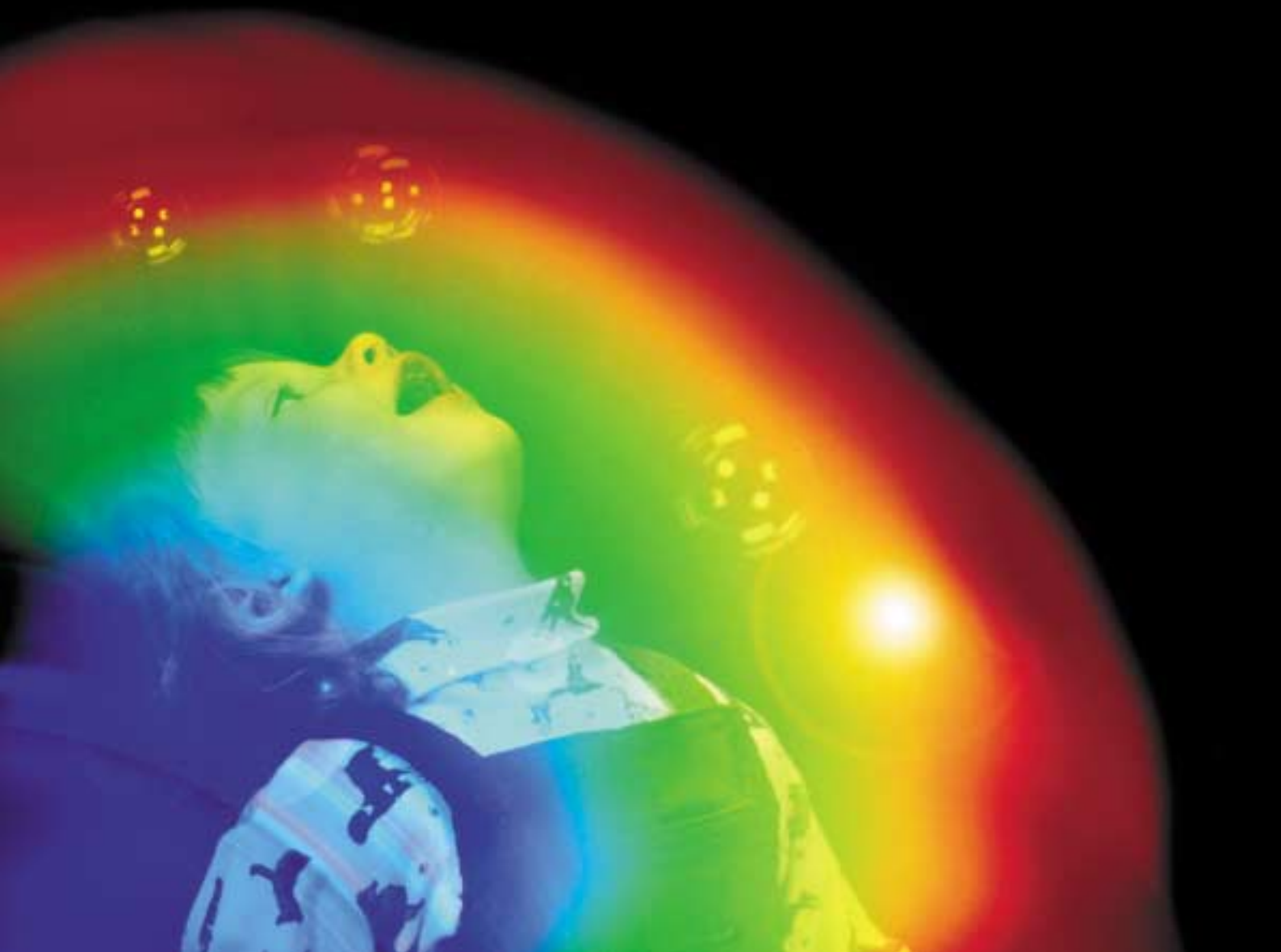




Task Force *on the* Physical Sciences

## Report and Recommendations

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Report and Recommendations  
of the Task Force on the Physical Sciences

This report is available online:

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<http://www.sciencetaskforce.ie/report>

## Foreword

Ireland's economic future depends critically on the supply of an increasing number of people qualified in science and engineering. But at the very time this demand is increasing, there has been a sharp fall-off in interest in the sciences throughout our education system.

This dilemma drove the setting-up of the Task Force on the Physical Sciences, which now presents its unanimous report.

The Task Force found that the problem is real; indeed, if anything its extent and importance have been under-stated. Unless there is a major national effort to reverse the fall-off, any other money we spend on attracting overseas investment will go largely to waste.

The positive side of the picture is our belief that prompt and comprehensive action, begun at once and carried out with commitment, can reverse the present decline in interest in the sciences. The result can be to increase not only the quantity but the quality of future graduates – equally important dimensions of the challenge.

Our 6-point action strategy addresses the many inter-linking facets of the problem, at all levels of the education system. The strategy is holistic: for success, it must all be carried out in full and simultaneously. Equally, it requires whole-hearted support – not only from the political system but also from all players in the education system and from industry. A readiness to change attitudes and to embrace new ways of doing things will be as important as the financial investment.

