point an inter-rater reliability analysis was undertaken with 100 previously uncoded questionnaires. Inter-rater reliability values calculated subsequently were all "good" or "excellent" (Robson, 2002, p. 342), with Cohen's Kappa (K) values of 0.634 or higher. To facilitate quantitative analysis of the questionnaire responses as a whole, the open question codes were also entered onto SPSS. It should be noted that there were a few cases in which pupils had responded to a question, but their response could not be coded because it could not be deciphered. Such instances were recorded as *uncodable*, a type of missing data, on entry to SPSS.

3.3.2 Teacher questionnaire

Instrument development

The teacher questionnaire was designed in a format that was felt to be readable and relatively quick and easy for teachers to complete

(Appendix A). The questionnaire was only intended to provide contextual information regarding each class of students and was not intended to gather information about the teachers' own backgrounds or attitudes to teaching science. It enabled the researchers to find out information about the survey students that it would have been inappropriate to ask the students to provide for themselves, for example, information about the school type, numbers of students in the class with special educational needs and so forth (see Appendix A).

Piloting

The teacher questionnaire was piloted with science teachers from one of the post-primary case-study schools described above. Adjustments and re-piloting were undertaken to ensure acceptable content validity.

Data analysis

Data obtained from the teacher questionnaires was entered onto SPSS alongside students' data from the relevant school and class, to facilitate further analysis of the student data.

3.3.3 Interview schedule

Instrument development

Group interviews as opposed to individual interviews were chosen. The intention was that the group interview would use the dynamics of the group to gain information and insights into the students' experiences of school science, something that might less likely be gained through individual interviews. Every attempt was made to make the students feel at ease. As recommended by Tammivaara and Scott Enright (1986) "Teacher-like controlling behaviours", such as telling the students not to "fidget" or to "sit up straight", were avoided. The students addressed the researchers by their first names and an informal chat preceded every interview to allow the students time to form a relationship with the researcher.

An interview schedule was designed for the interviews, which comprised seven broad open-ended questions, aimed at establishing the students' experiences and perceptions of science in school, both at post-primary and primary level (Appendix D). The interviews were semi-structured in an effort to "let the interviewees develop ideas and speak more widely on the issues raised by the researcher" (Denscombe, 2003, p. 167).

Piloting

The semi-structured interview schedule was piloted in one of the post-primary case-study schools. Minor adjustments to the questions were made in the light of discussions following the pilot. The final version of the semi-structured interview guide is provided in Appendix D.

Data analysis

The interviews were taped and transcribed. The transcriptions were put into a word document. The students' responses were read and re-read to establish and refine units of meaning to be reported and to identify any apparent links, patterns and similarities or differences. This unitising of data was conducted by hand, colour coding and numbering the different responses. Two of the researchers coded the interview transcripts to establish inter-rater reliability.

The findings obtained from the data collected during the survey and case study are presented in Sections 4 and 5 respectively. Data obtained in Phase 1, regarding primary pupils' attitudes towards science and the prospect of learning science in post-primary school will also be presented in Sections 4 and 5, where appropriate.

Section 4:

Student Survey:

Findings

In this section, the findings from the student survey are presented and analysed. These will be discussed in relation to the original aims of the study, as follows:

- What are older primary pupils' attitudes towards post-primary science?
- What are first year post-primary students' attitudes towards school and school science in post-primary school?
- Are there any differences in attitudes towards school science that can be seen in students from third class at primary level up to first year post-primary level?
- How do first year post-primary students view the differences between their primary and post-primary science experiences?
- What are first year post-primary students' aspirations in relation to future study of, or involvement in science?

In analysing data relating to each of the above questions, material will be presented from responses to the Likert items and open responses on the student questionnaire. This will allow for internal triangulation of data from different parts of the questionnaire. Data from the survey of primary pupils (1030 respondents), carried out in Phase 1 of this research study, will also be used where appropriate to add to the analysis of the post-primary students' responses. These analyses are additional to those carried out and presented in the Phase 1 final report (Varley et al., 2008). The methods of data collection in the primary pupil survey were described in detail in the Phase 1 final report, although it should be noted that the closed questions on the questionnaire and methods of collection were essentially similar to those described in the current report.

To contextualise the post-primary students' responses, some overall profile data about the schools and students will be presented first.

4.1 Profile of Respondents

4.1.1 Schools

Of the 15 schools in the sample that were chosen to participate in the survey, responses were received and collated from 13 schools. This represents a school response rate of 87%. A range of school types and approaches to organising science at Junior Certificate level was seen in the participating schools. Data about the schools represented in the survey are summarised in Table 4.1.

It was important to establish to what extent students might be basing their responses to the questionnaire on a breadth of scientific content experienced at post-primary level. Data collected from the teacher questionnaires revealed that at least nine of the survey schools had addressed all three curriculum components (physics, chemistry and biology) since September 2007. One school had covered aspects of chemistry and biology only, and data were not available from the three remaining schools. However, since the survey was conducted after at least two terms of Junior Cycle science, it seems likely that students in these schools would also have encountered a range of subject content areas at post-primary level.

Table 4.1: Profile of post-primary schools responding to student survey										
School	School type	Language of instruction	Designated disadvantaged	Gender	Location	Science for all in 1st year	JC Science compulsory	Science streaming	ESL pupils**	SEN pupils**
1	Vocational	English	Yes	Mixed	Rural	Yes	Yes	No	No	Yes
2	Secondary	English	nda*	Boys	Urban	Yes	Yes	No	Yes	Yes
3	Vocational	English	Yes	Mixed	Rural	Yes	Yes	No	No	Yes
4	Secondary	English	nda	Mixed	Urban	nda	nda	nda	nda	nda
5	Vocational	English	nda	Mixed	Rural	nda	nda	nda	nda	nda
6	Community	English	No	Mixed	Urban	No	No	No	Yes	No
7	Community	English	No	Mixed	Rural	Yes	Yes	No	No	Yes
8	Vocational	English	No	Mixed	Rural	Yes	No	No	No	Yes
9	Vocational	English	Yes	Mixed	Rural	Yes	Yes	No	No	Yes
10	Secondary	English	nda	Girls	nda	nda	nda	nda	nda	nda
11	Secondary	English	No	Mixed	Urban	Yes	Yes	No	Yes	Yes
12	Secondary	English	No	Boys	Rural	Yes	Yes	No	No	No
13	Secondary	Irish	No	Mixed	Rural	Yes	Yes	No	nda	No

* nda = No data available: Teacher questionnaires incomplete, and anonymous nature of survey meant that data could not be obtained subsequently.

** Indicate classes that contained at least one pupil with English as a second language (ESL) and /or at least one pupil with special educational needs (SEN), respectively.

4.1.2 Students

Questionnaires were sent to a total of 265 students in the survey schools. Of these, 234 were returned and coded for analysis in this report. This represents a response rate of 88% for students. Girls made up 42% of the respondents and boys 58%. A breakdown of the ages of the students is shown in Table 4.2.

Table 4.2: Age profile of students in post-primary survey			
		Frequency	**Percent**
Age	12	37	16
	13	173	74
	14	20	9
	15	3	1
Total		233	100

N=234; 1 missing response, not shown.

As trends in attitudes from primary to post-primary school will be discussed later in this section, a breakdown of the numbers of students in each of the classes from the primary and post-primary surveys is presented in Table 4.3.

Table 4.3: Numbers of students in primary and post-primary surveys				
		Girls	**Boys**	**Total**
Primary class	3rd class	108	152	260
	4th class	157	161	318
	5th class	148	125	273
	6th class	115	64	179
Post-primary	1st year	99	135	234
	Total	627	637	1264

N=1264

In the contextual teacher questionnaires, post-primary science teachers were asked to indicate the number of students with special educational needs in their classes. A total of 20 students (9% of all respondents) fell into this category, although the anonymous nature of the questionnaires meant that these students' responses were not individually identifiable. This figure comprised students from mainstream schools only.

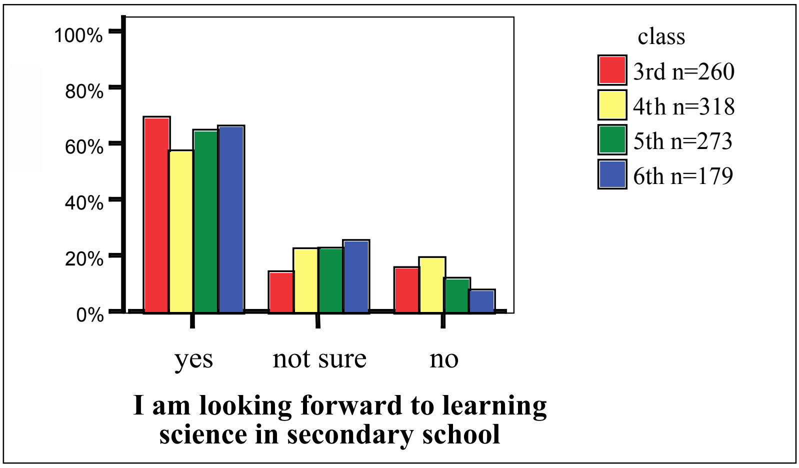
As a prelude to considering the first year students' responses about post-primary science, primary pupils' attitudes towards the prospect of studying science at post-primary school will be presented.

4.2 Primary Pupils' Attitudes Towards Post-Primary Science

Respondents in the primary school survey of third to sixth class pupils showed broadly positive attitudes towards the prospect of learning science in post-primary school. The majority[2] of all primary pupils surveyed (64%) expressed a positive response to the relevant Likert item in the primary questionnaire, "I am looking forward to learning science in secondary school" (Varley et al., 2008). The breakdown of responses from third to sixth class is shown in Figure 4.1. The majority of pupils within each class level expressed a positive attitude towards studying science at post-primary school. It is encouraging to note that in sixth class, the class closest to the point of school transfer, pupils exhibited the lowest negative response to this statement, with only 8% of pupils claiming that they were *not* looking forward to learning science in post-primary school.

2 In discussing responses to the Likert items, where the term "majority" is used, it describes a response to one point on that scale (e.g. "yes") which exceeds 50% of the total, that is, the responses to "yes", "not sure" and "no" combined.

Figure 4.1: Primary pupils' attitudes towards post-primary science



(Figures expressed as percentages. N=1030)

4.3 Post-Primary Students' Attitudes to School and School Science

4.3.1 Attitudes to school

Data relating to first year students' attitudes to post-primary school in general were gathered in the first six items in the Likert response section of the questionnaire (Appendix A). These are summarised in Table 4.4.

Table 4.4: Students' attitudes to school
(Figures expressed as percentages)

What I think about school	Yes	Not sure	No	Total
I like school	44	33	21	98
I'm happy at school	68	22	9	99
I work as hard as I can in school	60	30	9	99
I find school interesting	36	41	22	99
I enjoy doing school-work	18	32	49	99
I enjoy working with my friends at school	89	10	<1	100

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

For the majority of students, post-primary school would appear to be a sociable and happy place, as 89% of respondents enjoyed working with their friends at school, and 68% of respondents claimed to be happy there. However, students held more negative views in respect of liking school and finding it interesting, with less than half of students responding positively to the relevant statements. More encouragingly, 60% of students claimed they worked as hard as they could at school, although very few students were prepared to admit that they enjoyed the work itself. Students' responses about school are considered in relation to primary pupils' responses to the same items in Section 4.4. Responses about school science will be considered next.

4.3.2 Attitudes to school science

Data relating to students' general attitudes to school science (Table 4.5) were gathered in the final section of the Likert responses of the questionnaire, after students had answered many items relating to their attitudes to specific aspects of school science (Appendix A).

Table 4.5: 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.

It is encouraging to see that 59% of students claimed to find school science interesting, especially when that response is compared with only 36% of students finding school itself interesting (Table 4.4). However, the other responses in this category were not so positive, with a minority of students looking forward to science lessons or claiming to find them easy. Students' feelings about the perceived difficulty of post-primary school science are discussed further in Sections 4.4.1 and 4.6.1.

Almost a third of students claimed to like science better than other subjects. Although this might seem low, it should be borne in mind that science only represents one of the many subjects on offer to post-primary students. The fact that this proportion of students claimed to like science better than other subjects is therefore a very positive outcome for school science. A more detailed consideration of students' attitudes to science follows, which will consider attitudes towards scientific subject content areas and different methods of learning science.

4.3.3 Attitudes towards learning about scientific subject content

Students were asked about their enjoyment of learning about specified topics in science, within the Likert response items. These broadly accorded with subject areas that would be found in both the Primary Science Curriculum and Junior Cycle Science Syllabus. Students' attitudes towards learning various areas of scientific subject content will be discussed in relation to the broad divisions within the Junior Cycle Science Syllabus, namely physics, chemistry and biology. Key differences in attitudes in comparing the primary survey data with the first year post-primary survey data will be considered later, in Section 4.4.2.

Physics

The responses to Likert items relating to subject matter in the physics component of the Junior Cycle Science Syllabus will be considered here. First year post-primary pupils' responses are summarised in Table 4.6.

Table 4.6: 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.

Overall, students' attitudes to topics in physics were not very positive. Only two statements, relating to the topics of forces and magnetism in the curriculum, "how machines work and move" and "magnets", were regarded positively by 50% or more of the respondents. Negative views of learning about all the stated physics topics were expressed by between a fifth and a third of students. This contrasts with the primary survey, in which all but one of the same physics topics were regarded positively by the majority of pupils (Varley et al., 2008). The most negatively construed issue was "how we heat our homes", in which less than a third of students expressed a positive view of learning. This had also been the most negatively viewed topic in the primary survey (Varley et al., 2008).

Chemistry

Students' attitudes towards topics falling within the chemistry component of the Junior Cycle Science Syllabus are presented in Table 4.7.

Table 4.7: 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.

The vast majority of students showed positive attitudes towards learning about "what happens when you mix things together", with only 8% of students expressing negative attitudes. This had been the chemistry topic attracting the most positive response in the primary survey (Varley et al., 2008). However, other aspects of chemistry were not so favourably viewed, with 40-50% of students expressing a positive response towards learning about these topics.

Biology

Students' responses to aspects of learning about biology will be considered next, and are summarised in Table 4.8.

Table 4.8: 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.

In general, students' attitudes towards learning about biological topics appeared to be more positive than their attitudes towards learning about topics in physics and chemistry. Learning about topics within human and animal biology was seen positively by more than half of respondents. However, plant biology was not so positively construed, with less than half of respondents claiming to enjoy learning about this topic. The most negatively viewed aspect of biology was learning about "insects, bugs and invertebrates". One student wrote, "I'm afraid" and another "I hate bugs" in the optional comment box next to this Likert item, which indicates possible reasons for negative attitudes towards this topic. Interestingly, the equivalent in the primary survey, "insects and mini-beasts" had also been the most negatively construed biological topic (Varley et al., 2008).

Other topics

Likert items in the student questionnaire relating to scientific subject content also included three statements relating to subject matter covered in the Primary Science Curriculum strand of Environmental awareness and care. These topics would have equivalents in the Junior Cycle Science Syllabus, but would be covered within physics, chemistry or biology components where appropriate. For ease of discussion in relation to curriculum continuity, however, students' responses to these items are discussed as a separate group in this report. Students' responses are presented in Table 4.9.

Students showed only moderately positive views about learning these topics. The topic attracting the most enthusiastic response was "inventions and discoveries", in which 50% of students expressed a positive view. Environmental science topics were positively construed by less than half the respondents. Students' ambivalence about these three topics is rather discouraging, since these most clearly accord with the notion of understanding links between science, scientists and society, an aim which the Junior Cycle Science Syllabus seeks to foster (DES, 2003a). These attitudes contrast with the more positive views expressed by primary pupils (Varley et al., 2008). It is unclear to what extent the students had experienced learning about these topics within a post-primary setting, although it is worth noting that in the primary survey, pupils appeared to hold positive views about these topics despite limited reporting of experiences in these areas. Differences in attitudes towards learning about these topics are discussed further in Section 4.4.2.

Table 4.9: Students' attitudes to topics relating to the Primary Science Curriculum strand Environmental awareness and care (Figures expressed as percentages)

I enjoy learning about…	Yes	Not sure	No	Total
Saving energy and recycling	42	31	26	99
How to look after the environment	42	33	24	99
Inventions and discoveries	50	33	17	100

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

Attitudes towards learning about scientific subject content: Concluding remarks

Students in first year showed fairly ambivalent attitudes towards learning about the majority of scientific subject content areas stated in the questionnaire. However, topics in which the majority of students expressed positive responses were found within physics, chemistry and biology components. Biological topics connected with human life attracted highly positive responses although the most positively viewed topic of all was a chemistry topic, learning about "what happens when you mix things together". This latter enthusiasm could be a reflection of students' engagement with practical activities in a laboratory setting, in which they are working with chemicals that are perceived to be dangerous and exciting.

Survey students' later comments in the open questions were revealing in this respect: "we get to blow stuff up, use chemicals"; "they [experiments] are really fun especially the stink bomb".

At this stage, an analysis was carried out to compare students' attitudes to physics, chemistry and biology. Students' responses to Likert items within each component were combined to calculate scores for overall attitudes towards learning in each of the three: physics, chemistry and biology. Related samples t-tests were carried out to assess differences between attitudes to subjects. Students' overall attitudes to biology and chemistry were more positive than their overall attitudes to physics. The difference between their attitudes to physics and the other two subjects was statistically significant (biology: $t=-3.16$; $df=217$; $p<0.05$; chemistry: $t=-4.67$; $df=213$; $p<0.05$). In first year at post-primary level, it would appear that students have more negative feelings about learning physics topics than those from the other two disciplines. At this point, it is important to consider how the methods of learning science at post-primary level are perceived by first year students.

4.3.4 Attitudes towards different methods of learning science

Practical activities

Students' responses to the Likert items relating to practical activities are summarised in Table 4.10. The vast majority of students felt positive about conducting experiments with their friends, and these figures are almost identical to those showing students' overall enthusiasm for working "with my friends at school" (Table 4.4). The social aspect of working in groups to do practical activities would seem to appeal to students. One student added an optional comment here, "I like to be co-operative". However, students were rather less positive about doing other kinds of practical work, with less than

50% of students claiming to enjoy doing an experiment "by myself" or planning and doing "my own experiment". In relation to the first of these items, it is not clear to what extent students' responses reflected attitudes to experimental work itself or the idea of working alone. For example, one student used the optional comments box to write "I find it easier to work with others" alongside this Likert item. It may also have been the case that working in groups was the norm for most students during practical activities, and this could explain their more negative attitudes towards the idea of working alone.

Table 4.10: Students' attitudes to practical science activities (Figures expressed as percentages)

I enjoy science when…	Yes	Not sure	No	Total
I do an experiment by myself	44	19	35	98
I do an experiment with my friends	88	8	3	99
I plan and do my own experiment	37	30	32	99

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

It is of more concern perhaps that students did not appear to enjoy planning and doing their own experiments. It would be hoped that at least some practical activities in first year within the Junior Cycle Science Syllabus would involve independent enquiry, and that students would have been exposed to such experiences in positive way. One student's comment beside the Likert item, "it would be good" implied that for this first year, such investigations were not within their current experience at all. Although many students made reference to conducting "experiments" as part of their open responses later in the questionnaire, it was not possible to discern whether these had been open-ended investigations or not. This point will be discussed further in Section 5. The discussion of teaching and learning strategies will now consider methodologies other than experimental work.

Use of ICT

Students' attitudes to the use of ICT in science were explored in two Likert items in the questionnaire. Data relating to these are presented in Table 4.11.

Table 4.11: Students' attitudes towards using ICT in science (Figures expressed as percentages)

I enjoy science when…	Yes	Not sure	No	Total
I use computer programmes in science class	56	20	22	98
I use the internet at school to find out about science	60	18	21	99

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

Most students appeared positive about the use of ICT in science. However, as with the Phase 1 primary survey (Varley et al., 2008), these data should be interpreted with caution as they only measure students' *attitudes* towards using ICT in science, not their level of engagement with these technologies. Interestingly, students from five different survey schools used the comments boxes beside the relevant Likert items to remark that they had "never done" work with ICT in science. The survey did not ask students specifically about their use of ICT in post-primary science, however, no students mentioned ICT in their open responses relating to post-primary science. Some did make more general references to more "technology" or "hi-tech equipment" in post-primary science, although it is unclear if these references related to ICT (Table 4.15). Students' experiences of ICT in post-primary science were explored more fully during the interviews in the case study (Section 5).

Teacher demonstration and explanation

Students were asked to express their attitudes towards two different modes of learning in which the teacher was the central figure. These data are presented in Table 4.12.

Table 4.12: Students' attitudes towards teacher demonstration and explanation (Figures expressed as percentages)				
I enjoy science when…	Yes	Not sure	No	Total
I watch my teacher doing an experiment	36	31	33	100
My teacher explains things to the class	59	24	16	98

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

Students did not hold very positive views about watching their teachers "doing an experiment" and these attitudes were less positive than any of those expressed in relation to carrying out experiments for themselves (Table 4.10). In contrast, primary pupils in the Phase 1 study had responded in a generally positive manner to the idea of teacher demonstrations (Varley et al., 2008). In the open questions in the current study, some first years referred to the fact that they were having opportunities to conduct experiments themselves and by inference, that this had not been the case in primary school; "[post-primary school is different because] we do experiments by ourselves". Perhaps increased opportunities to conduct practical activities at post-primary level has made post-primary students view teacher demonstrations more critically as a way of learning science.

In contrast, the majority of students' attitudes towards teacher explanation were positive. Some students were appreciative of post-primary teachers in this regard: "She's [science teacher] the best at explaining!"; "Science in second level is explained. At primary they tell us it's just magic." Primary pupils' views of teacher explanation in science lessons had also been positive (Varley et al., 2008), which is interesting in the light of the previous comment from a post-primary pupil.

Reading, writing and use of visual aids

Table 4.13 summarises students' attitudes towards reading, writing and the use of visual aids in science. Students were very negative about all these methodologies, with the exception of watching science programmes. However, it is unclear the extent to which these methodologies were a regular feature of post-primary science. In the open responses later in the questionnaire, relatively few students referred to any forms of reading or writing, as their comments were dominated by references to practical activities (Section 4.5). However, writing in science did come in for occasional criticism: "[at post-primary level] you have to write everything down, which I hate"; "we have to write every experiment into our hardbacks". These aspects of science class were explored in more detail in the case study interviews (Section 5). In relation to reading the "science schoolbook" one student chose to comment "can get boring and hard to understand. Teacher explains it better".

Table 4.13: Students' attitudes towards reading, writing and the use of visual aids (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
We watch science programmes at school	52	24	23	99

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

Science outside the classroom, on trips and with visitors

As with the primary survey, these strategies were seen in a generally positive light. Few students chose to write comments beside these Likert items, however some did suggest that they "would like" to undertake these types of activities, which implied that they had not yet done so. Students in two survey schools did mention visits to "young scientist" exhibitions in the optional response box beside the relevant Likert item. The open responses later in the questionnaire revealed only one reference to working outside at post-primary level and no students mentioned other kinds of science trips, fairs or visitors. It would therefore seem that students' attitudes were positive but for many, may not have been based on actual experience.

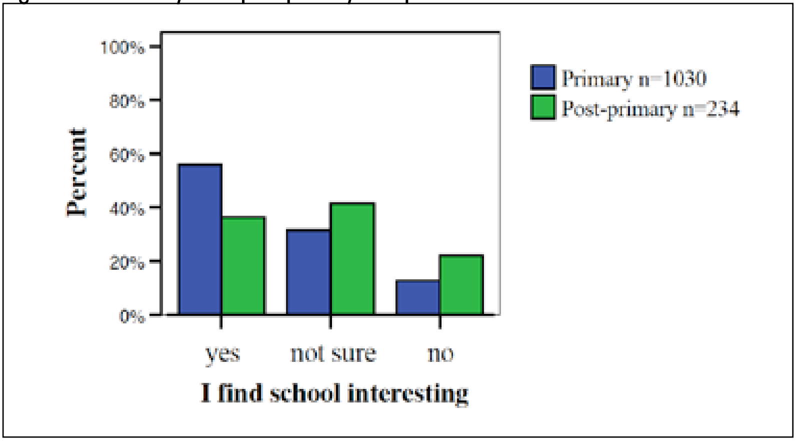
4.4 Comparison of Primary and Post-Primary Attitudes

Having discussed post-primary students' attitudes towards various aspects of science, it is relevant to consider how their attitudes contrast with the attitudes expressed by primary pupils in the equivalent survey (Varley et al., 2008). It should be borne in mind that attitudinal data were gathered from students in different classes during the same academic year, rather than from the same students over a period of time. These data therefore represent a "snapshot" measure of attitudes towards science in the fifth year of formal implementation of the Primary Science Curriculum (DES, 1999a) for students at different points in their school careers. The first year post-primary students would also have experienced at least two terms of science within the current Junior Cycle Science Syllabus (DES, 2003a).

4.4.1 Attitudes to school and school science

First year students' attitudes to school, measured using the first six Likert items on the questionnaire (Appendix A), were generally less positive than those of students in the primary survey. These differences were all statistically significant, with the exception of responses to the statement "I'm happy at school". In general, compared to their primary counterparts' responses, 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. Figure 4.2 is illustrative (Pearson chi-square: χ^2=31.0; df=2; p<0.01).

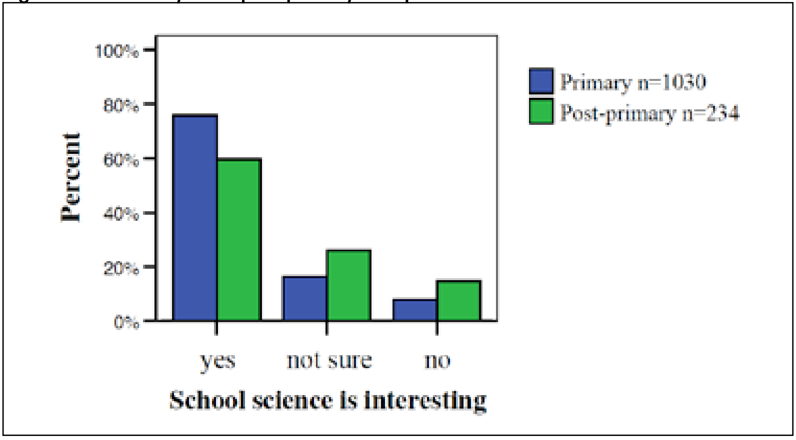
Figure 4.2: Primary and post-primary compared: Interest in school



(Figures expressed as percentages. N=1264)

A similar pattern was seen in students' responses to items relating to the enjoyment of science. Once more, post-primary students appeared to be more negatively disposed to school science compared to primary pupils, in that a smaller proportion claimed to find it interesting or looked forward to science lessons. These differences were statistically significant. Figure 4.3 is illustrative (Pearson chi-square: χ^2=26.2; df=2; p<0.01).

Figure 4.3: Primary and post-primary compared: Interest in school science

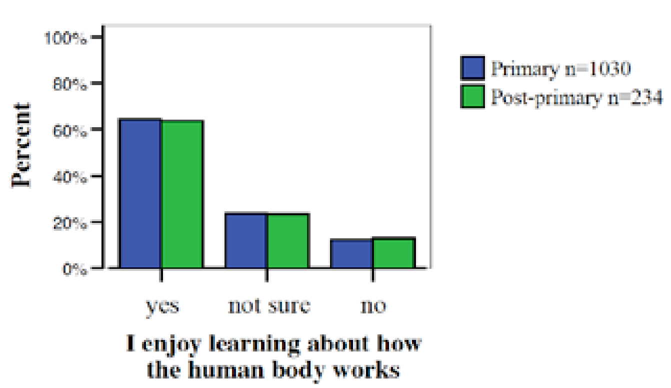


(Figures expressed as percentages. N=1264)

This apparent drop in interest in science at post-primary level is surprising, given that many first year students described their post-primary science experiences in glowing terms in the open responses (Section 4.5). An issue to be considered was whether post-primary students' apparent disinterest in science, according to Likert item responses, was merely symptomatic of their lack of enjoyment of school in general. To this end, first year students' responses to the statements "I find school interesting" and "school science is interesting" were compared. Their attitudes towards school science were more positive than their claimed interests in school, the difference being statistically significant (Wilcoxon signed ranks test: $Z=-5.081$; $p<0.01$). Thus it would appear that post-primary students' attitudes to school science were actually quite buoyant, when seen against the background of their interest in school.

Fewer post-primary students claimed that science was easy compared to primary pupils' responses, however this did not necessarily imply that students disliked science. Once again the difference between primary and post-primary attitudes was statistically significant (Pearson chi-square: $\chi^2=45.2$; $df=2$; $p<0.01$). However, a rather unusual pattern of responses was seen. This is shown in Figure 4.4.

Figure 4.4: Primary and post-primary compared: Ease of school science



(Figures expressed as percentages: N=1264)

First years' perceptions about the ease of school science were dramatically different when compared with primary pupils' views. However, within primary level, students' perceptions of the *difficulty* of science showed a decrease from third to sixth class, judging by the pupils who responded "no" to the Likert item. These differences between classes within primary level were also statistically significant (Pearson chi-square: χ^2=23.1; df=6; p=0.01). It may be the case that, within primary, science is judged to be easier, perhaps less challenging, by pupils approaching the age of transfer to post-primary school.

The data relating to pupils' responses to open questions in the primary survey (Varley et al., 2008) were re-examined in the light of these findings. Few mentioned the difficulty of science lessons they chose to describe, with just 2% mentioning "challenge" as a positive feature and just 3% being concerned about difficulty as a negative aspect. Proportionately fewer sixth class pupils mentioned difficulty, however; either in the positive sense of challenge (1%) or in the sense of work being too difficult (2%). It was not possible to determine if this difference was statistically significant, owing to the low numbers of responses that fell into these categories.

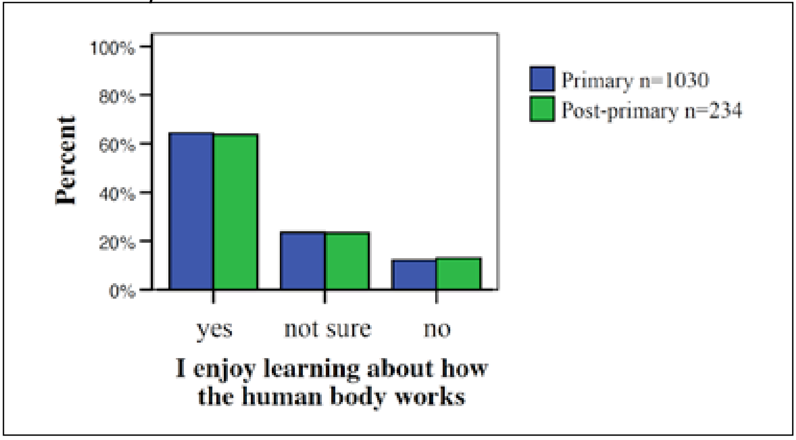
Returning to post-primary students, the increasing difficulty of science perceived by first years was remarked on positively by some, in the open responses later in the questionnaire: "Science is harder and more in-depth. I like science this year"; "[Post-primary] is more of a challenge, because if it was easy it would be boring". For others, the sudden increase in difficulty was seen as problematic: "the work is way harder to understand". If it is the case that upper primary pupils are perhaps unchallenged in science, then it seems this may have two negative consequences: It could prompt a decline in some pupils' interests in science before they even start post-primary school and it may lull others into a false sense of security, which proves detrimental to their ability to cope on transfer.

At this point, the discussion will consider whether there were any key differences between primary and post-primary students' interests in learning about specific science topics.

4.4.2 Attitudes to topics within science

There were 18 Likert items on the primary and post-primary students' questionnaires which sought attitudes towards learning about areas of scientific subject content. In all but one of these, a statistically significant difference was seen in attitudes at primary level compared with attitudes at post-primary level, with attitudes at post-primary level being more negative. In many cases, lower interest in these topics was seen from fourth class in primary level onwards (Pearson chi-square: data not shown). The only topic in which students' interest levels seemed to remain stable from primary to post-primary level was in learning about "how the human body works" (Figure 4.5).

Figure 4.5: Primary and post-primary compared: Attitudes towards learning about the human body



(Figures expressed as percentages: N=1264)

Again a consideration had to be made about post-primary students' generally negative attitudes to school, and how these might compare with their stated interest levels in learning about specific scientific topics. Post-primary students' responses to the statement "I find school interesting" were compared with their attitudes towards learning about each of the 18 stated aspects of scientific subject content. The results of this analysis are shown in Table 4.14.

Table 4.14: Post-primary students' attitudes towards learning about scientific topics compared with general interest in school.

I enjoy learning about…	Attitude relative to interest in school
How machines work and move	More positive*
Magnets	More positive*
Materials… such as wood, metal and plastic	More positive*
What happens when you mix things together	More positive*
How the human body works	More positive*
How to keep fit and healthy	More positive*
Animals from around the world	More positive*
Inventions and discoveries	More positive*
How sound travels	No difference
Light, mirrors and shadows	No difference
Electricity, batteries, bulbs and switches	No difference
Solids, liquids and gases	No difference
What happens to things when you heat or cool them	No difference
Plants and how they grow	No difference
How to look after the environment	No difference
Saving energy and recycling	No difference
How we heat our homes	Less positive*
Insects, bugs and invertebrates	Less positive*

N=234; *Wilcoxon signed ranks test: differences statistically significant at $p<0.05$

Eight curricular topics appeared to be viewed positively when compared with students' expressed interest in school. Aspects of physics, chemistry and biology were represented in this "more positive" category, as well as one topic which accorded with the strand Environmental awareness and care from the Primary Science Curriculum. Only two topics appeared to be more negatively viewed than students' general interest in school. The remaining eight specified topics were viewed in a manner that was not statistically significantly different from students' claimed interest in school. Students' stated enjoyment of learning about the majority of specified science topics would therefore appear to be at least as good as, if not better than, their claimed interest in school in general. Encouragingly, it would appear that some topics within the three components of physics, chemistry and biology are maintaining students' interest.

4.5 Students' Comparison of Primary and Post-Primary Science

The responses in the student questionnaire provided insights into the perceived differences between students' primary and post-primary science experiences. Their responses to the open question, "In what ways is science at second level different from the science you did at primary school?" are summarised in Table 4.15. Only those categories occurring in at least 2 (1%) of the responses are shown in the table.

From Table 4.15 it can be seen that students' responses mainly concentrated on the ways in which post-primary science was seen as an improvement on that experienced at primary level. Students commented on the increase in the amount of science at post-primary relative to the amount at primary level. Primary and post-primary curricula differ in the amount of time recommended for science each week (DES 1999c; DES, 2003a), so the students' comments about increased time are not perhaps very surprising.

Of more concern is that 16% of 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". Whilst it is difficult to verify these data, it seems likely that, for these students, if primary experiences had been more regular than claimed, these were either not memorable or not thought of as science. Perhaps it is the case that, for students, "doing science" at primary level only counted if it had included practical activities, and that it was these experiences that were rare. An analysis of the sources of these responses revealed that 12 out of the 13 post-primary science classes that responded to the survey contained one or more students who stated that they had never, or had rarely done science at primary school. This raises concerns about the range of experiences of primary science that first year students in a given post-primary science class may have, perhaps as a consequence of coming from different feeder schools.

Many students spoke enthusiastically about the greater quantity and frequency of experiments, some mentioning the more impressive nature of equipment for practical activities and having the chance to conduct experiments for themselves at post-primary level. It would be possible to infer from this last comment that, at primary level, some students had experienced practical work via teacher demonstrations rather than through hands-on work. In relation to this, it was interesting to note that two students spoke of teachers trusting them more at post-primary level with experimental equipment.

Students made more general comments about post-primary science, which collectively showed it in a positive light. Remarks were made about post-primary science being more fun and more interesting. Students talked of a wider range of subject coverage and that they were learning more. However, these were not necessarily entirely positive comparisons, as a number of students also commented that post-primary science was harder and for some of these students it would appear that this was seen as a negative attribute. It is notable that only a few students referred to having more writing or homework to do at post-primary level and interestingly, three students commented that there had been more bookwork at primary level.

Table 4.15: Differences between primary and post-primary science: Drawn from students' open question responses		
	Frequency	Percent
At post-primary…		
More experiments (general statement)	67	30
More difficult	42	19
Learn 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
Do 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 explain more/ better	5	2
More experiments (never at primary)	3	1
Better facilities	3	1
Teachers trust you more	2	1
More homework (or never at primary)	2	1
At primary…		
Bookwork only	3	1
Content was repeated within primary	2	1
Experiments easier	2	1

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

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

Comments relating to specific primary level experiences were infrequent and mixed in their connotation. Negative attributes of primary science included repetition of content in different classes, "in primary we did the same things over again", or only doing nature study (1 response each; not shown in Table 4.15). On the more positive side, individual students referred to primary science involving more work outdoors, fairs and projects (responses not shown in Table 4.15).

Overall then, it would appear that students reported post-primary science in very positive terms in comparison with primary science. It is therefore not surprising that, when asked to express a preference, the vast majority of students stated that they preferred post-primary level science (Table 4.16).

Table 4.16: Which is better?
Students' preference for post-primary/ primary science

	Frequency	Percent
Post-primary	166	79
Primary	30	14
Both	2	1
Neither	2	1
Don't know	6	3
Can't say (no primary science/ not schooled in Ireland)	4	2
Total	210	100

n for question=210; missing responses not included

The results shown in Table 4.16 mostly corroborated students' responses to the Likert item, "I like science at second level better than the science I did at primary school", to which 66% of students responded positively, with 17% answering negatively. The reasons for students' stated preferences also revealed some consistency with their earlier remarks about the differences between primary and post-primary science, discussed above. For clarity, the reasons given have been divided into two tables, which consider reasons for preferring post-primary (Table 4.17) and reasons for preferring primary science (Table 4.18). Some students gave reasons which acknowledged aspects of science in each setting; these reasons have been divided between the tables accordingly.

Reasoning for preferring post-primary science mostly referred to practical activities and the fact that students were able to conduct these themselves. Some remarks were made about the differing nature of practical activities, that is, that they took place in laboratories with better equipment and that this was perceived, positively, as being more dangerous: "[I prefer] second level because we use fire". Reassuringly, one student did also refer to being trusted more with practical equipment as a good feature of post-primary work.

Students also made general claims for post-primary science: that there was more of it; that there was more to learn; that it was more interesting and that there was a wider range of subjects. A few students responded that post-primary science was more challenging, and this was seen as a positive aspect. Only one student referred positively to a methodology other than laboratory-based practical activities, which was working outside. Post-primary science teachers also came in for occasional praise, with one student stating that they liked the teacher and four claiming that the subject was better explained than at primary level.

Table 4.17: Students' reasons for preferring post-primary science		
	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
There are laboratories	10	5
Just better	11	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
Trusted more with equipment	1	<1
Better experiments	1	<1
Less time per lesson	1	<1
Work outside	1	<1
Like the teacher	1	<1
Better friends	1	<1

n for question =204. Missing responses and "don't know" not shown.

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

Very few students stated that they preferred primary science, so the reasons given were correspondingly infrequent (Table 4.18). The main reason given was that primary science had been easier. It would seem that this subset of students did not relish the challenge that post-primary science was presenting. Individuals also noted positive features of the primary science that they had left behind, for example that it had involved working outside, had involved more projects and had been more creative and fun. Some reasons referred to perceived negative aspects of post-primary science, such as primary science being less dangerous, and involving less writing and revision.

Table 4.18: Students' reasons for preferring primary science

	Frequency	Percent
It was easier	13	6
More fun	3	2
Less writing	3	1
No need to remember and learn everything	2	1
Less frequent (preferred)	2	1
Worked outside	2	1
More projects	1	<1
More creative	1	<1
Fewer experiments at primary level (preferred)	1	<1
Just the right amount of science	1	<1
Simpler equipment (preferred)	1	<1
Less dangerous	1	<1

n for question = 204. Missing responses and "don't know" not shown.
Total does not add up to 100% as not all students gave answers in this category.

The picture of post-primary students' encounter with first year science appears to be largely positive. Practical activities and the greater frequency of science classes feature as central aspects of this experience. The emphasis of the Junior Cycle Science Syllabus on a practical approach appears to be in evidence, and is having positive effects. In the context of this study, however, it is a concern that students' views of their primary science experiences were so negative in comparison. In particular some students either stated or implied that at primary level, science had been a rare occurrence involving few, if any hands-on practical activities. It seems that students are forming positive attitudes to post-primary science in spite of, rather than because of their earlier primary experiences. However, it may also be the case that an overly negative view of primary science was conveyed by these students in an effort to distance themselves from the experience of primary school science in general. Certainly some students appeared to show a slight disdain for science at primary level: "we didn't do as much science in primary school…we just did it for fun".

At this juncture, it is pertinent to consider whether, with such a positive start, these first year students showed any enthusiasm for continuing their study of science. This will be discussed in the next section.

4.6 Post-Primary Students' Future Aspirations in Science

Students were asked in a Likert item on the questionnaire whether they would "like to study science subjects for [their] Leaving Certificate". Just under half of respondents, 44%, stated that they would, with 29% of students claiming that they would not. In the open responses, students were asked more generally if they would like to study science in the future. Their responses are presented in Table 4.19.

Table 4.19: Would you like to study science in the future? Students' responses to open question		
	Frequency	Percent
Yes (no further clarification of level)	96	43
Yes (Leaving Certificate)	6	3
Yes (Tertiary level)	1	<1
Yes, but only because I have to	2	1
Maybe/ probably	13	6
Not sure	36	16
Probably not	1	<1
No	67	30
Total	222	100

n for question=222. Missing responses not shown.

These responses mirror the findings from the equivalent Likert item responses, although different levels of uncertainty were more evident in the response to the open question. The reasons for their decisions were provided in answering the final open question. Responses were coded in a range of categories, which will be discussed in turn. It should be noted that many students gave reasons falling into more than one category.

4.6.1 Perceptions of science

Students made a number of generic comments about science in explaining their reasons for wanting to, or not wanting to pursue further scientific study. These are summarised in Table 4.20.

Table 4.20: Reasons relating to further study: Students' perceptions of science.		
	Frequency	Percent
Want to study science further because…		
Science is interesting	51	25
Specific sciences/ topics are interesting	14	7
It is fun/ exciting	13	6
It is useful	8	4
It is important	6	3
It is easy	7	3
Don't want to study science further because…		
It is too difficult	21	10
Science is boring	16	8
It is difficult at times/ may be in future	8	4
Specific sciences are boring	2	1
It is not challenging enough	1	<1

n for question=202; Total does not add up to 100% as not all students gave answers in this category.

It is encouraging to see that many students expressed a desire to study science in the future because it was seen to be interesting, although this reason is not perhaps very illuminating. A few students identified one or more of the individual science subjects, that is, physics, chemistry or biology, as the one in which they were especially interested. A few students referred to science being "fun" or "exciting" as a reason for continuing its study, which may be linked to students' earlier expressed enthusiasm for the practical emphasis of post-primary science. Surprisingly few students made reference to the overall importance or utility of science as a subject, which is of concern when both the Primary and Junior Cycle curricula would aim to promote the value of developing scientific literacy and hence an awareness of the relevance of science to society.

A number of students, who did not wish to continue their studies, expressed concerns about the difficulty, or potential difficulty of the science they might study in future. This corroborates students' earlier comments about the difficulty of the science they were studying currently. In contrast, very few students who wished to continue their studies remarked on the ease of science or indeed the challenge that it presented, as their reasons.

4.6.2 Enjoyment of science

Students also expressed personal opinions about their liking of scientific study (Table 4.21). Whilst these data are not perhaps very revealing, they do at least show that some students were already forming strong views about their enjoyment of the subject, or otherwise. It is rather discouraging to see that a small number of students who were only part-way through their first year at post-primary school were claiming that they were not planning to take science further as they did not enjoy it.

Table 4.21: Reasons relating to further study: Students' enjoyment of science.

	Frequency	Percent
Want to study science further because…		
I like/ enjoy science	13	6
Science is my favourite subject/ one of my favourites	7	3
Don't want to study science further because…		
I don't like/ enjoy science	12	6
I don't like science that much/ enough	3	1
I prefer other subjects	2	1<

n for question=202; Total does not add up to 100% as not all students gave answers in this category.