Carrying out this strategy will not be cheap: an additional €178 million in capital investment, plus additional recurrent costs of €66m each year. But to put this spending in context: what is at stake is the ability of our young economy to continue to grow, and to maintain the success already achieved.

Daniel O'Hare

Chairman



## Summary

### The Challenge

Ireland has positioned itself to take advantage of technological change by encouraging the inward investment of high-tech industries and by providing a highly-educated workforce to sustain and enlarge them. Employment of science, engineering and technology graduates at all levels has been a hallmark of the modern Irish economy, as the educational sector responded to the mix of skills demanded by industry. An outstanding record of graduate output has contributed to the phenomenal growth in Irish-based technology.

In an era of rapid technological change, the goal of "scientific literacy for all" has become a primary objective of a general education. Science is one of three literacy domains, along with reading and mathematics, that is included in measures of educational achievement by the OECD.

The vision to develop Ireland as a centre for world-class research is reflected in recent government investments in *Science Foundation Ireland*, in the *Irish Research Council for Science, Engineering and Technology* and in the *Programme for Research in Third Level Institutions*. But these programmes depend upon appropriate human resources in the key areas identified as the future niches of Irish expertise, biotechnology and information and communications technologies. This creates a new demand for highly-qualified graduates to take up positions as career scientists and engineers and as postgraduate researchers in disciplines based on the physical sciences.

It is critical that the demands of the labour market which supports the emerging technologies underpinning our economy are anticipated and strategically catered for. A continued supply of graduates with Science, Engineering and Technology (SET) skills must be guaranteed to ensure continued investment in these technologies. That investment will be strengthened by the ability of Irish graduates to drive the modern technologies higher up the 'value chain'.

In sharp contrast to this strengthening of demand, there has in recent years been a decline of interest in science throughout the education system.

**Science declining at second-level:** Since the early 1990s there has been a decline in take-up of science among second-level students. Although participation at lower secondary has been relatively stable, this is not the case at upper secondary. In 2001 only 12% of Leaving Certificate students were enrolled in Chemistry and 16% in Physics, a marked decline on the situation in 1990 when 16% took Chemistry and 20% took Physics. Physical sciences take-up is also put in context by take-up levels in Leaving Certificate Biology, which stood at 44% in 2001 (but down from 52% in 1988).

**Gender equity is a concern:** at lower secondary level only 80% of girls in single-sex schools take science compared with 96% of boys; at upper secondary, only 8% of girls take Physics compared with 25% of boys.

The problem is compounded by a decline in the overall size of the Irish school-going population. Together these factors contribute to lower follow through to the study of science-related subjects at third level.

**Science declining at third level:** Recruitment of students to science, engineering and technology courses in higher education is, in many instances, below capacity, with not enough first preference applicants to match the places on offer. Acceptances on to science, engineering and technology courses (including computing) as a proportion of total acceptances are declining. For degree courses the share dropped from 33% in 1999 to 30% in 2001; for certificate/diploma courses the share dropped from 51% in 1997 to 46% in 2001. The most dramatic decline is in science (including computing) at certificate/diploma level, where in 2001 there were only 1,282 student acceptances, down 43% from the 1996 peak of 2,268 acceptances.

There is a lowering of points for entry to science courses, with many certificate and diploma courses now offering places to "all qualified applicants". Moreover, there has been a shift in the last five years towards the computing area and away from the physical sciences and engineering courses whose graduates underpin the present success and future growth in the communications, chemical, pharmaceutical and biotechnology sectors.

Non-completion rates worsen the problem. Despite variations in non-completion for different subject areas across institutions, the SET areas consistently exhibit the highest non-completion rates in both universities and institutes of technology. These rates range from in excess of 20% for the university sector to in excess of 40% for the institute of technology sector.

A large pool of research scientists is necessary for value added, research-based development. But the level of postgraduates from Irish higher education institutions is below the strategic target set by various review bodies. The number of PhDs in science and engineering per head of population in Ireland is below the OECD mean.

If Ireland is to realise its ambitions as a knowledge-based society, then the level of student demand for science, engineering and technology courses in higher education must be addressed.

## The Situation Now

The Task Force researched the present situation in Ireland and abroad, received submissions and had discussions with all the main stakeholders, and conducted an extensive survey among second-level and third-level students and parents. A study of schools with a high take-up in the physical sciences was also undertaken.

We outline below some of the key factors that emerged, and which informed our development of the recommended action strategy that is set out in the next section.

### Schools

At primary level, only a small number of pupils are presently exposed to the physical sciences – although this will start to change in 2003 with the implementation of a new science component within the primary curriculum.

At lower secondary, while very few students go to schools that do not offer science, over 10% of the total lower secondary cohort is not enrolled in science. Within all-girls schools, the non-participation rate is 20%.

14% of Leaving Certificate students are in schools that do not offer Chemistry and 11% are in schools that do not offer Physics as separate Leaving Certificate subjects (compared with 1% of students in schools not offering Leaving Certificate Biology).

At upper secondary, 3% of the student cohort is in the 66 post-primary schools that do not offer any physical science subject to Leaving Certificate. These students are consequently at an obvious disadvantage in further study or careers related to the physical sciences.

Large variations in participation rates show up at upper secondary level. Many schools operate with relatively few pupils in Leaving Certificate physical science classes; there is concern that these schools may stop offering these subjects altogether.

Where schools have zero or low take-up of the physical sciences at upper secondary, they may not be able to justify employing a teacher with a background in the physical sciences. This can impact detrimentally on the treatment of the physical sciences in other programmes, particularly at lower secondary.

There are significant variations in the extent to which schools engage in practical work. While about half of the students do practical work each week, about 10% never work with apparatus or materials.

Levels of provision of laboratories are lower in Ireland than elsewhere. It is clear that a practical hands-on emphasis in science cannot be provided without such basic resources.



Our studies of schools with high take-up in the physical sciences suggest a number of strategies for increasing take-up; amongst these are:

- (i) a high priority attached to science at school management level;
- (ii) good subject-level co-ordination and planning;
- (iii) an emphasis on building positive student experiences at Junior Certificate and Transition Year;
- (iv) an emphasis on practical work.

These schools also had a higher level of laboratory resources than the norm.

### Student Choice

*Choice* emerges from our survey as the key factor influencing student take-up.

While it is necessary on grounds of equity to make science more widely available, it seems likely this will have only limited impact on up-take unless accompanied by strong action aimed at influencing student choice.

In general, students choose to study the physical sciences because of personal ability, personal interest, or because they feel they need the subject(s) for a college course or career. Some students, particularly in schools with lower take-up of science subjects, cite "school timetable" and "teacher" as factors also influencing their choice against take-up.

Two influencers for low uptake of the physical sciences are the perception of the science subjects per se and the perception of science-related careers.

Many Leaving Certificate students say they did not choose physics or chemistry because of the difficulty of the subjects. They also agreed they would be more likely to choose these subjects if it was easier to get good Leaving Certificate grades and if the subjects involved less mathematics.

The link between science and careers in technology is not well appreciated. The work of a scientist/technologist is seen as difficult, complicated and boring, as well as poorly paid. These perceptions are in place when students are making choices based on career aspirations. Attitudes are formed by the end of lower second level; if promotion is to be effective, students must be influenced by them.

There are many individual promotional initiatives for science, but none that integrates the many factors that together lead to informed decisions by students. Resources are not pooled nationally to promote the study of science at all stages of education. Promotion by science teachers and guidance counsellors is hampered by the lack of partnership between third level and industry.

Our survey shows that students see guidance counsellors as the most useful source of information on courses and careers. Effective career guidance at second level requires adequate numbers of guidance counsellors, and the present student:guidance counsellor ratio of 500:1 is an impediment. As a result little guidance happens in junior cycle (when students begin making career choices).

There is a poorly-developed culture of science in Ireland. We are one of the few countries among the progressive economies that does not have a National Interactive Science Centre. The promotion of science in the wider arena, among parents and the general public is compromised by this shortcoming.

### Teaching & Learning

Only a minority of primary teachers have taken a physical science subject to upper secondary level. The successful integration of science into the primary curriculum depends on adequate in-service training and support for the 22,000 serving primary teachers. Priority must be attached to the physical sciences in this training. There are major concerns about insufficient priority and time within pre-service teacher training to fully address both pedagogy and content relating to science.

The junior cycle science curriculum requires teachers to address all three sciences: physics, chemistry and biology. While two thirds of the syllabus is drawn from the physical sciences, the background of the approximately 3,000 junior cycle science teachers is primarily in the life sciences. There is also concern around Transition Year science, both in the extent of exposure to, and the quality of treatment of, science. Experience suggests that a strong emphasis on science in Transition Year may contribute to high science take-up at Leaving Certificate.

There is no evidence of an impending shortage of post-primary science teachers but this scenario is likely if Ireland's experience follows that of other countries. Our survey of student attitudes raised some concerns about this. Science teaching needs to remain an attractive and challenging career for graduates. A low demand for teachers may discourage science graduates from entering teaching, particularly when set against other employment opportunities.

Curriculum reform is a constant feature of modern education. There is a parallel movement towards more flexible and creative approaches to teaching and learning, and particularly towards more active learning by students. Our student survey confirmed the positive impact of practical work. All these changes depend on comprehensive, effective and on-going professional development and support if they are to effect real change in classrooms.

The application of new technologies to teaching and learning provides a positive pressure for change, and there is evidence of significant teacher support for this. The Irish school system, at primary and second-levels, has seen significant provision of computing infrastructure and teacher training over recent years and science education is well positioned to capitalise on this investment.

## Curriculum & Assessment

The introduction of a revised junior cycle science curriculum in 2003 is an opportunity to broaden access to a science education for all. Ireland would appear to be unusual in not requiring that all students continue to study science until the conclusion of the lower secondary phase of education. Girls are much more likely than boys to miss out on a science education.