4.6.3 Practical activities

Students had made many positive comments relating to practical activities at post-primary level in earlier sections of the open responses (Section 4.5). It was therefore interesting to see the degree to which students alluded to this aspect of post-primary science in the final open question (Table 4.22). Surprisingly few students made any reference to experimental work in these responses, either in a positive or negative context. It would appear then, that although practical activities are contributing to students' current positive views about post-primary science, these are not seen as a key factor in decision-making about further study in the sciences. Perhaps these students, even at early post-primary level, were looking at the future in a more pragmatic way. This will be discussed in the next section.

Table 4.22: Reasons relating to further study: Practical activities.		
	Frequency	Percent
Want to study science further because…		
I like experiments/ finding out results	9	4
Don't want to study science further because…		
There won't be as many experiments later on	1	<1

n for question =202; Total does not add up to 100% as not all students gave answers in this category.

4.6.4 Science examinations and careers

Few students made comments relating to school examinations and grades in their reasoning (Table 4.23). However, a minority of students already have perceptions of the strategic value of choosing subjects in which they can do well, or in which there is a perception of being able to do well: "You'd get high points for it in Leaving Cert."

Table 4.23: Reasons relating to further study: Students' perceptions of grades and subject choice.		
	Frequency	Percent
Want to study science further because…		
You can get high points at Leaving Certificate	3	1
I'll get good grades/ high points	2	1

n for question = 202; Total does not add up to 100% as not all students gave answers in this category.

A number of students made reference to the value of having scientific qualifications for tertiary level study or in relation to their future employment (Table 4.24).

Table 4.24: Reasons relating to further study: Tertiary level and careers.		
	Frequency	Percent
Want to study science further because…		
Science is necessary for my chosen career	21	10
Science is necessary for (good) employment/ improves employment chances	12	6
Perhaps… depends on job I want to do	3	2
Science at college would be good	3	1
It's a college requirement	1	<1
Don't want to study science further because…		
Science is not necessary for my chosen career	8	4
It won't be a college requirement	3	1
College science would be too hard	1	<1
I don't want to be a scientist	1	<1

n for question=202; Total does not add up to 100% as not all students gave answers in this category.

It is perhaps surprising to find that any first year students were focussed on their long-term futures and job prospects, but these data are illuminating in this regard. Several students referred to science qualifications enhancing their career prospects in general: "If you study science a lot of jobs are available to you". A larger number of students had already made plans for a chosen career, and knew that science would be an essential part of this, either for college entry or beyond. These career choices varied although students mostly referred to jobs in the healthcare sector. A small minority of students had already discounted further study of science because they were just as focussed on a future course of action that did not require science. It is not possible to say whether the students with firm ideas about their future careers are likely to change their minds or whether their career plans are realistic or not. However, these data suggest that even first year students are thinking about the long-term consequences of subject choices they might be making in upper post-primary school and this may be affecting their engagement with scientific study now.

4.6.5 Other reasons

A minority of students suggested other reasons for their stated decisions about future study of science. These were limited to individual responses and included references to: family pressure to do science; positive and negative perceptions of their science teachers; and the amount of time and learning involved in studying science.

4.7 Student Survey Findings: Summary

Students from a varied range of locations and school types in Ireland participated in this survey. This has provided a wealth of data relating to students' perceptions and experiences of school science early in their post-primary careers. It has also provided insights into these students' primary experiences and their future aspirations. This section has covered the responses to the first year student survey in detail, and where possible, has triangulated data between question types in order to corroborate or clarify the material presented. Attitudinal data have also been compared with those gathered during the equivalent Phase 1 primary survey of third to sixth class pupils, in an effort to reveal any overall patterns in findings. There are a number of issues arising out of this analysis, which will be summarised in relation to the themes of the research indicated at the start of this section.

4.7.1 Primary pupils' attitudes to post-primary science

Primary pupils are generally looking forward to studying science at post-primary school. Sixth class pupils appear to be anticipating this most keenly.

4.7.2 Post-primary students' attitudes to school and school science

First year post-primary students do not have especially positive attitudes towards school, particularly school work. In contrast, they have rather more positive attitudes towards school science.

Scientific subject content

Evidence from the teachers' contextual questionnaires suggests that most students have experienced scientific subject content from physics, chemistry and biology after two terms of studying science at post-primary school. Students' claimed interests in learning about these areas of science are mixed but rather negative, with less than 50% of students claiming to enjoy learning about 10 of the 18 topics stated on the questionnaire. It is encouraging however, that at least one topic within the components physics, chemistry and biology is seen in a positive light by the majority of students. Students are positively disposed towards learning a range of biological topics. Overall, students' attitudes towards learning biology and chemistry topics appear more positive than their attitudes towards learning physics topics.

Methods of learning science

Students are positively disposed towards practical activities, especially, it seems, when working with friends. Many students have positive things to say about practical activities at post-primary level and comments about this way of working dominate their remarks about post-primary science. Students do not appear to have such positive feelings about planning and carrying out their own investigations and it is unclear whether these are a common feature of survey students' experiences to date.

Students reveal positive attitudes towards using ICT in science and towards working outside, going on trips and having science visitors. However, there is virtually no data to suggest that these are methods of learning science which students have encountered at post-primary level. In stating this, it should be noted that the post-primary questionnaire did not explicitly set out to gather such data.

Students have quite negative views about teacher demonstrations of practical activities, but few responses suggest that these are a dominant feature of post-primary science. Teacher explanations are regarded quite positively and some students clearly value the ability of their teachers to explain interesting scientific ideas. In contrast, many students hold negative views about reading and writing as part of science class. These are the most negatively viewed aspects of school science. In fact, these ways of working in science are held in lower regard than students' general attitudes to school.

4.7.3 Comparison of primary and post-primary attitudes

First year post-primary students appear to be less well-disposed to school and to school science than their primary counterparts. In some cases, lower interest in aspects of school science is seen from fourth class onwards at primary level. However, post-primary students' attitudes towards science and in learning about specific science subjects are generally more positive than their claimed interest in school. Science as a subject therefore has a relatively positive profile, when students' general interest in school is taken into account.

Students' perceptions of the ease of science follows a rather unusual pattern, in that older primary pupils regard science as being relatively easy, whereas first years at post-primary find it quite challenging. This raises questions about the experiences that pupils are having at upper primary level, and whether these are an adequate preparation for transfer to science in post-primary school. On re-examination, Phase 1 data from survey pupils' responses to open questions corroborated the idea that few of them regarded their primary science lessons as difficult. First years in the current survey provide additional insights into the degree of change in scientific experiences on transfer from the primary to the post-primary setting, which are summarised next.

4.7.4 Post-primary students' comparison of post-primary and primary science

First year students appear to regard post-primary science in an extremely positive light in comparison with the science they encountered at primary school. When asked, the vast majority of these students claim to prefer post-primary science. The principal reasons for this are the emphasis on practical activities and the increased time devoted to science at post-primary level when compared with students' memories of primary science. Post-primary pupils seem to be enjoying the opportunity to conduct experiments for themselves, work in laboratories and use equipment that is regarded as more sophisticated than that used at primary level. Somewhat disconcertingly, a substantial minority of students claim to have had few, if any experiences of science at primary school, especially of a hands-on nature. All but one of the post-primary survey schools contained at least one student of this kind, which raises concerns about consistency of experience in different primary schools and the consequences that this might have for science teaching and learning in first year at post-primary school.

Many students also claim that post-primary science is more interesting than primary science, although the precise reasons for this claim are unclear. A proportion of students note that post-primary science is more difficult than primary science, some finding it substantially harder. A few students appear to regard this positively and find post-primary science to be a good challenge, whereas for others this increased difficulty of science appears to present something of a stumbling block.

4.7.5 Post-primary students' future aspirations

Just under half of the students surveyed stated that they were interested in studying science at Leaving Certificate. Even in first year, many students appear to have made up their minds about future study. Students' reasons relate to finding the subject interesting, fun and enjoyable, although some students already appear to be quite focussed on the career value of having scientific qualifications. Surprisingly few students refer specifically to practical activities as the motivating reason for continuing to study science in the future. This contrasts with a much greater proportion of students talking enthusiastically about practical activities as a feature of their current experience of science.

Nearly a third of students stated that they were not intending to study science at Leaving Certificate level or beyond. Again, these students appear quite certain of their decision. Key reasons for rejecting further study relate to interest levels and for some, a perceived irrelevance of science for their career plans. However, the most common reason given is the difficulty of science.

Recommendations arising out of these points will be discussed in Section 6 in conjunction with issues arising from the analysis of case study data. Section 5, which follows, considers the data gathered during the case study conducted in eight post-primary schools.

Section 5: Case Study: Findings

This section opens with a brief overview that explains how the case study data were essentially typical of the data gathered in the nationwide survey. A presentation of the findings obtained during Phase 1 of this commissioned research, regarding primary pupils' attitudes towards the prospect of learning science in post-primary school is then provided. The findings from the analysis of data obtained from seven group interviews and questionnaires returned by eight case study classes in Phase 2 are then presented under the following headings:

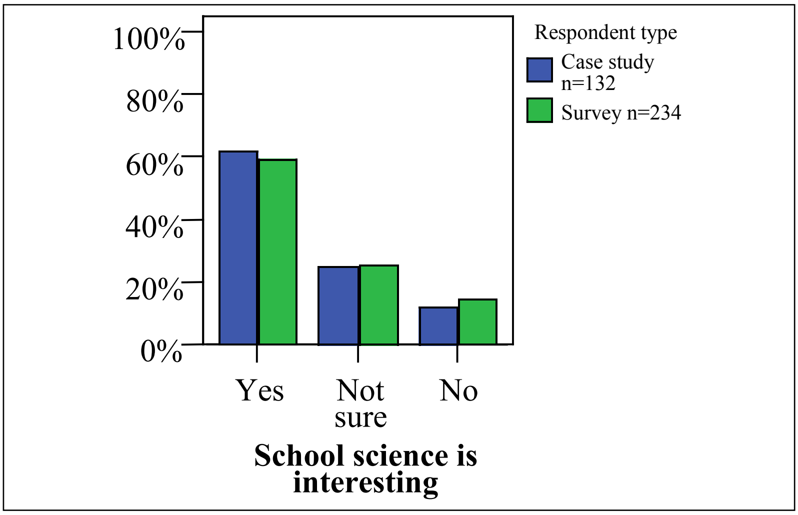
- Perceptions of post-primary school science;
- Experiences of science in post-primary school;
- Experiences of science in primary school;
- Attitudes towards school science;
- Future study in science.

5.1 Comparison of Case Study and Survey Students' Responses

All students in the eight case study classes were asked to complete questionnaires identical to those used in the survey (Appendix A). A total of 132 questionnaires were returned from an initial 160 distributed, representing a response rate for the case study of 83%. Of the questionnaires returned, 45% were from girls and 55% from boys. A Pearson chi-square analysis revealed that the proportion of girls and boys in the case study and survey were essentially identical. Analysis of the questionnaire responses allowed for a comparison of case study and survey students' attitudes.

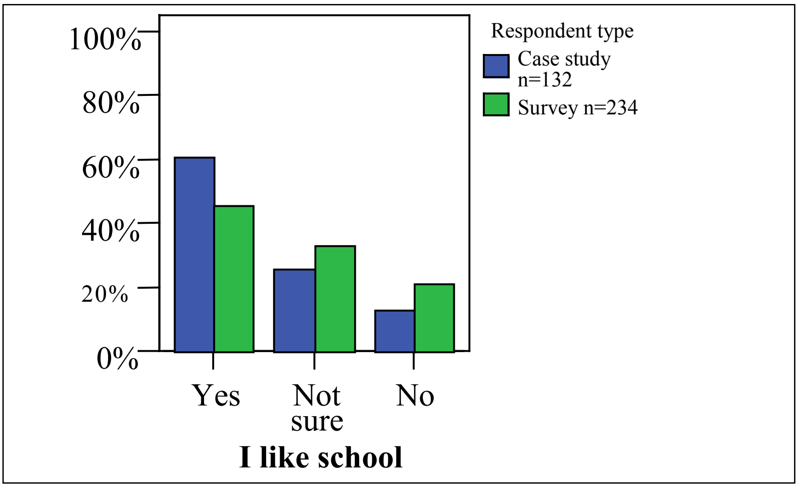
When interpreting data from the case study, it was important to consider whether the case study students' responses were reflective of those in the wider population of first year post-primary students who participated in the survey. To this end, Likert item responses from first years' questionnaires in the case study and survey were compared. Few statistically significant differences in attitudes were found. Case study and survey students held similar attitudes towards school science, learning about different science topics and methods of learning science. An example is provided in Figure 5.1, which shows that students' responses to the statement "school science is interesting" were broadly similar in the case study and survey.

Figure 5.1: Case study and survey compared: Interest in school science



Responses to 9 out of the 50 Likert items on the questionnaire revealed statistically significant differences in attitudes between the case study and survey students. One related to use of the internet and another to working outdoors, about which the survey students were more positive. Six related to learning about scientific topics, drawn from physics, chemistry and biology. Here, the case study students were more positive. Finally, one item on attitude to school revealed a statistically significant difference, where the case study students were more positive. Figure 5.2 illustrates an example of the case study students' more positive responses (Pearson chi-square: χ^2=8.35; df=2; $p<0.05$).

Figure 5.2: Case study and survey compared: Students' liking of school



It can be concluded that the attitudes of students in the case study towards school science in general, towards most scientific topics and towards virtually all stated methods of learning science were essentially similar to those of students in the survey. The case study students' views about school science would therefore appear to be fairly typical of the wider population of students who participated in the survey.

5.2 Primary School Pupils' Attitudes Towards Post-Primary Science

In Phase 1, pupils in five of the twelve group interviews were asked about what they perceived science would be like in post-primary school (Varley et al., 2008). The five groups that were asked this question comprised the more senior primary class groupings (third to sixth class), who were nearer the point of transfer to post-primary school. The junior classes (infants to second class) were not asked this question, as they were several years away from transferring to post-primary school. The pupils' responses to this question were very positive. Table 5.1 outlines some of these.

The data obtained from the case study group interviews indicate that the pupils in the primary case study schools maintained science in post-primary school would be interesting, would involve doing experiments and working in science laboratories. Students in all of the interviews also maintained that science in post-primary school would be book- based. Although pupils in four of the five case study groups believed post-primary science would be more difficult than primary school science, they were still looking forward to it. In short, it would appear these primary pupils were positively disposed towards the idea of doing science in post-primary school.

Table 5.1: Primary pupils' perceptions: What do you think science will be like in post-primary school?		
Categories	No. of interview groups addressing category (N = 5)	Sample of responses
Book-based	5	It depends what the teacher picks out, because if we don't have a book, he could he or she could pick out pieces from her or his book (6th) Maybe more book teaching … (6th) I think it's going to be like about [books]…because I went over to my friend's house and I saw his sister doing her homework, and I just see these weird books and all … (3rd)
Experiments	4	We will be mixing and stuff like that (6th) I think we'll do all experiments (6th) I can't wait until we're in secondary school, because my sister is. And she's in third year, and she does proper science. And she has little things and she pours stuff in them (3rd) There's going to be like, dissecting things (4th)
Difficult	4	Well, because we're going to be a lot older, and it's going to be more advanced (4th) It will be harder. And you can, they'll let you go further in, like, instead of just doing the basic bit, they might actually go further in, like you could study it harder (4th)
Interesting	3	I think it's going to be a bit more interesting and quite hard (6th) I'm going to do science in post-primary school, because like it's very interesting and all. You can learn loads of stuff about it too (6th)
In laboratory	2	I'm looking forward to secondary, because it says, like on the listing, we need a lab coat. And like, that it says you do biology, chemistry and physics. And I'm really looking forward to the chemistry bit, because I've always loved that (6th) We had this tour [of science lab in post-primary school] and it had all the weird shaped bottles and all, like chemicals and all (6th)
Exams	2	Tests, on like, when you like … at the end of the week, you might have a test and see if you remember it all (6th)

5.3 Perceptions of Post-Primary School Science

The first year students' responses regarding their perceptions of science in post-primary school are presented in this section under the following two headings:

- Perceptions of science following an introductory visit to post-primary school;
- Science in post-primary school meeting students' expectations.

5.3.1 Perceptions of science following an introductory visit to post-primary school

In the current phase of this research study, (Phase 2), students in all seven of the case study group interviews were asked about any visits to their post-primary schools, which they had made the previous year. They were asked whether they had visited the science laboratories, had seen somebody conducting or demonstrating an experiment, or whether they had taken part in some aspect of science during this visit. Responses in all seven of the case study group interviews indicated that the students had indeed visited the science laboratories and students in four of the case study group interviews indicated that they had seen other students demonstrating experiments during these visits. Students in two of the case study group interviews also indicated that they had taken part in some aspect of an experiment during this visit. Table 5.2 illustrates some of their responses regarding their visits to post-primary schools the year before entry.

It is clear from these responses that the students had positive experiences of science during their pre-transfer visits to post-primary school. These positive experiences of visiting laboratories and observing dramatic and exciting experiments appear to be typical of experiences encountered by primary pupils on pre-transfer induction days and, according to Galton (2002), often provide students with unreasonably high expectations of what post-primary science entails. However, in the next section it will become apparent that post-primary science for the students in this study seemed to meet or exceed the students' initial high expectations.

Table 5.2: First year students' experiences of visiting post-primary school prior to transfer

What pupils did during school visit	No. of interview groups addressing category (N = 7)	Sample of responses
Visited lab	7	• I think there was people in science labs doing experiments. And you walked around and watched them (U)[3] • We went to the science labs (Y) • We had a tour and visited the lab (V) • We just toured the school and visited the lab (T)
Saw people do experiments	4	• A few students would stay back after school and do the experiments while we walked around and watched them (U) • The science lab is really interesting on the open day too, because they're doing all these experiments (W) • It was like a senior fellow. And he had these chemicals, and he made a firework out of it (X) • All the sixth years were doing them [experiments] that you could mess around with (Y)
Took part in experiment	2	• There was a kind of a ball that, like, was moving. And when you touched it, your hair, your hair, and you touched it for a while. Put your hand over your head and your hair started to move up to it (X)

3 In this and subsequent tables, the letters T, U, V, W, X, Y and Z represent the seven case study schools at post-primary level where interviews were conducted (Appendix C).

5.3.2 Science in post-primary school meeting students' expectations

The first year students who took part in the case study group interviews were asked whether science in post-primary school was what they thought it would be like. For the most part the students indicated that science was similar to, or better than their expectations. Table 5.3 outlines some of their responses regarding whether or not their expectations of science in post-primary school had been met.

Table 5.3: Expectations of post-primary school science: Is post-primary school science what you thought it would be like?

Categories	No. of inter-view groups addressing category (N = 7)	Sample of responses
Yes it is what I thought	2	• Yeah … because like, I thought it would be all like, do you know, the gloves and all … and then when we came in it was like that (Y) • Well I thought we'd be in the lab and we are (X)
No not really	1	• No, not really. I didn't think, there's some stuff that I didn't learn in primary that I know now. Like, I didn't know what a Bunsen burner was before I came…. I knew that we'd have all science gloves, and the coats and stuff like that… But it's not what I expected it to be (Y)

It's better than I thought	6	• It's exciting. A lot better than primary (U) • It's actually better [than I thought]… we're doing more serious experiments (V) • It's better than I thought it would be, because it's, I don't know, I thought it might be a bit boring. But it's not really. The experiments are cool (W) • I wasn't really expecting much when I came from primary school. But it's really, really good now… it's more interactive. You get to do more things than you did in primary school… we have like, more equipment to do stuff with. In primary school, we had to like, when we were doing that plant thing, we had to use uh, yogurt cans, because you didn't have anything … [in post-primary school] you're more mature, like older to be trusted to do more than in primary… (Y) • I really like it now. It's got more experiments than I thought they're would be (Z) • I didn't know what to expect. We're allowed to do so much- it's great! (T)

It is evident from the group interviews that these first year post-primary students recalled their visits to their post-primary schools the previous year in a positive manner. Many of them had visited the science laboratories and had observed students conducting experiments. Some of the students in the case study classes were even provided with opportunities to engage in hands-on experiences during their visit. It would appear therefore, that prior to commencing science in post-primary school the students in the case study group interviews held positive perceptions regarding post-primary science. Fortunately it would also appear that, contrary to Galton's findings in the UK (2002), for the majority of these students their actual experiences of science in post-primary school have met or exceeded their expectations.

5.4 Students' Experiences of Science in Post-Primary School

During the case study group interviews the first year students were asked about their experiences of science in post-primary school. The students' responses in relation to their current science experiences will be presented under the following three headings:

- Content;
- How they learn science;
- Where they learn science.

5.4.1 Content

The aspects of science the first year students reported learning about in all of the case study group interviews were similar. Table 5.4 provides a summary of some of the students' responses regarding the aspects of physics, chemistry and biology that they had learned about to date in post-primary school.

Table 5.4: What have you learned about in science in post-primary school this year?		
Categories	No. of interview groups addressing category (N = 7)	Sample of responses
Physics	5	• We have magnets and we were like, writing down what they like, are attracted to… and we had a diagram like of a North and South … the magnetic field (W) • We're learning all the formulas and stuff, uh, how to calculate average, no, not average speed. But um, like acceleration and things (X) • You have to heat the water and it shoots up (U) • 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)
Chemistry	6	• With chemistry, there's all like, working with materials and things (V) • We're learning about mixtures and uh, elements (V) • 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)
Biology	7	• We learned how to test for starch, and …then we learned like which food had what in it (V) • We had to learn all the classifications and stuff like that (V) • In biology we go outside to find insects and things (Z) • We're learning about how plants and stuff grow (Y)

It is apparent from the students' responses that, to date, all students had learned about a wide range of different aspects from the physics, chemistry and biology components of the Junior Cycle Science Syllabus (DES, 2003a). For the most part, the case study students' responses regarding the content knowledge they have been learning about in post-primary science is extremely positive. There were some exceptions where students revealed more negative responses regarding learning scientific content:

> *Some of the facts can be quite hard… because like, there's so much in a chapter, and it's kind of hard to find it all… we have a test every two chapters… (Z)*

5.4.2 How they learn science

During the group interviews the students were also asked about how they learn science and what kind of things they do during their science classes in post-primary school. Tables 5.5, 5.6 and 5.7 provide an outline of some of their responses. In a similar manner to the students' responses regarding the *aspects* of science they have learned about to date, their responses regarding *how they learn* science in post-primary school were much the same across all interview groups. As these tables indicate, the students recalled numerous different experiences they encountered during science class in post-primary school. These will be considered under the following headings:

- Practical activities;
- Reading, writing and rote learning;
- ICT.