The planned introduction of science into primary schools will demand careful co-ordination between schools at first and second level. There is an opportunity to build partnerships between schools and all other public and private sector bodies who are "stakeholders" in Irish science.

The opportunity to use Transition Year to provide students with a balanced exposure to the sciences - and helping students to make informed subject choices for Leaving Certificate - needs to be developed.

Submissions to the Task Force have identified deficiencies in the Irish science curriculum. These assert that it:

- emphasises science education as a preparation for further study, rather than as a broad preparation for citizenship;
- is dominated by historical thinking and out of line with modern ideas, both scientific and pedagogic;
- promotes rote learning and recall of scientific facts, with insufficient emphasis on building higher-order skills;
- is too theoretical, missing opportunities to develop practical and investigative skills;
- is lacking in relevance to students' own lives and fails to examine the role and contribution of science in society.

There is a particular frustration with the slow pace of curriculum change. Many submissions argued the need to shorten the time taken for curriculum design and implementation. There is anxiety that the revised junior cycle curriculum, with its new approach to the learning of science, should be introduced as quickly as possible. Our student survey confirms that a positive experience of science at junior cycle has a strong influence on student choice subsequently.

Curriculum reform must be supported by changes in assessment, and this requires clarity about the outcomes anticipated from a science education. There is almost universal support for including practical work as a component in assessment.

There is a widely held perception that it is more difficult to get higher grades in the physical sciences than in other subjects. Preliminary findings from research commissioned by the Task Force confirm that this perception is based on fact. Other research on student attitudes shows that perceived difficulty inhibits student choice of the physical sciences. This situation calls for strong action by the Department of Education and Science to ensure comparability of grading at Leaving Certificate.

## Mathematics

Serious concern about the mathematical competence of students in schools and in higher education permeates the debate on the declining uptake of the sciences. The decline in performance in mathematics at second level was highlighted by the highest-ever failure rate (17%) in ordinary level Leaving Certificate Mathematics in 2001. This high failure rate rendered one-sixth of school leavers ineligible for many science, engineering and technology (SET) courses in higher education. Because failure among males was higher (19%), this reduced the pool of potential candidates for engineering technology courses in institutes of technology, whose applicants are predominantly male.

The Chief Examiner's report on the ordinary level Mathematics exam for Leaving Certificate 2001 highlighted a "noticeable increase in the incidence of difficulties experienced by candidates". Causes suggested for low grades included the knock-on effects of difficulty with the old junior cycle syllabus (which was revised in 1999), and the increase in part-time work by students. Many science, engineering and technology departments in higher education report a lack of adeptness in basic mathematical skills on the part of students with ordinary level Mathematics.

Students' perception of the difficulty of mathematics and their poor performance in the subject both act as barriers to participation and success in the sciences at second and at third level. The risk in not addressing the problem with mathematics is that of undermining reform in science education.

## Higher Education

We cannot assume that remedies to second level science uptake will translate automatically into a complete solution for the supply of graduates. The challenge facing third level institutions is, while maintaining the growth in numbers on computing/information technology courses, to encourage more applicants to the other SET courses. This recruitment effort has to reflect the complex interrelation between the supply of sub-degree graduates and more highly skilled graduates, and be tailored to meet strategic targets set by market forecasts.

## Recruitment

School-leaver decline must not put Ireland at a competitive disadvantage. The focus of recruitment must widen to include students other than immediate school-leavers: mature students, students from Post Leaving Certificate courses, from apprenticeship courses, from access and foundation courses. All categories of other learners should be considered more seriously as part of the potential pool of applicants. Mature students constitute only about 4% of CAO acceptances, and an even lower percentage of participants on SET courses, by contrast with 20% plus in many OECD countries.

## Access

Participation by mature students and other learners is not encouraged by the present diverse entry mechanisms to different institutions, nor by the poor clarity of information on courses. Also, the routes available to participation in SET education and training need to be made more flexible and responsive to

the widening social/academic background of these other learner groups. To enable access to higher education for this group, formats of further education and part-time education should be provided which lead to science and mathematics qualifications equivalent to Leaving Certificate. Apprenticeship has become a significant and important destination for young males; opportunities should be available for talented apprentices and craftspeople to progress to higher qualifications in advanced craft skills and other SET technical courses.

### **Information**

Clear, comprehensive information on college courses should be available to all prospective students. Studies show that some students entering higher education have poor information about their course, and know very little about their lower choices. They also have a poor understanding of the demands that course content will place on them. This has particular relevance for SET courses, where an increasing percentage of entering students are undertaking the study of the physical sciences for the first time. This lack of background can be a significant contributor to failure in first year.

### **Retention**

Measures to enhance recruitment must be accompanied by equally aggressive measures to combat the high levels of non-completion in the SET areas of study in every university and every institute of technology.

As the demand for places on SET courses has declined, there has been a broadening of profile of students on these courses. SET departments must meet the challenge of integrating an increasingly diverse student body into a quality teaching and learning environment.

An undergraduate teaching environment with modern physical infrastructure and opportunities for exposure to the excitement of research is imperative for attracting undergraduate students and subsequently developing their interest in pursuing higher qualifications. The future of postgraduate research depends critically on the ability to attract high-quality students on to postgraduate programmes. This, in turn, depends on infrastructural, physical, and financial supports; these must become a priority if we are to reach OECD norms in MSc, MEng and PhD postgraduate numbers.

## The Solution: A 6-Part Action Strategy

The view of the Task Force is that Ireland can achieve a world-class system in relation to science education. There are many reasons to believe that this is achievable. For example, the results of an OECD study (PISA: Programme for International Student Assessment) demonstrate that Irish students are performing to a high level, taking into account levels of educational investment that have historically been less than that seen elsewhere. Similarly, our surveys of student attitudes demonstrate very positive views of science in society.

The Task Force believes that no single action will achieve the desired impact on take-up. The problem is multifaceted and consequently so too must be the solution. The actions form a single, holistic strategy. They are designed for impact simultaneously at all levels of the education system, reflecting the interrelatedness of the issues concerned. It is crucial that the timing of provision respects this design and that connected actions are implemented in parallel. The recommended strategy is based around six areas for action:

1. Planning and Resources for School Science
2. Equity of Access
3. Teaching and Learning of Science
4. School Curriculum and Assessment
5. Promotion of Science and Careers
6. Science Education at Third-Level

### Cost

The cost of the actions recommended is €178 million in capital investment, plus an annual recurrent cost of €66 million (based on costs in February 2002).

Actions have been fully costed on the basis of information provided to the Task Force by the Department of Education and Science and others. The figures provide an estimate of the level of investment needed and are additional to present expenditure. They are based on costs at the time of writing (February 2002) and will need to be adjusted upwards to take account of inflation.

### Implementation Group

The importance of these proposals has already been stressed and cannot be exaggerated. It is important therefore that they are put carefully and effectively in place over a short period of time. Reflecting the high priority and urgency for action, we recommend the establishment by Government of a high level *Science and Technology Implementation Group* whose function would be to source the finances and to otherwise ensure the implementation of these proposals.

### Continuing Review and Annual Report

Continuing review and the creation of new initiatives and the elimination of unsuccessful elements is crucial in ensuring that the major national issue

which is the subject of this report is addressed and reviewed regularly. It should not be a matter which is addressed occasionally or when a crisis occurs. If a strategic review is carried out on an ongoing basis, it may point to the need for new elements to be grafted on to the strategy; changing demographics and evolving conditions in higher education and in the workplace may require that new initiatives are introduced or that the original ones are adjusted.

The Task Force recommends that the *Irish Council for Science, Technology and Innovation* (ICSTI) is the appropriate body to be responsible for this role and that it should establish a Standing Committee of the ICSTI Board for this purpose; it should report to Government annually on the state of science educational provision and the relevant Oireachtas Committee should receive that annual report and be expected to comment on it.

### **National Data Base**

During the course of its work the Task Force has identified a significant number of instances in which the national data is weak. For example: the extent of practical work in schools; the quantity, quality and level of usage of school laboratories; the background and qualifications of teachers; the level of expenditure on science at the school level. The efficacy and success of any future review is dependent upon good quality information on these and other issues. The Task Force recommends that the Department of Education and Science should take immediate steps to review its procedures in this regard. It also needs to be stated that building an accurate picture of school science is not solely the responsibility of the Department but also requires the co-operation of other stake-holders. For example, school managers must provide information on expenditure; teachers must facilitate the building of a picture of student experience and classroom practice.

### **Chief Scientist**

The Task Force also recommends to Government the creation of a position as *Government Chief Scientist* who would have responsibility for overseeing these and other science-focussed initiatives and to provide Government with advice and guidance on all aspects of science and technology policy. We have reflected on the fact that Ireland is unusual in the developed world in not having such an advisor to Government.

### Action Area 1: School Planning and Resources

Actions in this area will provide, at national, regional and local levels, the resources and support needed to enable all schools to target science education as a developmental priority.

A collaborative approach to planning and action will systematically address barriers to take-up of the physical sciences and will emphasise, particularly, increased levels of practical work within schools

#### 1.1 Ensure That Science Education Is Addressed In Every School Plan (page 116)

- **Support local planning for primary science**

Augment the existing planning and curriculum support team for primary science by appointing an additional 20 science trainers to support implementation of the science component of the primary curriculum in 2002/03.

**(€1m recurrent)**

- **Provide a national infrastructure to support science planning in every post-primary school**

Establish a planning and support team to ensure co-ordination between activity at schools-level and the provision of resources by the Department of Education and Science.

**(€1m recurrent)**

- **Ensure target-setting and resource management at school-level**

Within each post-primary school a teacher should be designated to take responsibility for the local co-ordination of the planning process and associated resources. This appointment will take the form of an ex-quota post of responsibility.