Practical activities

Table 5.5 outlines responses obtained during the case study group interviews in relation to students' experiences of practical activities at post-primary school.

Table 5.5: What do you do in science class in post-primary school? Responses relating to practical activities		
Categories	No. of interview groups addressing category (N = 7)	Sample of responses
Watch teacher do experiments	7	• We do it [experiments] as well. He [teacher] shows us, like, how to do it properly. And then we'll do it. (U) • Sir showed us that some [elements] even react with air. It was exciting (T) • The teacher can show everyone how to do it (V) • … if it's a big one she [teacher] just does it (W) • He shows us how to do them first. And then we're able to do it. (X) • It depends, sometimes he does it for us and then we can go off and do it … (Z) • Well she'd show us how to do it and then we'd have to do it ourselves (W)
Do experiments	7	• When you do an experiment, you're not told you're wrong. You have to try out yourself. And then, well, you work in a team to do it. And then if you do get it wrong, you just try it again (V) • 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 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. Its more interesting than reading or writing (T) • Yeah like each second day, we're in the science lab, and usually everybody's got an experiment to do (Z) • … sometimes he just like gives us steps or it's written in the book and we do it (Z) • I really like doing the experiments, that's when things come to life for me. You can read about reactions and colour changes but when you see them its easier to remember (T)

Table 5.5: What do you do in science class in post-primary school? Responses relating to practical activities (Cont'd.)		
Plan and do investigations	1	• She [teacher] 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)
Do experiments in pairs	7	• Mostly we work in pairs or groups of three (V) • We work in pairs with the person sitting beside us (Z) • We have a lab partner. We got them at the start of the year and we work together (T) • Well like if you're working with somebody like there's less work for you to do and it can be done quicker … one person can be working on the experiment and the other can be working on the other bit (Z)

In the interviews, all of the case study students reported conducting experiments themselves and observing their teachers demonstrate experiments. All of the students' comments regarding observing or conducting experiments were positive. It is interesting to note that the students' responses in relation to themselves conducting the experiments were more in-depth and provided greater detail than their responses relating to observing teacher demonstrations:

> *First we got the magnet, or the compass and put it to the magnet to see which way was North and South. And then what we did was, we put it in front of the thing.… You put it back and forth until you find the points and then you, whatever, if it's pointing South you draw a dot on it (W)*

> *…Sometimes she does the experiment on the front desk (W)*

These types of responses appear to suggest that the students' experiences of conducting the experiments themselves were more memorable than watching their teachers' demonstrations. It is also interesting to note that whilst students in all of the group interviews reported conducting experiments in post-primary school science, students in only one group reported planning and conducting an investigation themselves.

The case study students' responses in the questionnaires reveal rather more positive views regarding conducting hands-on practical activities over watching their teachers demonstrating practical activities. This was apparent in their responses to the Likert items relating to conducting practical activities, where 43% of the respondents indicated that they "enjoy science when I do an experiment by myself" (Figure 5.3) and 89% indicated that they "enjoy science when I do an experiment with my friends" (Figure 5.4).

Figure 5.3: I enjoy science when I do an experiment by myself (N=132)

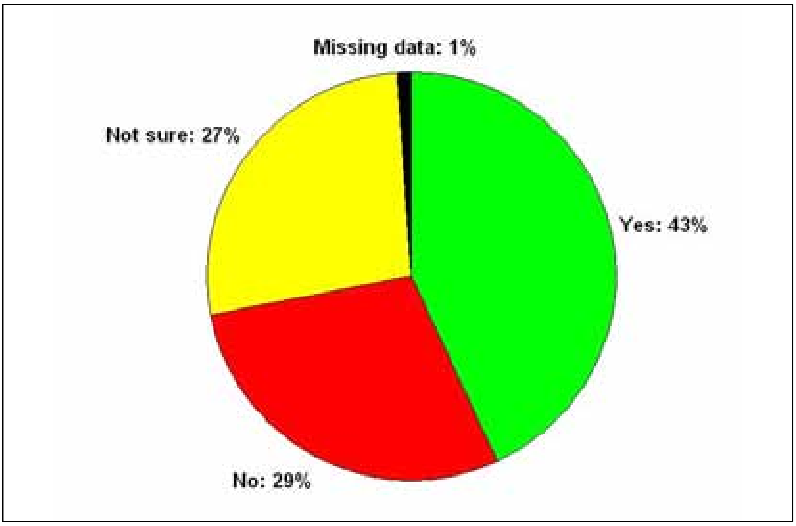
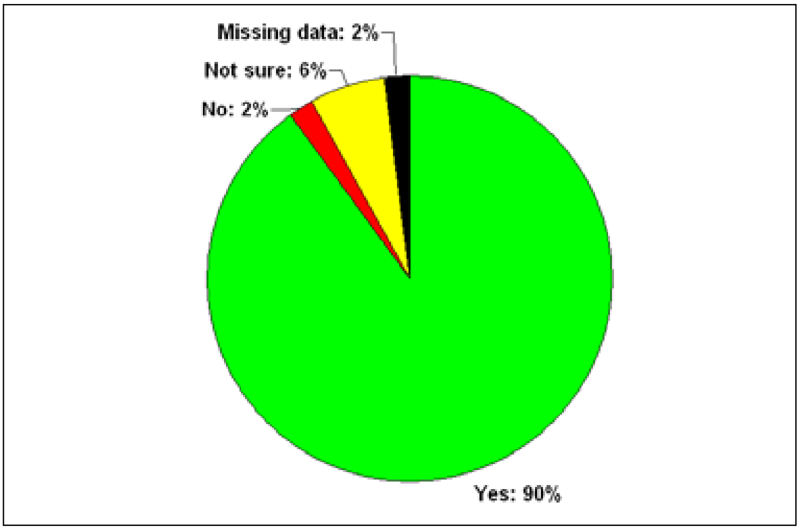
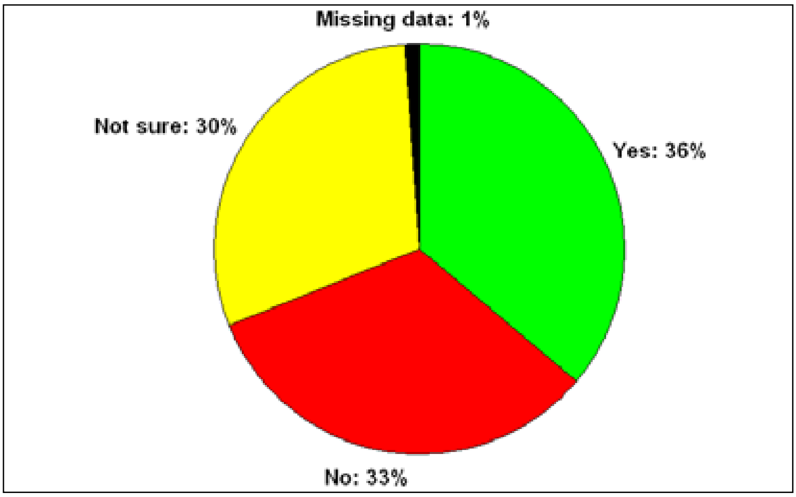


Figure 5.4: I enjoy science when I do an experiment with my friends (N=132)



This was in comparison with only 36% of the case study respondents who reported that they "enjoy science when I watch my teacher doing an experiment" (Figure 5.5).

Figure 5.5: I enjoy science when I watch my teacher doing an experiment (N=132)



Reading, writing and rote learning

Table 5.6 outlines responses obtained during the case study group interviews in relation to students' experiences of a range of more didactic techniques for teaching and learning science at post-primary school.

Table 5.6: What do you do in science class in post-primary school? Responses relating to reading, writing and rote learning

Categories	No. of interview groups addressing category (N = 7)	Sample of responses
Taking down notes	7	• She'll just talk about experiment. And then to write, she'd write it up on the board. And then we'll take down the notes and then maybe do it (V) • We take down the meaning of things which makes it easier to understand (T) • We mostly take down notes (W)
Write up experi-ments in workbook for Junior Cert.	7	• There's other things, take down a method how we could get, em, what would happen if we do it, and that we needed to use (V) • It's like a workbook where you use the big book and then it has questions on it, that chapter and you've to write them in… I don't really like that. (Y) • Well one of our copies is an experiment copy, and every time we do an experiment, we write it up, how we did it and what happened. And then our other copy is our notes copy, so if we're learning about something, we'll take down notes about what we're learning (Z) • We write about the experiments we've done. It's part of our Junior Cert but we get to start it in first year (T)
Write up experi-ments in hard back	6	• We write them into a hardback … the diagrams we do into our hardback copies. (U) • … It showed a picture that we have to do, and write into our hardback copies … nearly every page has one, one at least (U) • We have to write our, what our aim is, the date… We have loads of head, we have a couple of headlines (V) • Most of the time we have our hardback copies, and we're writing, like, notes and stuff, which we have to learn, and stuff like that… (W) • We have like a hardback as well for writing all the questions and stuff (Y)

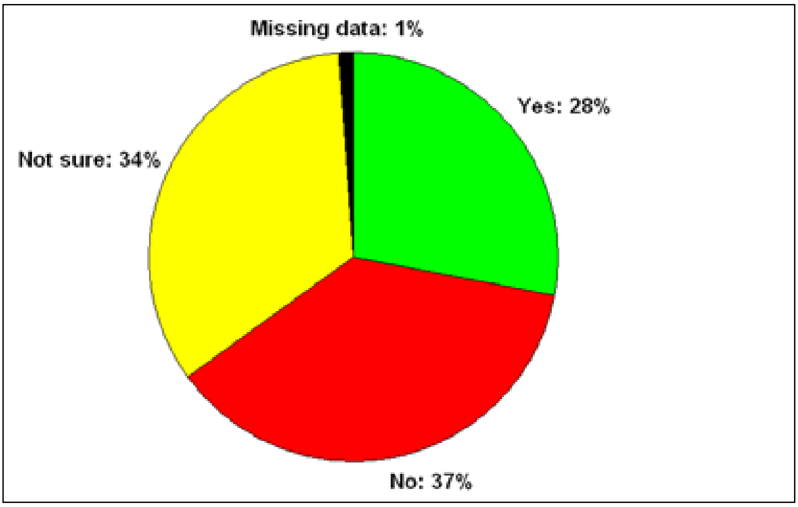
Read text book	7	• I bring it [science book] home because and uh, read it just ahead of things, because I really like it… (Y) • We have a science book…we read that (T) • Reading questions and then it has, uh, activities that are experimenting (U) • It's [textbook] is easy to understand… There's no really big words that nobody understands. It's all, simple stuff that you can read real easily (U) • … Read over chapters and stuff (Z) • Like firstly we probably read the chapter on what the experiment's going to be about … (Z)
Listen to the teacher	7	• Before we'd like start a chapter, she might start discussing it … (W) • The teacher goes through it with us (T) • The teacher explains things … (X)
Learn content / facts	7	• We do have to learn them because we have tests on them after every chapter. We had a huge test at Christmas and we've another in a few weeks for our Summer report (T) • What is heat and what is light and all those kinds of notes, just to help us in our tests (U) • Because you have to like, you remember like, the solutions and the colour of the solutions. And the periodic table (V) • They make you learn off the periodic table… well not all of it obviously (W) • Sometimes it can get a bit boring just like learning, trying to remember all the stuff (Z)

Students in all of the case study group interviews referred to reading in science class. In general their responses regarding reading in science class were positive:

> *I bring it [science textbook] home and read it, just ahead of things, because I really like it. (Y)*

However, the case study students' responses to the Likert item relating to reading in science were not as positive, in that only 28% indicated that they "enjoy science when I read my science schoolbook", and 37% reported not enjoying this (Figure 5.6).

Figure 5.6: I enjoy science when I read my science schoolbook (N=132)

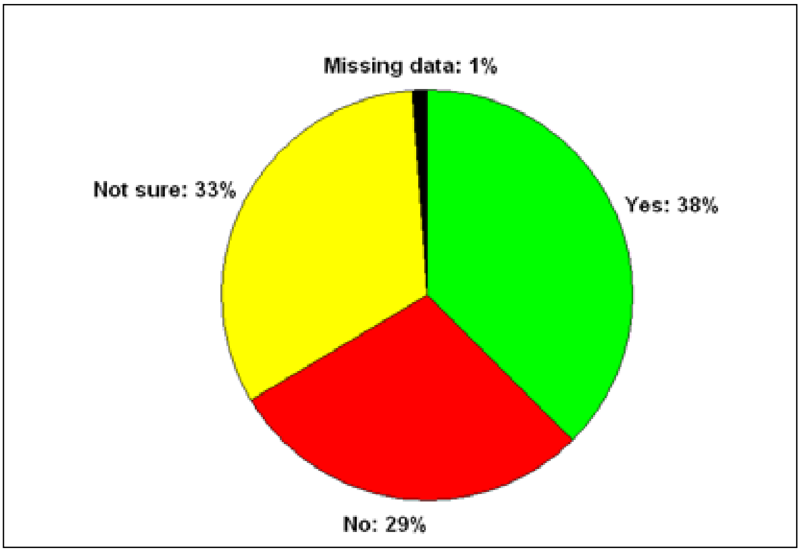


Students in all of the group interviews indicated that writing up experiments in a Junior Cycle workbook and taking down notes were typical and frequent features of science in post-primary school. Students in six of the seven group interviews also described writing up experiments in hard-back science copies. The students' views regarding writing in science class were mixed. While none of the children explicitly stated that writing was something they enjoyed about school science, some seemed conscious of a need for writing: "We write, whatever is in this book that the teacher feel we need to know" (W). However, some children indicated that writing was something they did not particularly like doing in science class:

> *Writing in science is okay, it's not like, fun, but it's you know, it's not boring really (W)*

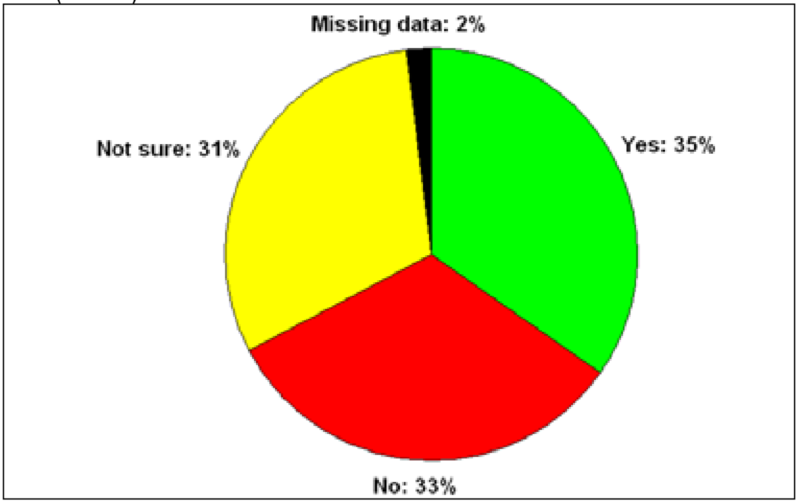
The case study students' questionnaire responses relating to writing in science class were not especially positive. On one of the Likert items that related to writing in science class, 38% of the students indicated that they "enjoy science when I fill in my workbook / worksheet" however, on the other hand 29% indicated that they did not enjoy this (Figure 5.7).

Figure 5.7: I enjoy science when I fill in my workbook/ worksheet (N=132)



In a similar manner, 35% of the case study students indicated that they "enjoy science when I write about something I've done in science class", however, 33% indicated that this was something they did not enjoy (Figure 5.8).

Figure 5.8: I enjoy science when I write about something I have done in science class (N=132)



It is important to note the apparent lack of enthusiasm some of these students have in relation to reading and writing in science class. Braund and co-workers (2003), for example, have suggested that the emphasis on written work and reading from textbooks in post-primary science could be key contributory factors in the apparent sharply declining interest in science amongst students as they progress through post-primary school.

Students in all of the case study group interviews indicated that learning science content and facts for tests was a typical characteristic of post-primary science. In general the students were not very positively disposed towards the rote-learning of scientific facts and content knowledge, many indicating that the content was often difficult:

> *We have to learn them [scientific facts] because we have tests on them after every chapter. Some of the facts can be quite hard… because like, there's so much in a chapter (T).*

ICT

It would appear from the group interviews (Table 5.7) that ICT is not commonly being utilised as part of science class in post-primary schools. Students in four of the group interviews explicitly mentioned that they do not use ICT during science class.

Table 5.7: What do you do in science class in post-primary school? Responses relating to ICT

Categories	No. of interview groups addressing category (N = 7)	Sample of responses
Don't use ICT	4	• We never get to use the computers (U) • We'll get to use them [computers] in Transition Year (T) • But we don't use computers… we could go into the computer room, like, in the future. But we haven't yet (W)

Teacher use of ICT in science class	3	• She uses [interactive white board] mostly just to write it, just to write stuff up. But uh, if we're finished an experiment, she'd like, pick things and have a test and stuff on it (Y) • … she showed us a heart on it… 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. It's easy to read (T)

However children in three of the groups mentioned that their teacher used ICT when teaching science:

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).

It was not possible to ascertain the frequency of ICT usage in post-primary science from the Likert items on the questionnaires. However, the case study students' responses did reveal that they were only moderately well disposed towards the idea of utilising ICT in science class. Just over half of the students (52%) indicated that they "enjoy science when I use computer programmes in science class" (Figure 5.9) and only 43% maintained that they "enjoy science when I use the internet at school to find out about science" (Figure 5.10).

Figure 5.9: I enjoy science when I use computer programmes in science class (N=132)

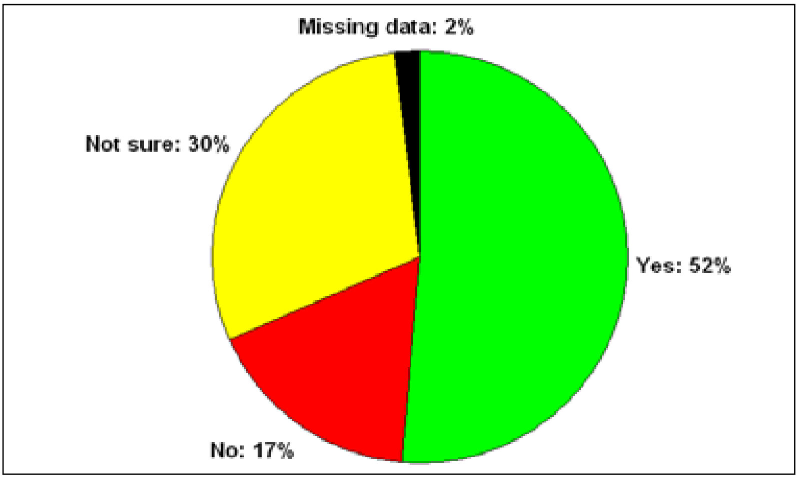
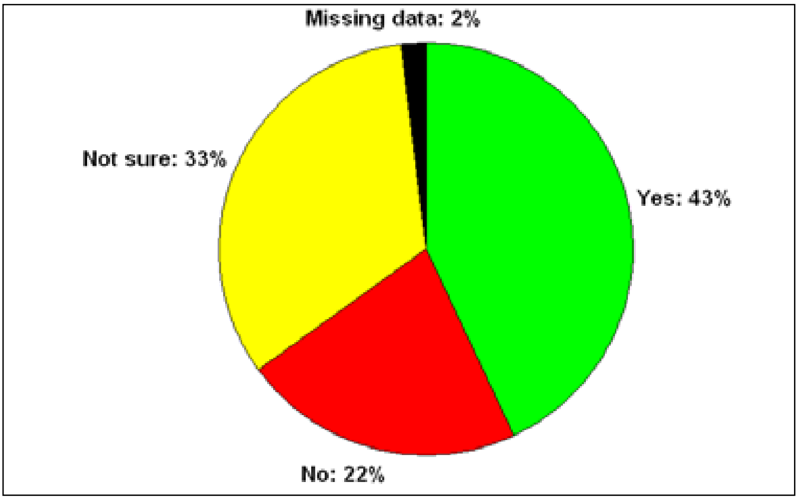


Figure 5.10: I enjoy science when I use the internet at school to find out about science (N=132)



The British Educational Communications and Technology Agency (BECTA) has conducted extensive research based on an analysis of data obtained from the Office for Standards in Education (Ofsted) inspectorate and the Qualifications and Curriculum Authority (QCA) (BECTA, 2003). This research explored the relationship between ICT usage and student achievement in national tests. The report highlighted the importance of providing students with good

ICT learning opportunities at post-primary level. The findings of the report indicated that there is a clear and positive relationship between good ICT learning opportunities and higher achievement amongst post-primary students in English, mathematics and science at Key Stage 3 and GCSE level. The report also revealed that there appeared to be a positive relationship between good ICT learning opportunities and good pupil attitudes, behaviour and attendance at post-primary level. The results of the BECTA (2003) study are important within the context of this study. If Irish post-primary pupils were provided with more frequent and meaningful ICT opportunities in science, this could lead to an increase in students' achievement in science and could help to promote positive attitudes towards science as they progress through post-primary school.

The data obtained from the case study interviews indicate that in general all students' experiences of learning about science in post-primary schools are similar. Typically students observe their teachers demonstrate experiments and are also provided with many opportunities to conduct experiments themselves. While the students' interview responses indicate that they were positively disposed towards observing and conducting experiments, their more in-depth and enthusiastic responses regarding their experiences of conducting experiments indicate the type of methodologies they prefer.

Writing in workbooks, hard-back copies and note-taking are also typical features of post-primary school science, as are reading from science texts and learning factual content. However, students do not appear to be very positively disposed towards these aspects of school science. When the students' responses regarding conducting experiments, reading about and writing up experiments and learning scientific content are compared, it is clear that students prefer conducting experiments to other methodologies they have experienced in science class.

5.4.3 Where they learn science

The students in the case study schools were also asked about where their science lessons are normally conducted in post-primary school. The majority of the case study group interviewees indicated that science was normally conducted in science laboratories. However, students from two of the group interviews indicated that some of their science classes are taught in a classroom. In one group interview the students talked about occasionally going to a demonstration room for science. Table 5.8 provides an overview of where the students typically learn about science in post-primary school.