**(€5.2m recurrent)**



## 1.2 Provide adequate resources to support practical science in schools (page 117)

- **Augment start-up funding for primary science**

Provide additional funds to all schools for "start-up" equipment to support the new primary science component commencing 2002/2003.

**(€3.9m capital)**

- **Provide on-going funding for primary science**

Provide all primary schools with an annual grant to fund "hands-on" practical science commencing 2002/03.

**(€5.8m recurrent)**

- **Improve the stock of laboratories and equipment for post-primary science**

Provide access to first-class laboratories and equipment in all post-primary schools through a 2 year capital investment programme commencing 2002/03.

**(€142.8m capital)**

- **Provide technical assistants in post-primary schools**

Establish a scheme to provide technical assistance and support for practical laboratory work in all post-primary schools adopting a "science plan" commencing 2003/04.

**(€18.8m recurrent)**

- **Augment funding for Junior Certificate and Transition Year science**

Augment annual funding to schools based on student numbers in Junior Certificate and Transition Year science programmes.

**(€2.0m recurrent)**

- **Augment funding for Leaving Certificate physical sciences**

Increase annual funding to schools based on student numbers in any of the three Leaving Certificate physical sciences subjects.

**(€2.8m recurrent)**

## Action Area 2: Equity

The Goal is to build capacity and broaden access so that every student has the opportunity to study the physical sciences from the beginning of primary to the end of post-primary education. In practice this means that the physical sciences should be on the curriculum menu in every school.

Actions here will ensure that students are not disadvantaged because of gender, school size, geographical location etc. Schools requiring additional intervention over and above the provision of physical resources will be targeted to ensure they derive maximum benefit from *Area 1: School Planning and Resources*.

### 2.1 Enhance teacher allocation to post-primary schools with low physical sciences enrolments (page 120)

- **Provide additional teaching resources to schools with small numbers of students enrolled in the Leaving Certificate physical science subjects**

Provide ex-quota teaching support to any school with fewer than 16 students enrolled in Leaving Certificate Chemistry and/or Physics and/or Physics & Chemistry (combined). This will benefit both schools with existing low enrolments (**€5.2m recurrent**) and schools taking up the Leaving Certificate physical sciences subjects *ab initio* (**€3.7m recurrent**).

### 2.2 Intervene to build school capacity to offer the physical sciences curriculum e.g. extend the number of schools offering Leaving Certificate physical science subjects (page 121)

- **Provide national planning and support to target equity and to broaden take-up of the physical sciences**

Establish a planning and support team to ensure that equity considerations are fully addressed and that all pupils (regardless of gender, socio-economic status, school size and geographical location etc.) benefit from the provision of resources by the Department of Education and Science.

**(€0.3m recurrent)**

- **Provide local support to increase the number of schools offering the physical sciences on their curriculum**

Develop school capacity by providing appropriate support (e.g. the provision of a visiting teacher with expertise in the physical sciences).

**(€2.2m recurrent)**

### Action Area 3: Teaching and Learning

The Goal is to catalyse innovation in teaching and learning in schools and to promote and support high calibre teaching as a critical determinant of a quality education in science.

Seed funding will promote the development of research and innovative models for pre-service and in-service training, including exploiting the potential of new technologies. Partnership across educational levels and the public and private sectors will be critical.

#### 3.1 Establish a Virtual Learning Environment for Science (page 124)

- **Provide a software infrastructure to support the teaching and learning of science**

To include...

- a software environment for science education utilisable by all schools, students, teachers and teacher trainers;
- a system accessible, via the Internet, for learners outside the conventional school system, including adult learners;
- a system, populated by e-learning content for science, particularly the physical sciences; open-ended system protocols so that teachers and others can seek to add their own content;
- a framework allowing teachers and others to structure and manage learning resources, curriculum content, student access, collaboration and assessment.

**(€1m recurrent).**

#### 3.2 Promote innovation and research in the teaching and learning of science (page 125)

- **Provide funding for research and innovation in the teaching and learning of science**

To stimulate...

- design, piloting and evaluation of innovative curricula, including Transition Year;
- piloting of innovative approaches to teaching and learning;
- development of innovative programmes for teacher training;
- development of science teaching resources;
- development of e-learning resources for science;
- research on effective pedagogy for the teaching of science;
- research on science education e.g. student attitudes.

**(€1m recurrent).**

### 3.3 Provide Incentives for the Recruitment & Retention of Teachers (page 126)

- **Provide funding for innovative ideas to support the teaching profession**

To include, amongst other initiatives:

- teacher sabbaticals in industry and research;
- work in schools by science graduates from industry and research;
- involvement by teachers in scientific research;
- support for participation by individual teachers in further education.

**(€1m recurrent).**

### 3.4 Review Pre-service Training for Primary & Post-Primary Teachers of Science (page 126)

**This action will ensure that appropriate steps are taken to address needs identified in relation to the pre-service preparation of teachers.**

- **Conduct a review of how science is handled within pre-service teacher training**

The Department of Education should oversee a review by the appropriate stakeholders of pre-service training in relation to science. This review should address the concerns raised in this Report. This review should take the form of a "Needs Analysis" which is speedily undertaken and which serves the dual purpose of helping providers of pre-service training to derive maximum benefit from the resources that will be provided as a consequence of the implementation of other Task Force recommendations. It should also help to identify opportunities for collaboration in relation to implementation.

#### Action Area 4: Curriculum & Assessment

The Goal is to advance, speedily, curriculum and assessment priorities.

This will include systematically addressing the well-documented difficulties of achieving high grades in the Leaving Certificate physical sciences.

Actions will work in partnership with the appropriate agencies to catalyse change in the existing curriculum and assessment structures.

### 4.1 Prioritise Curriculum Reform in Science (page 129)

- **The National Council for Curriculum and Assessment to fast-track action on school science**

To include:

- revised syllabus for Junior Certificate Science to be ready for implementation in schools commencing 2003;
- science curriculum and student experience within Transition Year must be reviewed and developed commencing 2002;
- immediate action to be taken to provide for the assessment of practical work within the sciences commencing 2002;
- an impact study to determine the feasibility of introducing a new, general science subject at Leaving Certificate to be completed in 2002;
- a revised Physical Science syllabus, with a particular focus on broadening up-take at Leaving Certificate, to be completed for implementation in schools in 2003;
- the physical science content of subjects within the technology and applied science grouping, particularly *Construction Studies* and *Engineering*, should be highlighted and enhanced;
- an evaluation of science content within the Leaving Certificate Applied to be completed in 2002;
- science to be a priority for the introduction of the on-going rolling review of subject syllabuses and programmes from 2002;
- planning for curriculum co-ordination across all phases of the education system should commence in 2002.

- **The National Council for Curriculum and Assessment to set a two-year target for the curriculum design process**

- **The Department of Education and Science to examine its procedures for curriculum implementation to facilitate the achievement of these actions within the specified time-scales**

#### 4.2 Establish science as a core subject in the lower secondary curriculum (page 130)

- **Ensure that all students study science until the end of lower secondary education by establishing science as a core curriculum requirement**

Broaden intake to the Junior Certificate Science curriculum in 2003/04, to coincide with the introduction of a revised syllabus.  
**(€1.6m recurrent)**

#### 4.3 Undertake a Review of Mathematics (page 130)

- **The Department of Education and Science should institute an urgent investigation into the problem of decline in mathematics performance**

In addition to an examination of academic factors, this investigation should also include an examination of the social and behavioural factors identified in the Chief Examiner's report on 2001 Ordinary Level Mathematics.

- **A Higher Education SET group should be appointed to consult with the National Council for Curriculum and Assessment course committee on Leaving Certificate Mathematics**

This SET group should be formed by the Universities and the Institutes of Technology.

- **The National Council for Curriculum and Assessment should undertake a review of Leaving Certificate Mathematics**
- **Higher education institutions should consider taking into account higher grades in Foundation Level Leaving Certificate Mathematics, in assessing entry requirements for certain courses**

#### 4.4 Ensure equity in grading physical science subjects in the Leaving Certificate (page 131)

- **A Standardising Committee should be established to conduct an annual review of the Leaving Certificate examinations in the physical sciences**

The Department of Education and Science should re-establish the annual practice of Standardising Committees reviewing the standard of the Leaving Certificate examination papers, commencing 2002.

- **Take immediate action to provide for equality of grading across Leaving Certificate subjects**

The Department of Education and Science should prepare a plan of action based on the report from the Educational Research Centre; this plan must clearly state what action will be taken to ensure that the variation in severity of grading between Leaving Certificate subjects is minimised. This plan should be in place for the 2002 examination results.

- **Introduce practical assessment in the Leaving Certificate physical science subjects**

The introduction of a practical assessment component should proceed as quickly as possible – beginning with students commencing the Leaving Certificate programme in 2002/03.

**(€0.6m recurrent)**

#### **4.5 Establish an Annual Forum on science education (page 131)**

- **Bring together stakeholders within all sectors (public, private) and levels (primary, post-primary, tertiary) to critically examine science education on an annual basis**

This forum, to be organised by the Irish Council for Science, Technology and Innovation with the assistance of the National Council for Curriculum and Assessment, should draw on expertise from both Ireland and abroad to identify opportunities for collaboration and innovation within Irish science education. The first of these annual forums should be held before the end of July 2002.

**(€0.1m recurrent)**

### Action Area 5: Promotion of Science

The Goal is to raise the level of awareness of the physical sciences among school students and parents both for their intrinsic value and for their potential to open up career opportunities.

This action will involve schools, industry, higher education institutions and professional bodies in a coordinated effort to increase interest in the study of science and to promote a positive attitude towards careers in science, engineering and technology.