Table 5.8: Where do you normally do science in post-primary school?

Location	No. of interview groups addressing category (N =7)
Lab only	4
Lab and demonstration room	1
Lab and classroom	2

5.5 Experiences of Science in Primary School

The students in all of the case study group interviews were asked about their experiences of science in primary school. Five of the case study primary schools in the Phase 1 study were feeder schools to six of the post-primary case study schools. It is important to note here that while the group interviews were conducted in only seven different post-primary schools, the students in these group interviews had come from a total of 17 different primary schools. Therefore the comments regarding first years' experiences of science in primary schools represent a larger number of primary schools than the number of interview groups. These responses will be presented under the following headings:

- Frequency of science classes;
- Content;
- How they learned science.

5.5.1 Frequency of science classes in primary school

The students' responses regarding how often they experienced science in primary school varied. The students in all of the group interviews had mixed experiences regarding the frequency of science in primary school. Table 5.9 provides a summary of their responses.

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 group interviews indicated that they rarely or never experienced science in primary school. This is rather worrying as formal introduction of the Primary Science Curriculum commenced in the 2003 / 2004 academic year. These students therefore should have experienced four years of the Primary Science Curriculum (DES, 1999a). One of the reasons for this apparent lack of engagement with science at primary school, may have been due to the fact that during their final year in primary school, these students' teachers may have been focusing on post-primary entrance examinations, perhaps to the detriment of other subjects that were not being covered on these examinations. Indeed it would appear from many of the students' responses that this may have been the case:

> *I don't think we did many 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).*

Table 5.9: How often did you do science in primary school?		
Categories	No. of interview groups addressing category (N = 7)	Sample of responses
Did science	4	• We did a fair amount. We did like, the circuits, and we did a bit of magnetism… we were given like boxes and we had to set up the experiments ourselves. Like with all the stuff in it (W) • We did a bit of science. We made circuits with bulbs and batteries. I made a lighthouse with my friend (T) • We got to do it … we got to do the light bulbs (V)
Sometimes did science	5	• We did some, but not much (U) • Well we didn't really do that much but sometimes we did making circuits with wires and electric light bulbs and things (Z) • Not really [do science in primary]. We wouldn't have got that much in a week we might do it once maybe every two weeks (X)
Rarely did science in primary school	6	• Well in my school we didn't do a lot of science, because ours was mostly based on history (V) • Science wasn't really a thing in primary school for me (Y) • We didn't. Not that I remember anyway (T) • We did other stuff. But we didn't do that much experiments. We … didn't actually do that much science. We just if we did do science, we would rarely do an experiment. We would pretty much like read from the book (W) • I can actually remember only doing one experiment. And it wasn't a big one. It was just to see if an orange floated (W) • We'd usually do, like [science] maybe once a month (V) • In primary, we wouldn't do very much of it (U) • Like in sixth class we didn't have a book or copy or anything so it meant that we didn't really do it at all because mostly like if we were doing a subject, you'd be able to read it from the book and revise when you're at home (Z) • … Teachers like in primary school, they're mainly focused on Maths and English and stuff. But like science is important and I think there should be like knowing that with the confirmation and that like there wasn't going to be enough time in the curriculum (Z)

Nevertheless it is still of concern that children in six of the seven group interviews could not recall doing much and in some cases any science in primary school. As mentioned in Section 1, national testing in primary science currently takes place in some other countries including England and Northern Ireland. Test preparation in England was found to affect the nature of teaching in the final year of primary level, resulting in a reduction in time for practical activities (Collins et al., 2005). This was thought to have a negative impact on older primary pupils' attitudes to science. In a similar manner Murphy and Beggs (2002), suggested that "transfer tests" in Northern Ireland could be a factor in the declining interest in science amongst older primary school children. Although there are no national or transfer tests in the Republic of Ireland, it would appear from some of the responses from students in this study that a significant amount of curriculum time in sixth class at primary school is allocated to preparation for post-primary entrance tests. It seems that this could be to the detriment of science. Science teachers who facilitated case study interviews with their students were not asked about the use of entrance tests at their schools, however a large-scale Irish study indicated that use of such tests in the "core" subjects of mathematics, English and Irish are commonplace in the post-primary sector (Smyth et al., 2004). Given students' remarks in the current report, the impact of such tests on sixth class practices would appear to merit further study.

5.5.2 Content experienced in primary school

The case study data also raise some concerns regarding the breadth of the content being addressed at primary school, in that the students did not appear to recall experiencing aspects of many of the strand units outlined in the Primary Science Curriculum (DES, 1999a). When discussing their experiences of primary science, there were certain aspects of the Primary Science Curriculum (DES, 1999a) that the students tended to refer to more frequently than others and some strand units that were not referred to at all. Table 5.10 provides a brief overview of aspects of science the students recalled learning about in primary school.

Table 5.10: What kinds of things did you learn about in science in primary school?	
Strand/ strand units of Primary Science Curriculum	No. of interview groups addressing category (N = 7)
Living things	5
Human life	3
Plants	1
Animals	4
Energy and forces	7
Light	1
Sound	1
Heat	0
Circuits (Electricity)	7
Magnets	4
Forces (Floating and sinking)	1
Forces (Other)	1
Materials	3
Properties of materials	2
Materials and change (Mixing powders)	2
Environmental awareness and care	0

Students in five of the seven case study group interviews recalled learning about aspects from the Living things strand and three mentioned learning about aspects from the Materials strand of the Primary Science Curriculum (DES, 1999a), "We just really, did one of the volcanoes with vinegar and stuff like that" (Y); "we built you know the little rockets where you put in one of the tablets that dissolve, and then you just let it shoot up" (U).

Students from all seven of the case study group interviews recalled learning about aspects from the Energy and forces strand of the Primary Science Curriculum. Students in four of the group interviews recalled "doing the magnets" (V) and in seven of the interviews students indicated that they had experienced making electrical circuits in primary school: "I can just remember lighting up a light bulb" (U).

None of the students discussed learning about aspects from the Environmental awareness and care strand of the Primary Science Curriculum. The paucity of responses regarding the students' experiences of Environmental awareness and care were similar to the lack of responses obtained from children in the nationwide survey and case study group interviews conducted during Phase 1 of this study (Varley et al., 2008). The lack of breadth regarding the strand units the students reflected on learning about in primary school could be another indicator of their infrequent experiences of primary science.

5.5.3 How they learned science at primary school

The first year students in the case study group interviews were asked about how they learned science in primary school and the kind of things they typically did during science class. They were also asked whether they recalled using ICT as part of their science classes in primary school. Table 5.11 illustrates some of their responses.

Table 5.11: How did you learn about science in primary school?		
Category	No. of interview groups addressing category (N = 7)	Sample of responses
Recorded observations	2	• You had to put like the magnifying thing. And you had to look at them then and write everything down … and they're horrible [minibeasts] (Y) • You had to look at the chart to find out what it [minibeast] was and record it on the sheet (T)
Watched teacher do experiments	3	• The teacher would mostly do them. And then maybe, we'd get to do them sometimes (U) • 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).
Did experiments	5	• We do one [experiment] probably half a year. We've done like that one … and then the rest is all questions and reading (U) • We got to do it … we got to do the light bulbs (Y) • I also made a lighthouse with my friend (T)
Read from a book	2	• You'd just be reading from a book … (X) • We didn't do that much experiments. We didn't actually do that much science. If we did do it we would rarely do an experiment. We pretty much read from the book (Z)
Writing	4	• The teacher would write them up on the board and we'd just take them down (U) • There's a lot more writing than learning involved in primary school (X) • We wrote like, down all the experiments and we had to draw … and we'd be tested it and all (Y) • We usually just got a worksheet (Y) • We had to draw pictures of the lungs and answer questions (T)

ICT for primary science	3	• We had computers… because the computer was in the science room… you had like, all computers inside here … and then the computers were really only used for science… we went on the internet to like look up, do you know all the pictures on intestines and the plants and the insects as well (Y) • We looked up information for projects on them (T) • 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)
No didn't use ICT	2	• No, we never got to use the computers (U)

Encouragingly, students in five of the seven group interviews reported conducting science experiments in primary school. However, it is difficult to establish the frequencies of these experiences, because as indicated earlier, students in six of the seven group interviews indicated that they rarely did science in primary school. Students in three of the case study group interviews indicated that they watched their teachers demonstrating experiments in primary school. Students in four and two group interviews respectively, indicated that writing and recording observations were features of their experiences of primary science.

Reading in science class was an aspect of science that was recalled by students in only two group interviews. Students in three of the group interviews reported using ICT to obtain scientific information, yet students in two of the group interviews specifically mentioned not using ICT during primary school science. This apparent lack of usage of ICT as an integral part of science class in primary school was also highlighted in Phase 1 of this study (Varley et al., 2008). However, for the most part the students' recollections of primary science were not in-depth and it was not especially evident from their responses that they had engaged with the Primary Science Curriculum to any great extent.

5.6 Attitudes Towards School Science

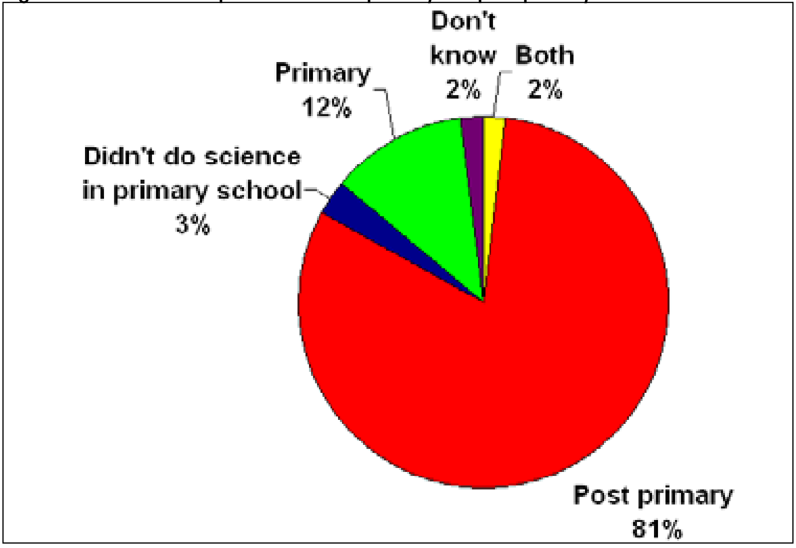
During the group interviews, the first year students in the case study classes were asked to compare primary and post-primary school science. This section will consider the students' responses under the following headings:

- Comparison of primary and post-primary school science;
- How science in primary school could be improved.

5.6.1 Comparison of primary and post-primary school science

In the case study students' questionnaires, 81% of the students' responses to the relevant open question in the questionnaire indicated that they preferred post-primary science to primary science (Figure 5.11).

Figure 5.11: Students' preferences for primary or post-primary science



(n for question = 121)

During the group interviews, the first year students in all of the case study groups were asked whether they preferred science in post-primary school to science in primary school. All of the students interviewed maintained they preferred post-primary school science. Table 5.12 illustrates some of their responses and reasons regarding their preferences for post-primary school science.

Table 5.12: Post-primary school science is better than primary school science because…

Category	No. of interview groups addressing category (N =7)	Sample of responses
Didn't do it in primary	2	• In primary we didn't do very much of it (U) • We didn't do it (T)
More frequent	6	• Yes… we don't really get to do much in primary school. So, I like … was looking forward to science (W) • It's on our timetable now. We actually do it (T) • Now it's a lot better because we get to do loads of different stuff… loads of new experiments (U)
Do more experiments	5	• You get to do more…more better experiments (U) • 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) • Like the experiments help like remember stuff, like about what you're doing, like but we didn't really have experiments in primary school (Z)

More exciting / fun	5	• It's just more fun (W) • It's really exciting (T)
More challenging	5	• It's harder but it's more interesting (Y) • It's more difficult- well challenging. We have to think more which I like (T) • It's a challenge because in primary school you're the… the miss just does it …you don't get to do it really … so here the mistress is giving you a chance to do it yourself (Y) • It's really different here… It's harder (Y) • It's a bit more complex (U) • You learn more (U) • I think science in secondary school is harder because you're to learn about the periodic table and like the elements and about what's a compound and all that (Z) • Secondary is harder because you have to remember like, the solutions and the colour of the solutions and the periodic table (V)
More informative	5	• This one's [post-primary school science] more like main stuff. Like stuff that we done back there, like we didn't know much about it. Like now we have to write it all up, and we know what we're doing more (X) • We're learning lots more now (T) • Well we're doing about biology and chemistry and physics and it's better than primary school (V) • We're learning about plants and animals and the food chain and habitats, we're doing like about elements and atoms and stuff like that (Y) • 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 science book and we're like reading and learning things (Z) • It's challenging in a good way. It makes us think. We're not children anymore (T)

Students in six of the case study interviews maintained that the reason they preferred science in post-primary school was because it was more frequent, while students in five of the case study groups indicated that they preferred post-primary science since they were provided with more opportunities to conduct experiments. Science at post-primary level being more exciting and challenging were reasons provided by students in five of the case study interviews for preferring post-primary science. Students in five of the group interviews maintained post-primary science was more informative and therefore preferred it to primary science.

While it is encouraging that these first year post-primary school students are obviously enjoying science, it is a little worrying that the main reasons they offered for their preferences of post-primary to primary science were frequency and the provision of more opportunities to conduct experiments. It is apparent from these students' responses that they did not have frequent experiences of hands-on science in primary school, despite this having a significant emphasis in the Primary Science Curriculum and the aspect of science that appears to be most popular amongst Irish primary pupils (Varley et al., 2008). In general the data appear to suggest that many of the pupils had very limited experiences of learning science at primary level.

Negative experiences of science in primary school

The first year students, who discussed experiments they had done in primary school, recalled these experiences in a positive manner, during the group interviews. However, when comparing their experiences of primary and post-primary school science, many of the students reported negative experiences of primary science. These included the infrequency of science lessons and experiments, lack of equipment and some students suggested that the content of their primary science experiences was repetitive or lacking in continuity. Table 5.13 provides an overview of some of their responses relating to aspects of primary science the case study students disliked.

Table 5.13: Things I disliked about science in primary school		
Category	No. of interview groups addressing category (N = 7)	Sample of responses
Infrequent/ disconnected	5	• Sometimes like we went two, three weeks without doing science (V) • Well whenever we did it in primary school, I liked doing it in primary school. But the fact that we didn't do enough and like, you kind of lost track of it… and like, the teachers didn't know what the previous year had done, so like, they couldn't really know what you'd done, so they'd be going over something like, totally new that you don't understand (W) • We didn't do it…not really in primary school (U) • We definitely didn't do it enough… Like definitely should have done a bit more … (X) • It was just so repetitive. You just learned the same things as the other years. And it just, you already knew everything. (W) • The teachers didn't know what the previous year had done, they couldn't know what you'd done and they would have gone over the same stuff again. (W)
Lack of equipment	3	• They could get more equipment … when we were doing science, we'd have to get science equipment from another class. So like just the one class would have all the science equipment … (Z) • We have lots of equipment [by contrast] and we get to use it (T) • In primary school we had to like, when we were doing that plant thing, we had to use yogurt cans, because you didn't have anything (Y)
Didn't do experiments	4	• But in primary school you wouldn't really be allowed… [to do experiments] (Y) • You didn't get to do them [experiments] in primary school … (W) • We didn't do any experiments (T) • We just read the book and did the questions (V)

It is encouraging that the case study students' responses generally indicate that they are positively disposed towards science. It is of considerable concern, however, that their responses suggest that they were not provided with frequent opportunities to do science or to engage in hands-on scientific inquiry at primary level. This is despite the formal introduction of the Primary Science Curriculum from September 2003. The question regarding the frequency of hands-on scientific inquiry at primary level was also raised as a matter of concern during the first phase of this study (Varley et al., 2008).

5.6.2 How science in primary school could be improved

The students were asked to suggest ways in which they felt that science in primary school could be improved. Table 5.14 illustrates some of their responses.

Many of the students' responses regarding how primary science could be improved related to increasing its frequency. Students in four of the case study interviews suggested that they should "do more science in primary" (U) with students in four of the groups suggesting that if science were time-tabled this could lead to more science being taught. Interestingly children in five of the case study interviews suggested that primary science could be improved if the content was increased and if they were provided with more information. However, some of these students had probably not covered the existing recommended range of content knowledge in the Primary Science Curriculum, due to the infrequency of their lessons at primary school. Students in three of the interviews suggested that the provision of more equipment would improve primary science while students in four of the case study group interviews suggested that primary science should cover science content that would benefit students at post-primary level. Many of the students suggested that primary science should aim at "preparing you for first year science" (W). Students' suggestions regarding the provision of more science equipment is pertinent particularly in relation to one of the recommendations from the report from the first phase of this study. This proposed that primary schools should be provided with ring-fenced funding for the purchase of science equipment on a yearly basis (Varley et al., 2008).

Table 5.14: How do you think science in primary school could be improved?

Category	No. of interview groups addressing category (N = 7)	Sample of responses
Have a time-tabled class once a week	4	• 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 that date. It would just like whenever your teacher decided that she had some spare time to do it [science] (Z) • I'd have science either every week or every fortnight (T) • … maybe every Friday morning … or start of every week with it and end the week with it… last class on a Friday would be good because it's easy, it's a bit of an easier class for you for the weekend (X)
Do more science	4	• 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) • Do more science in primary (U)

More explanations / more content knowledge	5	• Probably that the primary school teachers should go into more detail, and more science. And tell them to more help… They don't really explain like… (V) • I just think the teacher should ask the children a lot more so they will, so they'll be able to remember it more themselves like (V) • I think like they should learn about compounds and to acids and bases and stuff, but not like the pH scale and all that, but like so you know what an acid is and what a base is (Z) • A bit more explaining what you did and said … they usually just write the basics what they did. Instead like, they should explain what they got (X)
More equipment	4	• Well they could get more science equipment (Z) • We hadn't got the equipment to do it (Y) • I think they need more equipment stuff…we had to share everything back then and there wasn't enough for everyone. People would mess while they were waiting. Now we have enough for everyone so we're all working together (T)
Do more practical activities	3	• If the teacher tells us that like how the light bulb lit up, if he asked us how the light bulb lit up and he told us what we needed to know, that we should take like … an experiment on it as well. Just, instead of writing it down, we should do an experiment. (V) • I think there should be more experiments in Primary (T)

Bridge the gap between primary and second level	5	• They should really be preparing you for first year science (W) • I think there should be a little bit of chemistry…easy fun stuff to make it easier on them when they go to secondary. Everything gets harder and we've new subjects to learn (T) • In like sixth class, they're uh they're pretty much preparing you for first year. And like, they're all doing, uh getting ready for your entrance exams. But you should also be getting ready for science as well (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 made us better in first year now (X) • [Learning more science content in primary school would]… take the pressure off a bit in secondary school (Z) • I think it would have been better to have done like a bit of learning in primary school to help us when we're in secondary school because like lots of people didn't really know what like the acid, the bases and everything were. So like, we kind of had to start from scratch on everything, but if we did in sixth class, then we would learn a little about what they were (Z) • Look at the secondary school book for first year and look at the curriculum for first year and sort of incorporate that into like a book for primary school, but like easier definitions (Z)

5.7 Further Study in Science

Students in the interviews were also asked about their future study of science at school. In two of the seven case study schools where interviews were conducted, science was not a compulsory subject for the Junior Certificate. In one of these schools it was compulsory for first year and the students could then opt to take science to Junior Certificate. Out of the five students who were interviewed in this school, three indicated that they would like to take science for Junior Certificate and two of the students were unsure. In the second school where science was not a compulsory subject for first year, the students had the option of taking science to Junior Certificate from the start of first year. These students had therefore already opted to take science to Junior Certificate.

Students in six of the seven case study groups therefore, were taking science to Junior Certificate from the beginning of first year. The students in these six groups were asked whether they would like to take a science subject to Leaving Certificate. Table 5.15 provides an overview of some of their responses.

Many of the students from the case study schools appear to be positively disposed towards the idea of taking a science subject beyond Junior Certificate. Chemistry and biology appear to be the most popular scientific disciplines with students from four and three of the interviews respectively indicating a preference for studying these subjects after Junior Certificate. Students from one of the case study interview groups indicated a desire to study physics to Leaving Certificate and students from three of the case study interview groups were undecided whether or not they would study a science subject to Leaving Certificate. One of the students in the case study class where science was not compulsory to Junior Certificate indicated a desire to study science at third level. In the open questions on the questionnaires, 48% of the case study respondents indicated that they would like to study science in the future.

In general the case study students' responses appear to indicate that they are broadly positive about the idea of studying science beyond the point of choice. However, interestingly, physics appears to be the least favourite of the three disciplines.

Table 5.15: Would you like to take a science subject to Leaving Certificate?		
Science subject	No. of interview groups addressing category (N = 6)	Sample of responses
Yes, Physics	1	• Maybe physics, I like physics (W)
Yes, Chemistry	4	• I'm interested in chemistry (W) • Yes … because I want to be a forensic scientist, because I watch CSI (Y) • I'd say I'd want to do chemistry, because it looks kind of good (X)
Yes, Biology	3	• I'll be doing biology … I would sort of like to be a, maybe a zoologist (W) • I want to be a nurse so I'll probably do biology (T) • I'd be picking biology because physics is a bit confusing with all the maths and all (X)
Don't know yet	3	• I think I might keep science up for my Leaving Cert, but I'm not too sure (Z)
Yes, third level	1	• I want to go into science when I'm older. I want to study it in college (V)

5.8 Case Study Summary

5.8.1 Primary pupils' attitudes towards post-primary science

The primary school pupils interviewed for the case study in Phase 1 were enthusiastic about the idea of doing science in post-primary school. They maintained that post-primary science would involve doing experiments and working in science laboratories. They were looking forward to doing science at post-primary level, even thought they believed it would be more difficult than primary science.

5.8.2 Perceptions of post-primary school science

The case study students in the current study had positive experiences of science during their pre-transfer visits to post-primary school and it would appear that for virtually all of these students, their subsequent experiences of science in post-primary school met or exceeded their expectations.

5.8.3 Experiences of science in post-primary school

All students in the case study interviews appeared to be learning about a similar range of topics from the physics, chemistry and biology components of the Junior Cycle Science Syllabus (DES, 2003a). In general they were positive about the science content they had learned about to date.

Similarly, the case study students from the different schools appeared to be experiencing equivalent methodologies in science at post-primary level. Students were particularly enthusiastic and positive about conducting practical activities themselves, whilst students expressed more mixed feelings about watching their teachers conduct experiments. Their responses regarding reading and writing in science class were mixed, though at times rather negative. Whilst students expressed an interest in using ICT as part of science class, it was not apparent that this was a frequent occurrence.

5.8.4 Experiences of science in primary school

Many of the students in the case study did not appear to have had frequent experiences of engaging with the Primary Science Curriculum (DES, 1999a). Where students had engaged in primary science, there were some concerns regarding the breadth of content these students appeared to have experienced at primary level. Although some of the students reported having engaged in hands-on scientific enquiry during their primary schooling, many of them explicitly stated that they had rarely or in some cases had never done science of this, or any other kind, in primary school.

5.8.5 Attitudes towards school science

The group interviews and the case study questionnaires revealed that the vast majority of students in the case study preferred post-primary to primary science. The students maintained that post-primary science was more frequent and provided them with more opportunities to engage in practical activities. They also indicated that post-primary science was more interesting and informative than primary science.

When reflecting on their experiences of primary science, many students had negative recollections. These included the infrequency of science lessons and practical activities and the lack of equipment. Some suggested that the content of primary science was repetitive. The students offered a number of suggestions as to how primary science could be improved. These included increasing its frequency via regular time-tabling, enhancing the content, providing more equipment and bridging the gap between primary and post-primary science.

5.8.6 Further study in science

The students in the case study interviews appeared to be open to the idea of taking science as a subject beyond Junior Certificate. Where specified, chemistry appeared as the most popular option, with biology a close second. Students in three out of the six case study groups were undecided.

The data from the survey and the case study will be considered together in the next section, after which overall conclusions and recommendations will be made.

SECTION 6: CONCLUSIONS AND RECOMMENDATIONS

This section presents overall conclusions that can be drawn when considering the data obtained from the survey and the case study. Recommendations relating to these are then discussed.

The findings presented in Sections 4 and 5 provide valuable insights into some of the key issues surrounding students' attitudes to and perceptions of school science around the time of transfer between primary and post-primary schools. These will now be considered together under the following headings:

- Students' attitudes towards post-primary science;
- Science in post-primary school;
- Students' comparison of primary and post-primary science;
- Students' future aspirations in relation to the study of science.

6.1 Students' Attitudes Towards Post-Primary Science

6.1.1 Primary pupils' attitudes

The survey and case study data obtained during Phase 1 of this study indicate that for the most part the pupils held positive attitudes towards the prospect of doing science in post-primary school. The majority of the primary pupils surveyed expressed a positive response to the Likert item "I am looking forward to learning science in secondary school". Encouragingly, the responses from the pupils in sixth class, those closest to the point of school transfer, revealed the lowest negative response to the statement, where only 8% of these pupils claimed that they were not looking forward to learning science in post-primary school.

In a similar manner, the older primary pupils interviewed in the case study of Phase 1, discussed in Section 5, maintained that post-primary science would be interesting, would involve experiments and working in science laboratories. It would appear therefore that the pupils in the primary survey and case study held positive views about the prospect of learning science in post-primary school.

6.1.2 Post-primary students' attitudes

Attitudes to school

It appeared from the questionnaire data that school was a sociable and happy place for the majority of the students. Most students in the survey (89%) and case study classes (88%) claimed that they enjoyed working with their friends in school. The majority of students stated that they were happy at school, with 68% of survey students and 80% of case study students making this claim. However, the survey and case study questionnaire responses also revealed that many of the students held more negative views regarding liking school and school work and finding school interesting.

Attitudes to school science

Encouragingly, 59% of the respondents in the survey and 61% in the case study questionnaires indicated that they found school science interesting, which is positive when it is considered that only 36% in the survey and 47% in the case study found school itself to be interesting. However, the respondents' other views regarding school science were not as positive in that only a minority in both survey and case study classes revealed that they looked forward to science lessons and found them easy. On a more positive note, 31% of the survey students and 23% of the case study students indicated that they liked science better than other subjects, which is encouraging, considering the number of other subjects these students were likely to be studying in their first year at post-primary school.

In the case study interviews, the students maintained that post-primary science was similar to or better than their expectations. For some students, their views about post-primary science had been shaped by their visits to post-primary school in the previous year. Students in all seven case study interview groups indicated that during these visits, they had seen science laboratories and students in four of the case study group interviews indicated that they had observed others conducting experiments. It seems that their current experiences accorded with, or exceeded expectations. It would be interesting to explore whether these students would maintain their positive attitudes towards science as they progress further in post-primary school, or whether their interest would begin to decline, as research on this issue in the US, UK and Australia suggests (Morrell and Lederman, 1998; Francis and Greer, 1999; Dawson, 2000; Osborne et al., 2002).

6.2 Students' Experiences of Post-Primary Science

An overview of the students' experiences of and attitudes towards post-primary science will be provided in this section under the following headings:

- Scientific subject content;
- How students learn.

6.2.1 Scientific subject content

The findings suggest that the students in all of the case study classes are experiencing similar aspects of physics, chemistry and biology in school. Throughout the interviews the students did not express a like or dislike for any particular science topic, rather they expressed likes and dislikes regarding how they learned science. These will be referred to again in the next section. In relation to scientific subject content, a number of students did comment on "learning facts off" for tests, however, for the most part, the case study students' responses regarding the scientific content they were learning in school were positive. Many of them indeed indicated that the science content, whilst at times difficult, was interesting and informative.

In the questionnaire, 18 of the Likert items sought to establish students' attitudes towards different topics within the three science components covered within the Junior Cycle Science Syllabus. There were topics within each of physics, chemistry and biology for which the majority of students expressed an enthusiasm. Learning about the chemistry topic, "what happens when you mix things together" was an aspect of science that the majority of survey (72%) and case study (85%) students claimed to enjoy. When attitudes towards all topics within each discipline were combined and compared, it was found that survey students' overall attitudes to biology and chemistry were broadly similar, and that these were more positive than attitudes to physics topics, at a statistically significant level. In the case study questionnaire responses, it appeared that students were most positively disposed towards learning about chemistry, then biology and last of all, physics topics. The differences between these attitudes towards learning the three subjects were statistically significant. It is interesting to note that in the case study interviews, the science subject that the students most commonly wanted to study at Leaving Certificate was chemistry, whereas there were no particular subject preferences apparent in the data from the survey students' open response about future study.

Students' high level of interest in biological subjects within science is perhaps not surprising. It appears to mirror the recent PISA study findings in relation to the attitudes of 15-year-olds towards science, in which over 75% of respondents expressed an interest in learning about human biology (Eivers et al., 2007). Uptake of Leaving Certificate biology is also at a high level; in 2006 it was the fifth most common subject taken at Leaving Certificate, attracting 49% of candidates, an increase from 40% in 2002 (McNaboe and Condon, 2007). However, the current study appears to paint a particularly encouraging picture of interest in learning about chemistry, which contrasts with recently published figures. The PISA study revealed that fewer than 45% of Irish respondents expressed positive views of learning about chemistry and this was similar to the figures for physics (Eivers et al., 2007). Chemistry at Leaving Certificate level is still a relatively minor subject, with only 14% of candidates taking it in 2006, albeit an increase from 12% in 2002 (McNaboe and Condon, 2007). Compared with these earlier studies, this report is the first in which all participants have studied science, including chemistry, under the current Junior Cycle Science Syllabus (DES, 2003a). However, the students in the current study are also only in their first year at post-primary school. It remains to be seen whether this early enthusiasm for chemistry topics is maintained and translates itself into increased uptake of chemistry at Leaving Certificate in the future.

When the Likert item responses from students in third class at primary level up to first year post-primary in the surveys from Phases 1 and 2 were compared, post-primary students were less positive about school, science and the majority of science topics than primary pupils. At times lower interest was recorded from fourth class onwards within primary level, but for the majority of topics the most marked difference in interest levels was seen when comparing primary with post-primary responses.

As discussed in Section 1 of the report, research in Ireland, the UK, US and Australia has indicated that students' interest in science declines in the early post-primary years, and in some cases from the year of entry to post-primary school (Dawson, 2000; Francis and Greer, 1999; Jarvis and Pell, 2002; Morrell and Lederman, 1998;

Murphy and Beggs, 2003; Osborne et al., 2003; Smyth et al., 2004). One might question whether the apparent decline in interest in science topics in the current study is related to the fact that older students are less interested in science or perhaps whether this is simply indicative of their level of interest in school in general?

Comparison of attitudinal data about school and school science revealed that in this study, many science topics and most aspects of school science were viewed more positively than students viewed their interest in school. One science topic, human biology, attracted a robustly high interest level irrespective of year group. These data appear to indicate that first year students' interest in science is in fact relatively positive when viewed against an overall background of low interest in school. This corroborates data from the case study interviews and open responses on the questionnaires, which indicated that the first year students were very positively disposed towards science. This contrasts with a US study conducted with students from upper primary to upper post-primary level, where interest in school science apparently declined more sharply than equivalent interest in school (Morrell and Lederman, 1998).

6.2.2 How students learn

Practical activities

The survey and case study questionnaire responses indicated that the vast majority of students held positive views about doing practical science activities with their friends, however their responses regarding doing experiments on their own or planning their own experiments were less positive. In the open questions on the questionnaire, the students' responses were extremely positive regarding practical activities: "[in post-primary science] we do cool experiments". The data from the case study interviews also corroborated this in that, students in all of the case study schools revealed that they were provided with opportunities to conduct practical activities themselves. These responses also indicated that they were extremely positively disposed towards this aspect of post-primary science.

It is of concern however that, from the relevant Likert item responses, only a minority of survey students (37%) and case study students (36%) claimed to enjoy planning and doing their own experiments. The Junior Cycle Science Syllabus promotes the notion of independent enquiry, and it would be hoped that first year students would have engaged in this kind of practical activity and that this would foster positive attitudes. This may not be the case, however: In the case study interviews, it appears that the practical activities in which the students are engaging at post-primary school are prescriptive and teacher-directed. There was only one case study group where students reported conducting a more open-ended student-led investigation at post-primary level. This appears to mirror a finding in the Phase 1 study, in which child-led investigations were infrequently recorded in comparison with more prescriptive practical activities (Varley et al., 2008).

Perhaps at post-primary level, science teachers are not engaging first year students in independent enquiry because they are focussing on the format of mandatory practical activities for Coursework A and are leaving scientific investigations for third year, when the more open-ended Coursework B has to be conducted (DES, 2007). Since data from Phases 1 and 2 of this study would suggest that students at primary and early post-primary levels are afforded few opportunities to develop skills of independent enquiry, this could mean that they are ill-prepared when they come to attempt the assessed Coursework B component of Junior Certificate Science. There could be other negative consequences of this lack of student-led investigative work: A study of transfer from primary to post-primary science in the UK (Galton, 2002) suggested that early post-primary practical activities were highly prescribed and thus did not engage students, leading to disillusionment with science. In an effort to counteract this, Galton proposed that early post-primary experiences should seek to develop creativity and foster students as independent learners and thinkers. Interestingly, this is mirrored in one of the key aims of the Junior Cycle Science Syllabus, "to encourage the development of…skills through practical activities that foster investigation, imagination and creativity" (DES, 2003a, p. 4).

Use of ICT

It appears that in general the first year students in the case study are not using ICT as part of their science experiences. However, there is some evidence that their teachers are utilising ICT as a tool to teach science. The survey did not provide substantial data about the use of ICT or otherwise, although some students did use the optional comments boxes alongside the relevant Likert items to suggest that they had never used computer programmes or the internet as part of their science classes. The survey and case study questionnaires did reveal that students appear to be moderately positively disposed towards the notion of using ICT in science. However, as with the survey results in Phase 1 (Varley et al., 2008), these data should be interpreted with caution as they only measured students' *attitudes* towards using ICT in science, rather than their level of engagement with these technologies.

ICT is seen as an important part of working in science within the Junior Cycle Science Syllabus. However, no explicit reference is made to ICT in the guidance for conducting and reporting on practical activities for Coursework A or B and indeed the students are specifically required to submit "handwritten reports" for their coursework B scientific investigations (DES, 2007, p. 68). This guidance would not appear to encourage the use of ICT as part of students' work on practical activities. This is perhaps just one of the reasons why first year students appear to have been offered few opportunities to use ICT during their science classes. Whatever the reasons are, it would appear to be important that they be identified and overcome: A large-scale study conducted in the UK showed that appropriate use of ICT is strongly associated with improvements in student achievement and motivation in science at post-primary level (BECTA, 2003).

Teacher demonstration and explanation

The survey and case study questionnaire data indicated that students did not hold entirely positive views regarding observing their teachers conducting experiments. Only 36% of students in survey and case study responded positively to the relevant Likert statement in the questionnaire. Students' attitudes in relation to this mode of teaching were less positive than any of those expressed in relation to students carrying out their own experiments. In contrast, the case study and survey students revealed relatively positive responses regarding teacher explanations, and some students clearly valued this aspect of science class: "[My science teacher] she's the best at explaining!".

Reading and writing

The survey indicated that post-primary students were generally very negatively disposed towards reading and writing in science class. These were the science methodologies about which the survey students expressed the most negative attitudes. There was a marked difference in the responses of primary and post-primary respondents towards "reading my science schoolbook", "writing about something I have done in science class" and filling in "my workbook/ worksheet", with post-primary students viewing all of these methodologies in a more negative light (Pearson chi-square:

Statistically significant for all at $p<0.01$). Post-primary students' particular lack of interest in using these methodologies was even lower than their claimed interest in school in general (Wilcoxon signed ranks test: All statistically significant at $p<0.01$). This pattern in attitudes was also seen in the case study questionnaire responses. These data would appear to suggest that something about the nature of the reading and writing in science at post-primary level has changed in comparison to primary science and that this is negatively construed.

In relation to writing, the case study interviews indicated that there appears to be a strong emphasis on students keeping "hard-back copies" up to date, on note-taking, and on recording experiments in workbooks. Some of these activities would accord with the suggestion in the Junior Cycle Science Syllabus that "students are required to complete reports on these [mandatory practical] activities" (DES, 2007, p. 62), which are recommended to be maintained in a "laboratory notebook" (DES, 2007, p. 62). Perhaps students are being encouraged to follow a written format suggested for the assessment requirements in reporting all their practical activities, not just the mandatory ones. There was no evidence in this study that students were instead being encouraged to explore other, non-written methods of communicating their findings.

The case study interview students' views regarding writing in science class were mixed. While none of the interviewees explicitly stated that writing was something they enjoyed about science, some did indicate that writing was something they did not especially like in science class: "It [writing] does actually get quite boring, if it's a double class" (W).

6.3 Students' Comparison of Primary and Post-Primary Science

6.3.1 Frequency

In many respects the group interviews revealed that first year students held less positive attitudes regarding their experiences of primary than post-primary school science. Students in six out of seven of the case study interview groups indicated that they preferred science in post-primary school. One reason for this was that the students maintained that science in post-primary school was more frequent.

While it is encouraging that these students appear to be enjoying their experiences of post-primary science, it is worrying that it also appears that they did not have frequent experiences of learning about science in primary school. While students in five of the seven case study interviews recalled learning science in primary school, students in six of the interviews indicated that they only sometimes or rarely did science in primary school:

> *Well in my school we didn't do a lot of science, because ours was mostly based on history. (V)*

> *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)*

In the relevant open response on the questionnaire, 30% of students in the survey also indicated that they had science more frequently in post-primary school, some 16% indicating that primary experiences were absent or rare, "in sixth class I didn't do 1 day of science". Although it is difficult to verify the data obtained from interviews and open questions, it would seem likely that for these students, if primary experiences had been more frequent than stated, these were either not memorable or not thought of as science. This is rather worrying, as these students should have experienced the Primary

Science Curriculum for four years since its formal introduction in 2003.

Some of the case study students' responses at interview suggested that one reason for the apparent lack of engagement with science in sixth class may have been due to the fact that the pupils were being prepared for post-primary entrance examinations, perhaps to the detriment of subjects that were not being covered on these assessments:

> *I don't think we did many 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)*

This would appear to reinforce findings from an earlier, more general study of school transfer in Ireland, in which O'Brien raised a concern about the "effort and pressure" associated with preparation for these post-primary assessments (O'Brien, 2004). The use of post-primary assessments around the time of transfer appears to be widespread in Ireland (Smyth et al., 2004). The consequent emphasis on "core" subjects could perhaps be reducing the time accorded to science at upper primary level.

6.3.2 Frequency of practical activities

Students in five of the case study interview groups revealed that they preferred post-primary school science because they were provided with more frequent opportunities to engage in practical activities. In consequence, the case study interviews raised concern regarding the frequency of the students' experiences of engaging in hands-on activities at primary level. The case study data appear to indicate that some of these first year students had not been provided with frequent opportunities to engage in practical activities at primary level. The data from the survey corroborated this, in that 30% of students indicated that post-primary science featured more experimental work in comparison with primary science.

6.3.3 General comparisons of primary and post-primary science

Students made more general comments about post-primary science, which collectively showed it in a positive light. The survey and case study students' remarks both referred to science in post-primary school being more fun, more interesting, more informative and more challenging. It is important to note that comments where students referred to science being challenging were almost exclusively positive. The students in the survey and case study also talked about post-primary science covering a wider range of topics and that they were learning more. However, learning more was not always reflected on in a positive manner, as a number of students also maintained that post-primary science was harder and for some of these, it would appear that this was seen as a negative attribute:

> *I think science in secondary school is harder because you're to learn about the periodic table and like the elements and about what's a compound and all that. (Z)*

Comments relating to specific primary level science experiences were rarer and rather mixed. In addition to infrequent experiences and lack of opportunities to engage in practical activities, some students in the open questions on the questionnaire and in case study interviews also reflected on the repetition or lack of continuity of content in different classes: "in primary we did the same things over and over again".

In light of all these positive attributes accorded to post-primary science, it is perhaps not surprising that the responses from the survey and case study students showed that an overwhelming majority, over

70% in the relevant open question on the questionnaires, preferred post-primary to primary science. The principal reason given for this preference was that students were being afforded opportunities to conduct more experiments at post-primary level and that significantly, they were being allowed to conduct these for themselves.

In the interviews, the students in the case study offered a number of suggestions on how to improve science in primary school. These included: time-tabling science, the provision of more equipment and providing pupils with more opportunities to engage in practical activities. Students from five of the case study schools even suggested that primary school should try to prepare primary pupils for post-primary school science:

> *I know they can't get like, get out Bunsen burners and let the primary kids like, burn salt and so like, they should still be doing more work on science… because it's like when we started here, we didn't know anything at all about science, apart from like, how to make a balloon car. (W)*

Interestingly, students in five of the cases study classes suggested that primary science should comprise more content knowledge: "Probably that the primary school teachers should go into more detail and more science … they don't really explain like…" (V). It may be case that students making such remarks had not, in fact, experienced the full range and depth of subject content in the current Primary Science Curriculum (DES, 1999a).

6.4 Future Science Aspirations

In spite of these positive attitudes to post-primary science, students were not entirely convinced that they were going to continue studying science in the future, that is, to Leaving Certificate or beyond. In the survey, only 44% of students indicated that they would like to study science subjects for Leaving Certificate and 48% of the case study students responded positively to the same Likert item on the questionnaire. The open questions probed students as to their reasons for this decision, which revealed that different factors were influencing students' decisions.

In the survey, just under a third of students claimed that their interest in science, or particular science topics, would motivate them to continue their study, whilst relatively few students indicated that a lack of interest was contributing to their decision not to continue. Comments relating specifically to physics, chemistry and biology were fairly balanced.

About 14% of students in the survey and 17% of students in the case study questionnaires indicated however, that science was too difficult to continue, or at least that it might be in future. In relation to this, it was interesting to note that the questionnaire responses to the Likert item "school science is easy" were not very positive and this was in marked contrast to primary pupils' responses. In the post-primary questionnaires, 34% of survey students and 30% of case study students claimed that school science was not easy. The perceived difficulty of post-primary school science and associated lack of uptake at upper post-primary level has been highlighted in other Irish studies, discussed earlier in Section 1.3 (Matthews, 2007; Smyth et al., 2004; Smyth and Hannan, 2006). Although differing methodologies mean that the figures are not directly comparable, those in the current study are a little lower than those reported previously, which is encouraging. It may be of relevance to note that the data presented in this report are the first in which all respondents have studied within the current Junior Cycle Science Syllabus (DES, 2003a).

In contrast with their post-primary counterparts, upper primary pupils in the survey appeared to find very little difficulty with science, which may indicate a lack of challenge and hence a lack of preparation of older primary students for the science they will meet at post-primary level. It would certainly appear that, even at first year, the increased difficulty of post-primary science is a key factor in turning some students off future study.

Some students seemed already to be focussing on longer-term aspirations and some 16% of survey students stated that having science qualifications was important for gaining good employment, or a necessity for the career path that they envisaged. In the latter category, a range of careers was indicated, mostly in the healthcare sector. Although other types of response were relatively rare and will not be discussed at this point, it is interesting to note that very few students mentioned that they were planning to study science in future because they enjoyed the experimental nature of post-primary science. Thus it seems that, although hands-on experiences were proving to be popular now, these were not necessarily influencing students' views about future study.

In the case study interviews, students in all of the schools appeared to be open to the idea of taking science as a subject beyond Junior Certificate. Chemistry appeared as the most popular option, with biology a close second. Students in three out of the seven case study groups were undecided.

Whilst it is not surprising that some students in both the case study and survey were as yet undecided about future study of science, it is worth noting that others had already formed quite firm views about science and in particular, about their futures. For such students, this longer-term view may have an impact on their engagement with science as they continue with their studies at Junior Cycle level.

6.5 Concluding Summary

This section has brought together the data from the survey and case study components of the current report. Before making recommendations arising out of this work, a summary of the overall conclusions will be provided. These will be presented as positive outcomes and areas of concern.

6.5.1 Positive outcomes

It is encouraging that these first year students appear to have largely positive attitudes towards science in post-primary school. Practical activities and the greater frequency of science classes are central components of their experiences and are aspects of science which they like. The emphasis of the Junior Cycle Science Syllabus on a practical approach appears to be in evidence and is obviously having a positive effect on its participants.

6.5.2 Areas of concern

In the context of this study, however, it is a concern that students' views of their primary science experiences are not as positive. In particular some students in the survey and case study schools indicated that at primary level, science had been a rare occurrence involving few, if any, hands-on practical activities. It should be noted that, although a total of 21 post-primary schools were involved in this study, the views of these students about their primary schools most likely represent experiences drawn from a greater number of primary schools.

It would therefore seem that students appear to be forming positive attitudes towards post-primary science in spite of, rather than because of their experiences of primary science. However, it is possible that these students may have presented an overly negative view of primary science in a bid to distance themselves from their experiences of primary school in general.

6.6 Recommendations

It is apparent from these data that there are still challenges with the implementation of the Primary Science Curriculum. Whilst some first year students have experienced at least some science at primary school, which accorded with the Primary Science Curriculum, this is not the case for all. Post-primary students from different feeder schools could therefore potentially be entering the same post-primary school with widely varying experiences, skill levels and levels of attainment in scientific subject knowledge. By inference, this would present a challenge for post-primary science teachers in pitching scientific content and practical activities appropriately for all students. It is therefore essential for curriculum continuity, that the experiences of primary pupils should be similar for all schools. This problem could be addressed in a number of ways.

6.6.1 Continuing professional development for primary teachers

Prior to the implementation of the Primary Science Curriculum, all primary teachers who were in post at the time were able to participate in three days of professional development workshops that focussed specifically on science (Varley et al., 2008). In spite of this support, data in both the Phase 1 and Phase 2 reports suggest that implementation of the Primary Science Curriculum has not yet been fully realised. It would appear that the amount and nature of professional development support need to be enhanced. A large-scale study in the US examined the effectiveness of continuing professional development courses in primary science and found that it was only after approximately *80 hours* of intensive and sustained professional development that teachers "reported using inquiry-based teaching practices significantly more frequently" (Supovitz and Turner, 2000, p. 973). This study further argued that effective professional development in primary science should include: immersion of the teachers themselves in enquiry, question-raising and experimentation; reflection on teachers' work with students and that school leadership was "critical to school reform" (p. 965).

A key recommendation of this report therefore, is that longer term, more in-depth continuing professional development should be provided to key individuals in primary schools, such as the science co-ordinators and post-holders. Access to these professional development experiences could be organised for groups of primary teachers from clusters of schools that would normally feed into the same post-primary school. This would facilitate a move towards schools taking ownership for future progress in curriculum implementation and also assist primary and post-primary schools within a given area to consider common goals and share expertise.

6.6.2 Ring-fenced funding

For hands-on science to be improved and sustained as an endeavour at primary level, money must be allocated for the purchase of equipment, *including* consumables on a yearly basis.

6.6.3 Post-primary/primary school liaison

This would be essential to maximise the impact of any future supports provided, and to ensure continuity and progression for students. This applies to planning and dissemination of good practices, rather than merely providing information on primary pupils' attainment prior to transfer. One fruitful mechanism for bringing groups of schools together for this purpose mentioned earlier in Section 1, might be to set up "bridging units" of practical activities that started in upper primary level and continued early in post-primary school experiences (Galton, 2002). The development and use of such "bridging units" could be beneficial for teachers and students alike. In creating "bridging units" within an Irish context, cognisance should be taken of Galton's concern regarding the teacher-directed nature of early post-primary science practical activities that often do not engage students effectively. Therefore, if such units are to be developed, they should be aimed at facilitating students in developing their scientific enquiry, creativity and independent thinking and learning skills. This focus would serve to enhance students' engagement with independent enquiry, which would appear to be a feature of both primary and early post-primary experiences that is currently underdeveloped. The "bridging units" could help to promote the use of ICT in science; this aspect of school science also appears to be underrepresented at primary and post-primary level at present (Varley et al., 2008).

This report does not recommend, however, that liaison should involve post-primary mentoring of primary teachers. Activities in any "bridging units" developed would also need to be appropriate to the primary or post-primary phases, and not, for example, involve a rehearsal of simplified post-primary activities taken from the Junior Cycle Science Syllabus.

6.6.4 Documentary support for curricular continuity

The PCSP performs a key role in promoting the Primary Science Curriculum and the JSSS, as part of the Second Level Support Service (SLSS) provides a similar support for the Junior Cycle Science Syllabus. Both organisations have developed websites to support the teaching of science. The PCSP website could be developed to provide some information about the Junior Cycle Science Syllabus. In a similar manner, the JSSS website could also provide additional information about the Primary Science Curriculum, in particular in relation to the skills of working scientifically. Information and guidance relating to curricular continuity could also be disseminated to schools through relevant professional publications. If it does not already occur, liaison between these two support services would appear to be a potentially fruitful way of developing the suggested materials to support curricular continuity.

6.6.5 Further research

The research reported here and in Phase 1 (Varley et al., 2008) of this work commissioned by the NCCA presents a "snapshot" of Primary Science Curriculum (DES, 1999a) implementation and some insights relating to curricular continuity between it and the Junior Cycle Science Syllabus (DES, 2003a). Both of these curricula are in the first few years of implementation and it would be hoped that further initiatives and supports will be made available to schools, teachers and students in the future, including those that occur as a consequence of the recommendations made above. It is also not yet clear, for example, what effect the Primary Science Curriculum or indeed the Junior Cycle Science Syllabus will have on students' enthusiasm for, and participation in scientific study at Leaving Certificate level and beyond. Another review in a few years' time could act to assess the impact on students of any ongoing or new initiatives, as well as assessing the longer-term impact of early scientific experiences at school on these key players in Ireland's future.

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GLOSSARY

These are definitions for key terms as they are used in the current report.

Experiment: This was a term commonly used by students during this research study and indeed by the researchers in devising the wording of the student questionnaire. In focus group discussions with students during piloting of the questionnaire, the term was understood to mean any kind of scientific activity, which involved use of materials, equipment and/or exploration of living things. It therefore encompassed all types of student **practical activities** and **teacher demonstration**. Its meaning in relation to these terms would be interpreted according to context. The term experiment, as used by students in this study, therefore has a wider meaning in comparison with the definition of this term in the Junior Cycle Science Syllabus (DES, 2003a, p. 7).

Investigations: In this report, these are understood to be a subtype of **practical activity.** These are characterised by students attempting to answer a question, which they may even have posed for themselves. Examples might include: What will happen to the light bulb if I add more batteries to the circuit? Or: Where will I find the most woodlice? Students would be expected to show a degree of autonomy in planning and decision-making regarding the procedures of carrying out the investigation. Investigations therefore have the potential for students to utilise many scientific skills. This definition equates with that given for investigations in the Junior Cycle Science Syllabus (DES, 2003a, pp. 6-7).

Main topic: This term is used in the Junior Cycle Science Syllabus (DES, 2003a), to mean a particular defined area of scientific subject knowledge, within a given section of the curriculum. Each section of the curriculum (of which there are nine) has a number of main topics. Examples of main topics include: food; digestion; and enzymes, all from Section 1A of the Junior Cycle Science Syllabus. Each is further subdivided into **sub-topics.**

Mini-beasts: This term is in common usage in primary classrooms and primary science publications and is a child-friendly term that describes animals that would be classed as invertebrates e.g. snails, worms, spiders, insects and woodlice. As such it is more technically accurate than describing such animals collectively as "insects" or "bugs" and it does not have the negative connotation associated with the phrase "creepy-crawlies".

Practical activity: In a post-primary context, this phrase is used to encompass any work in which the students themselves handle concrete materials, equipment and/ or living things for the purpose of learning science. Typically this work would take place in a laboratory classroom. This term encompasses the two forms of work that are envisaged by the Junior Cycle Science Syllabus, namely experiments and investigations (DES, 2003a).

Scientific literacy: The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. The definition of this term is based on that used in the PISA study (Cosgrove et al., 2005).

Strand: This term is used in the Primary Science Curriculum (DES, 1999a) to mean a particular broad area of scientific subject knowledge. In this curriculum there are four such strands, which are: Living things; Energy and forces; Materials and Environmental awareness and care.

Strand Unit: This term, also used in the Primary Science Curriculum (DES, 1999a), is a further subdivision of each subject knowledge **strand.** For example, the strand of Materials includes the two strand units: Properties and characteristics of materials and Materials and change.

Sub-topic: This term is used in the Junior Cycle Science Syllabus (DES, 2003a), to mean a specifically defined area of scientific subject knowledge, within a given section and **main topic** of the curriculum. Each section of the curriculum (of which there are nine) has a number of main topics. Two examples of sub-topics are: major parts and functions of the digestive system; and teeth, types and function, which make up the two subdivisions of the **main topic** digestion.

Teacher demonstration: This involves a teacher conducting an **experiment** using scientific equipment, materials and/ or living things, usually in front of the whole class. In a teacher demonstration, the materials, equipment and so on are exclusively or principally handled by the teacher throughout the entire process. Students may be involved, through teacher questioning or by being called to the top of the class to assist, but even so the process is essentially directed by the teacher. Teacher demonstration, in this report, is not regarded as falling within the description of **practical activities.** Through teacher demonstration, students may acquire subject knowledge and indeed some scientific skills may be developed, such as observation, but the types of skills that can be developed are likely to be rather limited. This term *does not* include situations in which a teacher shows or explains a particular procedure or device to students, as a prelude to students engaging in practical activities themselves.

Topic: This general term is used to mean the overall subject matter of a particular lesson. This may simply be a given **sub-topic** in the curriculum, such as states of matter, or could be part of the subject area described in a given sub-topic, for example, liquids. Equally, the focus of a given lesson could be a particular **practical activity**, in which case the topic would be the principal activity, for example, growing crystals or using a microscope. The term topic is distinct from the terms **main topic** and **sub-topic,** which both have specific uses in relation to the Junior Cycle Science Syllabus.

APPENDIX A

STUDENT QUESTIONNAIRE TEMPLATE

STUDENT QUESTIONNAIRE INSTRUCTIONS TEMPLATE

ACCOMPANYING TEACHER QUESTIONNAIRE TEMPLATE

Questionnaire for Second Level Students

Ask your science teacher if you need help filling this in

I am a girl ☐ I am a boy ☐ (Please tick)

My age: I am ☐ years old

Class: I am in 1st ☐ 2nd ☐ year (Please tick ONE box)

Colour in the smiley face that is closest to your opinion

What I think about school:	**Yes** ☺	**Not sure** 😐	**No** ☹
1. I like school	☺	😐	☹
2. I'm happy at school	☺	😐	☹
3. I work as hard as I can in school	☺	😐	☹
4. I find school interesting	☺	😐	☹
5. I enjoy doing school-work	☺	😐	☹
6. I enjoy working with my friends at school	☺	😐	☹

I enjoy learning about…	**Yes** ☺	**Not sure** 😐	**No** ☹	**Please add a short comment here if you wish**
1. Insects, bugs and invertebrates	☺	😐	☹	
2. Magnets	☺	😐	☹	
3. Saving energy and recycling	☺	😐	☹	
4. How the human body works	☺	😐	☹	
5. How sound travels	☺	😐	☹	
6. Solids, liquids and gases	☺	😐	☹	
7. How we heat our homes	☺	😐	☹	
8. Materials we use for making things such as wood, metal and plastic	☺	😐	☹	
9. Plants and how they grow	☺	😐	☹	

I enjoy learning about…	Yes ☺	Not sure 😐	No ☹	Please add a short comment here if you wish
10. How machines work and move	☺	😐	☹	
11. How to look after the environment	☺	😐	☹	
12. What happens when you mix things together	☺	😐	☹	
13. Animals from around the world	☺	😐	☹	
14. Electricity, batteries, bulbs and switches	☺	😐	☹	
15. Inventions and discoveries	☺	😐	☹	
16. What happens to things when you heat or cool them	☺	😐	☹	
17. How to keep fit and healthy	☺	😐	☹	
18. Light, mirrors and shadows	☺	😐	☹	

Colour in the smiley face that is closest to your opinion

What I enjoy in science lessons: I enjoy science when….	Yes ☺	Not sure 😐	No ☹	Please add a short comment here if you wish
1. I do an experiment by myself	☺	😐	☹	
2. I do an experiment with my friends	☺	😐	☹	
3. I watch my teacher doing an experiment	☺	😐	☹	
4. I plan and do my own experiment	☺	😐	☹	
5. I copy from the board	☺	😐	☹	
6. My teacher explains things to the class	☺	😐	☹	
7. Visitors come in and talk to us about science	☺	😐	☹	
8. We go on school science trips	☺	😐	☹	
9. We go outside the classroom to do science	☺	😐	☹	

What I enjoy in science lessons: I enjoy science when….	**Yes** ☺	**Not sure** 😐	**No** ☹	**Please add a short comment here if you wish**
10. I use computer programmes in science class	☺	😐	☹	
11. I use the internet at school to find out about science	☺	😐	☹	
12. We watch science programmes at school	☺	😐	☹	
13. I fill in my workbook/worksheet	☺	😐	☹	
14. I write about something I have done in science class	☺	😐	☹	
15. I design and make my own things	☺	😐	☹	
16. I read my science schoolbook	☺	😐	☹	

Colour in the smiley face that is closest to your opinion

What I think about science:	**Yes** ☺	**Not sure** 😐	**No** ☹	**Please add a short comment here if you wish**
1. School science is easy	☺	😐	☹	
2. School science is interesting	☺	😐	☹	
3. I like science better than other subjects	☺	😐	☹	
4. I look forward to science lessons	☺	😐	☹	
5. I would like to study science subjects for my leaving certificate	☺	😐	☹	
6. I like science at second level better than the science I did at primary school	☺	😐	☹	
7. When scientists give an explanation about something it is always true	☺	😐	☹	
8. Once a science fact is discovered it doesn't change	☺	😐	☹	
9. Different scientists can have different answers to the same questions	☺	😐	☹	
10. Scientists sometimes use their imaginations to explain things	☺	😐	☹	

Think about the science classes you attend at **second level.** Now compare these classes with the science you did at **primary school**.

In what ways is science at second level **different** from the science you did at primary school?

____
____
____

Which is better? Why?

____
____
____

Would you like to study science in the future? (Leaving Certificate; 3rd level etc.)

____
____

Why? Why not? Explain your answer.

____
____
____
____

Thank you!

Teacher Guidelines for Administering Questionnaire

Please read through these guidelines before giving the questionnaire to your class.
Read the following instructions in *italics* aloud to your class:

> ***Our school has agreed to complete this questionnaire on school science. Students all over Ireland are also completing this questionnaire. It is really important that every question is answered so that we can find out what second level students like you think about science at school. This information may help us to make school science better.***
>
> *Please do not put your name on the questionnaire.*
>
> ***We will begin by filling out the first box.***
> ***I am a girl/ I am a boy. Please put a tick in the box next to the correct answer.***
> *Now fill in your age.*
>
> ***I am in what year. Please tick the correct box, so if you are in 1st year please tick that box.***

At this point, please check pupils have completed these boxes correctly.

> ***For the rest of the questions, there are no right or wrong answers. Your answer is about what you think.***
>
> ***If you fill in an answer and then change your mind do not rub it out but instead put an x through that answer and fill in what you meant to say.***
>
> ***You also have an opportunity, if you wish, to fill in comments on your responses while completing the questionnaire.***

It may be necessary to demonstrate this on the board.

Part 1: What I think about school. I like school-

If you think yes, I like school, colour in the first smiley face.
If you think I'm not sure, it depends, colour in the middle face.
If you think no, I don't like school, colour in the sad face.

At this stage please check to see if pupils have understood what to do.

The class may then proceed and complete the questionnaire unaided. However, you may continue reading the questionnaire aloud. This may be useful if there are many children with special needs in your class.

The last page requires children to write some answers. If there are members of your class who you feel may have difficulties here, please feel free to help them.

If a child is stuck, please read the question to them. Please do not explain or re-phrase the question. If they are still unsure ask them to '*answer how you think best*'. Please remind them that there are no right or wrong answers to these questions.

If there is something that child does not want to fill in they can leave it blank.

It is vital that all types of children are represented in this study and we thank you for your time and patience in the facilitation of this study

Thank you for your cooperation

Science in Schools: National Survey
Class Teacher Questionnaire

Thank you for completing this. Your responses will help us with further analysis of the pupils' questionnaire.

Please tick as appropriate:

1. Are you Male ☐ Female ☐

2. How many children are in <u>this</u> science class? Total ☐
   Number of Boys ☐
   Number of Girls ☐

3. Is science a compulsory 1st year subject for pupils in your school? ☐

4. Is science a compulsory Junior Certificate subject for your students? ☐

5. Are pupils streamed for science in 1st year? ☐
   If so, which stream is completing the questionnaire ________________

6. How many children with special needs are in your class? ☐

7. How many children are there with English as a 2nd language in your class? ☐

8. In what type of school do you teach? Please tick <u>ALL</u> relevant boxes
   a) Location Urban ☐
   Rural ☐
   Type of school Secondary School ☐
   Community School ☐
   Comprehensive ☐
   Junior Comprehensive ☐
   Other Please specify ____________
   b) Gender mix Boys only ☐
   Girls only ☐
   Mixed gender ☐
   c) Language of instruction English ☐
   Irish: Gaelscoil ☐
   Irish: Scoil sa Ghaeltacht ☐
   Other Please specify _____________
   d) Does your school have designated disadvantaged status? Yes ☐
   No ☐

9. Does your class use a science textbook? Yes ☐
   No ☐
   If yes please name _________________

10. Please tick the area(s) from the curriculum that this class has met since September
    Physics ☐
    Chemistry ☐
    Biology ☐

Thank you for taking the time to complete this questionnaire.
Please return this with your pupils' questionnaires.

Ceistiúchán do mhic léinn dara leibhéal

Faigh cabhair ó do mhúinteoir eolaíochta len é seo a chomhlánadh (líonadh) más gá.

Is cailín mé ☐ Is buachaill mé ☐ (Cuir tic sa bhosca)

M'aois: Tá mé ☐ (m)bliana d'aois

Rang: Tá mé sa 1ú ☐ 2ú ☐ bliain (Cuir tic i mbosca AMHÁIN.)

Dathaigh an aghaidh is gaire do do thuairim.

Cad é mo thuairim faoin scoil:	**Is ea** ☺	**Níl mé cinnte.** 😐	**Ní hea** ☹
1. Is maith liom an scoil.	☺	😐	☹
2. Tá mé sona ar scoil.	☺	😐	☹
3. Bím ag obair chomh crua agus is féidir liom ar scoil.	☺	😐	☹
4. Tá suim agam sa scoil.	☺	😐	☹
5. Is breá liom obair scoile.	☺	😐	☹
6. Is breá liom bheith ag obair le mo chairde ar scoil.	☺	😐	☹

Is breá liom bheith ag foghlaim faoi …	**Is ea** ☺	**Níl mé cinnte** 😐	**Ní hea** ☹	**Scríobh cuntas gearr anseo más maith leat le do thoil.**
1. Feithidí, frídí agus inveirteabraigh	☺	😐	☹	
2. Maighnéid	☺	😐	☹	
3. Ag sábháil fuinnimh agus ag athchúrsáil	☺	😐	☹	
4. Conas a oibríonn an corp daonna	☺	😐	☹	
5. Conas a thaistealaíonn fuaim	☺	😐	☹	
6. Solaid, leachtanna agus gáis	☺	😐	☹	
7. An saghas teasa atá inár dtithe cónaithe	☺	😐	☹	
8. Ábhair a úsáidimid chun rudaí a dhéanamh mar shampla, adhmad, miotal agus plaisteach	☺	😐	☹	
9. Plandaí agus conas a fhásann said	☺	😐	☹	

Is maith liom bheith ag foghlaim faoi …	**Is ea** ☺	**Níl mé cinnte** 😐	**Ní hea** ☹	**Scríobh cuntas gearr anseo más maith leat le do thoil.**
10. Conas a oibríonn agus a bhogann meaisíní	☺	😐	☹	
11. Conas aire a thabhairt don imshaol	☺	😐	☹	
12. Cad a tharlaíonn nuair a mheascann tú rudaí le chéile	☺	😐	☹	
13. Ainmhithe ó áiteanna mórthimpeall an domhain	☺	😐	☹	
14. Leictreachas, cadhnraí, bolgáin solais, lasca	☺	😐	☹	
15. Aireagáin agus fionnachtana	☺	😐	☹	
16. Cad a tharlaíon do rudaí nuair a théann tú agus nuair a fhuaraíonn tú iad	☺	😐	☹	
17. Conas is féidir a bheith aclaí agus sláintiúil	☺	😐	☹	
18. Solas, scátháin agus scáileanna	☺	😐	☹	

Dathaigh an aghaidh is gaire do do thuairim.

Na rudaí is maith liom faoi cheachtanna eolaíochta: Is breá liom an eolaíocht nuair ….	**Is ea** ☺	**Níl mé cinnte** 😐	**Ní hea** ☹	**Scríobh cuntas gearr anseo más maith leat le do thoil.**
1. Déanaim triail liom féin	☺	😐	☹	
2. Déanaim triail le mo chairde	☺	😐	☹	
3. Bím ag féachaint ar mo mhúinteoir ag déanamh triaile	☺	😐	☹	
4. Pleanálaim agus déanaim mo thriail féin	☺	😐	☹	
5. Cóipeálaim ón glcár bán/dubh	☺	😐	☹	
6. Míníonn mo mhúinteoir rudaí don rang	☺	😐	☹	
7. Tagann cuairteoirí isteach agus labhraíonn siad linn faoin eolaíocht	☺	😐	☹	
8. Téimid ar thurais eolaíochta ón scoil	☺	😐	☹	
9. Téimid taobh amuigh den rang chun eolaíocht a dhéanamh	☺	😐	☹	

Na rudaí a mbainim taitneamh astu i gceachtanna eolaíochta: Bainim taitneamh as an eolaíocht nuair a ….	**Is ea** ☺	**Níl mé cinnte** 😐	**Ní hea** ☹	**Scríobh cuntas gearr anseo más maith leat le do thoil.**
10 Úsáidim cláir ríomhaireachta sa cheacht eolaíochta	☺	😐	☹	
11 Úsáidim an t-idirlíon ar scoil chun eolas a fháil faoin eolaíocht	☺	😐	☹	
12 Breathnaímid ar chláir eolaíochta ar scoil	☺	😐	☹	
13 Comhlánaim (líonaim) an leabhar saothair/bileog saothair	☺	😐	☹	
14 Scríobhaim faoi rud éigin atá déanta agam sa cheacht eolaíochta	☺	😐	☹	
15 Dearaim agus déanaim mo chuid rudaí féin	☺	😐	☹	
16 Léim mo leabhar scoile eolaíochta	☺	😐	☹	

Dathaigh an aghaidh is gaire do do thuairim.

Cad é mo thuairim faoin eolaíocht:	**Is ea** ☺	**Níl mé cinnte** 😐	**Ní hea** ☹	**Scríobh cuntas gearr anseo más maith leat le do thoil.**
1. Tá eolaíocht scoile éasca	☺	😐	☹	
2. Tá eolaíocht scoile suimiúil	☺	😐	☹	
3. Is maith liom an eolaíocht níos fearr ná aon ábhar eile	☺	😐	☹	
4. Bím ag súil leis na ceachtanna eolaíochta	☺	😐	☹	
5. Ba mhaith liom staidéar a dhéanamh ar ábhair eolaíochta don Ardteistiméireacht	☺	😐	☹	
6. Is fearr liom an eolaíocht ag an dara leibhéal ná an eolaíocht a rinne mé sa bhunscoil	☺	😐	☹	
7. Nuair a mhíníonn eolaithe rud éigin, bíonn sé fíor i gcónaí	☺	😐	☹	
8. Nuair a bhíonn firic eolaíochta aimsithe, ní athraíonn sí	☺	😐	☹	
9. Bíonn freagraí difriúla ag eolaithe éagsúla ar na ceisteanna céanna	☺	😐	☹	
10. Úsáideann eolaithe a gcuid samhlaíochta chun rudaí a mhíniú uaireanta	☺	😐	☹	

Smaoinigh ar na ceachtanna eolaíochta a bhíonn agat ag an **dara leibhéal**. Anois déan comparáid idir na ceachtanna seo agus na cinn a rinne tú **sa bhunscoil.**

Cé na bealaí ina bhfuil an eolaíocht ag an dara leibhéal **difriúil** ón eolaíocht a rinne tú sa bhunscoil?

Cé acu is fearr? Cén fáth?

Ar mhaith leat staidéar a dhéanamh ar an eolaíocht sa todhchaí? (Ardteistiméireacht, 3ú leibhéal srl.)

Cén fáth? Abair cén fáth nár mhaith leat? Mínigh do fhreagra.

Go raibh maith agat!

Treoirlínte do Mhúinteoirí d'fhonn an Ceistiúchán seo a Bhainistiú

Léigh na treoracha seo ar dtús sula dtugann tú an ceistiúchán seo do do rang, le do thoil.

Léigh na treoracha seo a leanas, atá scríofa *i gcló iodálach,* os ard do do rang:

> ***Tá an scoil s'againne tar éis a gheallúint go gcomhlánfaimid (líonfaimid) an ceistiúchán seo ar an eolaíocht scoile. Beidh mic léinn ar fud na hÉireann ag comhlánú an cheistiúcháin seo freisin. Tá sé an-tábhachtach go bhfreagrófaí gach ceist chun go bhfaighimid amach céard/cad iad tuairimí mic léinn cosúil libhse ar an eolaíocht mar ábhar scoile. B'fhéidir go gcabhróidh an t-eolas seo linne an eolaíocht mar ábhar scoile a fheabhsú.***
>
> *Ná scríobh d'ainm ar an gceistiúchán le do thoil.*
>
> ***Tosóimid leis an gcéad bhosca a chomhlánú (líonadh):***
> ***Is cailín mé./Is buachaill mé. Cuir tic sa bhosca in aice leis a bhfreagra ceart.***
>
> *Anois líon isteach d'aois.*
>
> ***Cén bhliain ina bhfuil mé? Cuir tic sa bhosca ceart, mar sin, má tá tú sa chéad (1ú) bhliain cuir tic sa bhosca sin, le do thoil.***

Ag an bpointe seo, deimhnigh go bhfuil na mic léinn tar éis tic a chur sna boscaí cearta.

> ***Maidir leis na ceisteanna eile, níl aon fhreagra ceart nó mícheart. Is é do thuairimse an freagra, is é sin, cad a cheapann tusa?***
>
> *Má tá freagra scríofa agat agus má athraíonn tú d'intinn, ná glan amach é. Cuir X tríd, agus scríobh an rud a bhí i gceist agat a scríobh.*
>
> ***Tá an seans agat freisin, más maith leat, cuntas pearsanta a scríobh le do fhreagraí nuair a bheidh tú ag líonadh an cheistiúcháin.***

B'fhéidir go mbeidh ort é seo a thaispeáint ar an gclár dubh/bán.

> **Cuid 1: Cad é mo thuairim faoin scoil. Is maith liom an scoil-**
>
> *Más é do thuairim, Is ea, is maith liom an scoil, cuir dath ar an gcéad aghaidh shona.*
> *Más é do thuairim, Níl mé cinnte, braitheann sé, cuir dath ar an aghaidh sa lár.*
> *Más é do thuairim, Ní maith liom an scoil, cuir dath ar an aghaidh bhrónach.*

Ag an bpointe seo deimhnigh gur thuig na mic léinn cad a bhí le déanamh acu.

Ansin is féidir leis an rang dul ar aghaidh agus an ceistiúchán a líonadh gan aon chabhair. Is féidir leatsa leanúint ar aghaidh ag léamh an cheistiúcháin os ard, mar sin féin. Cabhróidh sé seo má tá mic léinn le riachtanais speisialta i do rang.

Ar an leathanach deireanach tá ar na mic léinn freagraí a scríobh. Má tá mic léinn i do rangsa a cheapann go mbeidh deacrachtaí acu leis seo, is féidir leat cabhrú leo.

Munar féidir leis an mac léinn leanúint ar aghaidh, léigh an cheist dó/di. Ná mínigh an cheist le do thoil, agus ná simpligh an teanga. Má tá siad neamhchinnte fós abair leo '*Tabhair an freagra is fearr atá agat.*' Meabhraigh dóibh nach bhfuil aon fhreagra ceart nó mícheart.

Má tá spás éigin nach dteastaíonn ón mac léinn a líonadh, is féidir leo é a fhágáil folamh.

Tá sé an-tábhachtach go mbeidh réimse leathan mac léinn sa staidéar seo. Gabhaimid buíochas leat as do chuid ama agus do chuid foighne in éascú an staidéir seo.

Buíochas faoi do chomhoibriú!

APPENDIX B

CORRESPONDENCE WITH CASE STUDY SCHOOLS

Coláiste Phádraig
Droim Conrach
Baile Átha Cliath 9

(Coláiste de chuid Ollscoil
Chathair Bhaile Átha Cliath)

St Patrick's College
Drumcondra
Dublin 9

(A College of Dublin City
University)

Children in Primary Science: National Project

Dear Parent/Guardian,

We are working on a study funded by the National Council for Curriculum and Assessment (NCCA) to review science in primary schools. As part of this study we are currently interviewing 1st year post-primary students about their memories of science in primary school. These interviews will enable us to build a comprehensive picture of young peoples' attitudes towards learning science at school. Your child's school has kindly agreed to take part as one of our case-study schools.

Each researcher in our team is a qualified, experienced primary school teacher. As part of this study one researcher will interview a small group of students from your child's science class. They will talk to these pupils about their experiences of primary school science and ask them to compare it to science at second level.

This interview will be tape-recorded so that it can be typed up afterwards. This tape will be destroyed once its contents have been typed up. No child will be identifiable by name, class or school. Only the research team will have access to any notes made.

If you wish to ask further questions about the interview and research, please contact the research coordinators, Janet Varley, Clíona Murphy and Órlaith Veale at St. Patrick's College, Drumcondra, Dublin 9 (Tel: switchboard: 01 884 2000).

- Your child does not have to participate in the group interview.
- Your child can choose to withdraw from the study at any time.
- You can request that your child/ your child's data be withdrawn from the study at any time.

Permission Slip. Please sign and return to your child's science teacher by ______

I agree/ do not agree* to allow ___________to take part in this research.

I agree/ do not agree* to allow _______________ to take part in a group interview about science.

(*Delete as appropriate)
Signature of parent/ guardian ______________________________ Date __________

Coláiste Phádraig
Droim Conrach
Baile Átha Cliath 9

(Coláiste de chuid Ollscoil
Chathair Bhaile Átha Cliath)

St Patrick's College
Drumcondra
Dublin 9

(A College of Dublin City
University)

Science in Primary Schools Research Project

Information for Second Level Case Study Schools

Who is doing this project?

This project is being conducted by Janet Varley and Clíona Murphy, who are both lecturers in science education in St. Patrick's College, Drumcondra, Dublin 9. A third member of the research team Órlaith Veale, has been seconded from primary teaching for the duration of the project.

What is the research for?

The researchers are interested in finding out how pupils' experiences are shaping their views of school science and their general attitudes towards science. This is the second phase of a project that has been funded by the NCCA. The first phase of the project explored primary children's experiences of the Primary Science Curriculum. The current (second) phase of the project aims at establishing the impact that the revised Primary Science Curriculum has had on first year, post-primary school pupils' interests in and attitudes towards science. In doing so it is hoped that these pupils' perceptions of, and aspirations for their studies of science at second level will be established. Information will be gathered via pupil interviews and questionnaires.

When will this take place?

We would aim to conduct pupil interviews at mutually convenient dates during February/ March 2008.

What will it involve for my school?

For each school, we would like to conduct one small group interview (4 pupils) of pupils from one class. The aim of these interviews would be to find out more about the students' engagement with, and their interests in school science. The interviews would be conducted by one of the three researchers named above.

What will it involve for the pupils?

Selected pupils from a participating class would be interviewed in a small group, on school premises and in school time. Suitable pupils for the small group interviews would be selected in liaison with the school principal/ vice principal and class teacher, with permission from the pupils, and their parents or guardians also being obtained. The interviews will need to be tape recorded, for ease of data gathering.

What will happen to the information collected from my school?

The names of participating schools and pupils will be confidential and will not be revealed or identifiable in any publications. Any tape recordings of pupil interviews will be destroyed once the information has been transcribed in a suitably anonymous format. The data from this project will be written up and presented in a report to the NCCA. Further publications in academic/ professional journals and at academic/ professional conferences may also be prepared. Most importantly, the researchers aim to write a report for principals, teachers and parents that will summarise the outcomes of the research for this audience. This will be circulated to all participating schools after completion of the project.

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Páistí agus Eolaíocht sa Bhunscoil: Tionscadal Naisiúnta

A Thuismitheoir/Chúramóir, a chara,

Táimid ag déanamh staidéir, maoinithe ag an gComhairle Náisiúnta Curaclaim agus Measúnachta (CNCM), chun athbhreithniú a dhéanamh ar an eolaíocht sa bhunscoil. Tá an staidéar ag iarraidh a dhéanamh amach cén tionchar atá ag eispéiris na ndaltaí ar an eolaíocht sa bhunscoil. Táthar ag iarraidh a fháil amach freisin céard é dearcadh na ndaltaí i leith na heolaíochta i gcoitinne. Tá an scoil, ina bhfuil do pháiste, tar éis a rá go mbeidh siad páirteach sa staidéar. Táimid ag scríobh chun cead a fháil uait le go nglacfaidh do pháiste páirt sa staidéar náisiúnta seo.

Cuirfear **agallamh** ar ghrúpa daltaí as rang do pháiste le fáil amach céard iad a dtuairimí faoin eolaíocht sa bhunscoil. Déanfar taifeadadh fuaime den agallamh gearr, neamhfhoirmiúil seo chun go mbeifear in ann é a athscríobh. Scriosfar an taifeadadh nuair a bheidh an t-ábhar clóscríofa.

Is múinteoirí cáilithe le taithí iad gach uile bhall den fhoireann taighde. Bí cinnte go gcoimeádfar ainmneacha na scoileanna agus na ndaltaí atá páirteach sa tionscadal faoi rún, agus nach n-ainmneofar iad féin ná na daltaí in aon cháipéis a chuirfear i gcló.

Más mian leat tuilleadh ceisteanna faoin tionscadal taighde a chur, déan teagmháil le comhordaitheoirí an taighde; Janet Varley, Clíona Murphy agus Órlaith Veale ag Coláiste Phádraig, Droim Conrach, Baile Átha Cliath 9 (Fón: 01 884 2309).

- Ní gá do do pháiste páirt a ghlacadh sa staidéar.
- Is féidir le do pháiste aistarraingt as an staidéar ag am ar bith.
- Is féidir leat iarraidh go n-aistarraingeofar do pháiste/sonraí do pháiste ón staidéar am ar bith.

Míle buíochas,

Janet Varley, Clíona Murphy agus Órlaith Veale

Páistí agus Eolaíocht sa Bhunscoil: Tionscadal Náisiúnta

Duillín ceada. Sinigh é seo agus cuir ar ais chuig múinteoir eolaíochta faoi 22/05/2008

Aontaím/Ní aontaím* gur féidir taifeadadh fuaime a dhéanamh de ghrúpagallamh faoin eolaíocht, ina mbeidh mo pháiste páirteach.

(*Scrios mar a oiltear)
Síniú an tuismitheora/chúramóra ____________________________Dáta __________

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A Phríomhoide/a Mhúinteoir eolaíochta, a chara,

Mar atá a fhios agat ón litir a sheol an Chomhairle Náisiúnta Curaclaim agus Measúnachta (CNCM) le gairid, táimid ag tabhairt faoin dara cuid de thionscadal atá ag iarraidh a dhéanamh amach cén tionchar atá ag eispéiris na ndaltaí ar an eolaíocht scoile agus a ndearcadh i leith na heolaíochta. D'fhiosraigh an chéad chéim den tionscadal eispéiris pháistí bunscoile ar an eolaíocht sa churaclam eolaíochta bunscoile. Tá an chéim reatha (an dara céim) ag iarraidh tionchar an Churaclaim Eolaíochta ag leibhéal na bunscoile, ar dhaltaí sa 1ú bhliain san iar-bhunscoil. Agus é sin á dhéanamh táimid ag súil le heolas a fháil ar an gcaoi a mbreathnaíonn na daltaí ar an eolaíocht, agus céard leis a bhfuil siad ag súil le linn dóibh a bheith ag staidéar na heolaíochta ag an dara leibhéal.

Cé atá i mbun an tionscadail seo?

Tá an tionscadal seo á stiúradh ag Janet Varley agus Clíona Murphy, atá ina léachtóirí le hoideachas na heolaíochta i gColáiste Phádraig, Droim Conrach, Baile Átha Cliath 9. Tá an tríú ball den fhoireann taighde, Órlaith Veale, ar chonradh ón mbunscoil ar feadh an achair.

Céard atá i gceist le mo scoilse?

Bheimis thar a bheith sásta dá mbeadh do scoilse páirteach sa staidéar tábhachtach seo. Táimid ag súil go mbeidh rang amháin chéad bhliana eolaíochta in ann ceistiúchán na ndaltaí a chomhlánadh (líonadh). Ba cheart nach dtógfadh an ceistiúchán seo níos mó ná 10-15 nóiméad d'am an ranga. Bheimis buíoch dá gcabhródh an múinteoir eolaíochta leis an tiondscadal a chur i gcrích. Tá ceistiúchán an-ghearr, aon leathanach ar fhad, le comhlánú ag an múinteoir eolaíochta ranga freisin. Tá cóip den dá cheistiúchán faoi iamh leis seo le go gcaithfidh tú súil orthu.

Cén uair a tharlóidh sé seo?

Beimid i dteagmháil leis an scoil roimh dheireadh na seachtaine le fáil amach an bhfuil do scoilse sásta bheith páirteach sa tionscadal. Táimid ag súil le cóipeanna den cheistiúchán a chur chuig do scoilse faoi dheireadh na seachtaine agus bheimis buíoch ach iad a fháil ar ais i nDroim Conrach faoin Aoine, 9 Bealtaine 2008.

Céard a tharlóidh don eolas a bhaileofar ó mo scoilse?

Bí cinnte go gcoimeádfar ainmneacha na scoileanna agus na ndaltaí atá páirteach sa tionscadal seo faoi rún, agus nach n-ainmneofar iad féin ná na daltaí in aon cháipéis a chuirfear i gcló. Clárófar torthaí an tionscadail agus cuirfear ar fáil i bhfoirm scríofa don CNCM iad. Tá seans go n-ullmhófar páipéir d'fhoilseacháin acadúla/ghairmiúla agus do chomhdhálacha acadúla/gairmiúla freisin. Thar rud ar bith, is é an aidhm atá ag na taighdeoirí ná tuairisc a scríobh do phríomhoidí, do mhúinteoirí agus do thuismitheoirí a dhéanfaidh achoimre ar thorthaí thaighde an tionscadail. Cuirfear é seo ar fáil do na scoileanna atá páirteach nuair a bheidh deireadh leis an tionscadal.

Más mian leat tuilleadh ceisteanna faoin tionscadal taighde a chur, déan teagmháil le comhordaitheoirí an taighde; Janet Varley, Clíona Murphy agus Órlaith Veale ag Coláiste Phádraig, Droim Conrach, Baile Átha Cliath 9.

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A Phríomhoide/a Mhúinteoir eolaíochta, a chara,

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Mar chuid den staidéar seo, líonfaidh daltaí 1ú bhliana in iar-bhunscoileanna ar fud na hÉireann ceistiúchán gearr i dtaobh a ndearcadh faoin eolaíocht. Tá cleachtadh ag na daltaí seo ar an eolaíocht sa churaclam athbhreithnithe bunscoile, agus tá súil againn fáil amach céard é a ndearcadh i leith na heolaíochta. Táimid ag súil le heolas a fháil ar an gcaoi a mbreathnaíonn siad ar an eolaíocht, agus céard leis a bhfuil siad ag súil le linn dóibh a bheith ag staidéar na heolaíochta ag an dara leibhéal.

Bheimis thar a bheith sásta dá mbeadh do scoilse páirteach sa staidéar tábhachtach seo. Táimid ag lorg cead do rang amháin chéad bhliana eolaíochta chun an ceistiúchán seo a chomhlánadh (líonadh). Ba cheart nach dtógfadh sé níos faide ná 10-15 nóiméad. Bheimis buíoch dá gcabhródh an múinteoir eolaíochta leis an tiondscadal a chur i gcrích. Tá na ceistiúcháin, atá le comhlánú ag na daltaí, faoi iamh.

Bí cinnte go gcoimeádfar ainmneacha na scoileanna agus na ndaltaí atá páirteach sa tionscadal faoi rún, agus nach n-ainmneofar iad féin ná na daltaí in aon cháipéis a chuirfear i gcló.

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Míle buíochas,

Janet Varley, Clíona Murphy agus Órlaith Veale

Páistí agus Eolaíocht sa Bhunscoil: Tionscadal Náisiúnta

Appendix C

Summary of Post-Primary Case Study Schools

Summary of post-primary case study schools

School	Language of Instruction	DEIS status	School type	Gender	Location	Takes pupils from case study primary	JC science compulsory	Science class streamed	ESL student(s)*	SEN student(s)**	Group interview
S	Irish	No	Secondary	Mixed	Urban	F	No	No	No	Yes	No
T	Irish	No	Secondary	Mixed	Rural	n/a	Yes	No	No	No	Yes
U	English	No	Secondary	Boys	Urban	J	Yes	No	Yes	No	Yes
V	English	Yes	Secondary	Girls	Urban	C	No	No	Yes	No	Yes
W	English	No	Community	Mixed	Urban	H	Yes	Yes (2nd)	Yes	Yes	Yes
X	English	Yes	Secondary	Boys	Urban	E	Yes	Yes (1st)	Yes	No	Yes
Y	English	Yes	Secondary	Girls	Urban	n/a	No	No	Yes	No	Yes
Z	English	No	Comprehensive	Mixed	Urban	E	Yes	No	No	No	Yes

*Indicates classes that contained at least one ESL student(s) = student(s) with English as a second language.
**Indicates classes that contained at least one SEN student(s) = student(s) with special educational needs.

APPENDIX D

SEMI- STRUCTURED INTERVIEW GUIDE (STUDENTS)

Semi- Structured Interview Guide (Post-Primary Students)

The following interview guide was used during the group interviews of 4-5 students from each class in each case-study school. The length of each interview was scheduled for approximately 30-40 minutes.

The following areas were focused on during the group interviews. Samples of some of the verbal prompts/ probes used to explore science learning in school are also included.

Experiences of science in post-primary school

What kind of things do you learn about in science?

- What things did you like learning about? Why?
- What things do you not like learning about? Why?
- Did you ever learn about any of these topics when you were in primary school?
- (Yes) Was it any different to what you learned about in secondary school? How?
- Do you think learning about X is difficult? Why? What parts?
- Did you think learning about X in primary school was difficult? Why? What parts?

Do you do experiments?

- Do you do experiments very often?
- Who normally does the experiments?
- Where do you normally do science?
- What kind of experiments have you done this year?

- Do you find experiments difficult? Why / why not?
- Did you ever do these experiments before?
- Did you do any experiments when you were in primary school?
- Did you do them every week?
- Did you do them as often as you do them in secondary school?
- Were they the same kind as you do now?
- How were they the same / different?
- Do you find doing experiments in secondary school more difficult, easier or about the same as the experiments you did in primary school?

Do you have a science book?

- Do you use it often? Do you like reading your science book?
- Do you think the science book is difficult?
- Did you have a science book in primary school?
- Was it like the science book you use now?
- How was it the same / different?

Do you have a science copy?

- What kind of things do you do in your science copy? Do you like writing in your science copy?
- Do you write in your copy very often?
- Did you do much writing in science when you were in primary school?

- What kind of things did you write about in science class in primary school?
- Is writing in science in secondary school different to the writing you used do in primary school? How?

Do you ever use computers or computer equipment / software during science class?

- Did you ever use computers during science class in primary school?

Pre-visit to school

Last year when you were in sixth class, did you visit this school before you started in September:

- What did you do during this visit?
- Did you go to the science lab/room?
- Did you get a chance to do an experiment?
- Did a teacher show you an experiment?
- Were you looking forward to doing science in secondary school?
- Is science in secondary school like what you thought it would be like? How? How is it different?

Perceptions of science in post-primary school

What kind of things do you like / dislike about science in school?

- What kind of things would you like to do more of?
- What kind of things would you like to do less of?

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