#### 5.1 Establish an integrated, national science awareness programme (page 133)

- **Coordinate promotional activities for one national effort**

This will require one publicly funded body to take charge of drawing together all the many science promotional activities in order to maximise their effectiveness. It should subsume the existing awareness promotion activities under Forfás, involving the Department of Education and Science and the Department of Enterprise, Trade and Employment. Industry groups and professional bodies should formally co-ordinate or integrate their promotional efforts with this national strategy. This body will:

- Audit promotional activity vis-à-vis geographical reach and regional equality;
- Provide advice to all participants on how to benefit from activities and provide advice on best practice;
- Dispense funding for the maintenance of worthy initiatives and the establishment of new initiatives;
- Undertake an evaluation of activities.

It will ensure that all schools benefit from a specially designed promotional package containing resources for students (at all levels), teachers and guidance counsellors. This will require the joint participation of academic institutions, industrial partners and professional bodies.

This school-focussed programme will include the following elements:

- roadshow (college and career stands 'manned' by academics, scientists and engineers);
- awareness programmes/ career seminars for science teachers and guidance counsellors;
- partnership scheme to link schools and local industry;
- schools-college links for science promotion by SET lecturers;



- volunteer programme for teacher-scientist network;
- resource material (customised for different student groups: Junior Certificate, Transition Year, Leaving Certificate, and including information to address gender balance);
- associated interactive website.

The role of the Irish Science Teachers' Association in science promotion should be supported and reinforced through the secondment of a member to a full-time position, to work with this coordinating team.

**(€3.0m recurrent)**

- **Industry to participate in a co-ordinated strategy**

Industry must become more proactive in raising the awareness of the science sector amongst the Irish population in general and use every opportunity to develop the profile of science careers as both interesting and rewarding.

- **Evaluate the School Guidance Enhancement Initiative with a view to its extension**

The Task Force has noted the priority given by the Department of Education and Science to proposals within this initiative that focussed on school links with industry and on the promotion of science in the senior cycle. The Department of Education and Science should review the experience of this initiative at the earliest opportunity, with a view to extending an enhanced career guidance provision to further schools in 2002/2003.

- **National Interactive Science Centre**

The Task Force is conscious of the need to promote science in the wider arena, among parents and the general public, as well as among the student body. It welcomes the fillip that the advent of a National Interactive Science Centre would give to increasing the public awareness of science at a time when it seeks to promote science uptake in schools and at third level and encourages Government to take an early positive decision to develop such a National Science Centre.

### Action Area 6: Science Education at Third Level

The goal is to increase recruitment to science, engineering and technology courses in higher education institutions and to improve the teaching and learning experience within SET departments.

The underpinning rationale is that quality is a driver of participation, integration and retention.

#### 6.1 Promote Recruitment to Higher Education Science, Engineering and Technology (page 137)

- **Support links with schools**

Provide funding and invite bidding by SET departments to collaborate with the national promotional effort to foster schools links and develop resources. Incentivise school-college links for promoting Transition Year science and for maximising the preparedness of disadvantaged students.

**(€0.5 m recurrent)**

- **Advertise courses effectively**

Ensure that college brochures/prospectuses are re-designed in consultation with all stakeholders to ensure that effective advertising reaches all potential student target groups.

#### 6.2 Promote Access, Transition and Transfer (page 138)

- **Fund course development for wider access and for successful transition to higher education for students**

To include:

- new foundation courses for mature students;
- introductory courses for disadvantaged groups and other learners;
- enabling courses in mathematics and engineering science for apprentices to prepare them for further appropriate SET courses;
- part-time SET courses in higher education for different student groups;
- additional preliminary and bridging courses in science and mathematics aimed at poorly prepared students in higher education institutions.

**(€8.0m recurrent)**

- **Improve access routes for all applicants**

Ensure that SET departments within each sector (university and institute of technology) draw up a common system of selection and assessment for mature student applicants (to be guided by the principles laid out by the Action Group on Access to Third Level Education). Ensure that pathways for progression, for full-time and part-time courses, are facilitated within the new national qualifications framework.

- **Provide recognition for prior learning**

Encourage SET departments, within the framework of individual institutional assessment structures, to give course credits – or subject exemptions - to first year students with high grades in the physical sciences in the Leaving Certificate.

- **Facilitate student movement between third level institutions**

Ensure that a review of transfer mechanisms between different third level institutions is undertaken and agreements drawn up to facilitate the movement of students across institutions.

### 6.3 Promote Quality in Teaching and Learning within Undergraduate SET (page 139)

- **Provide start-up and on-going funding for a Collaborative Centre for Teaching and Learning in SET**

Encourage participation by individuals and partnerships within and across institutions and sectors to develop and disseminate new teaching and learning and assessment techniques in SET and in mathematics and to share best practice in the development of resources for science promotion.

**(€1m capital, €0.5m recurrent)**

- **Promote Quality Teaching**

Provide a fund for staff development related to SET teaching and for the development of, and incentivising of participation in, pedagogic training courses for lecturers.

**(€1m recurrent)**

It is strongly recommended that SET departments set goals for the acquisition by lecturing staff of a teacher training qualification, including new members of staff, and put in place mandatory modules in pedagogic training for postgraduate students.

## 6.4 Provide Physical Infrastructure to support Quality in the Teaching and Learning Environment (page 140)

- **Upgrade undergraduate teaching laboratories**

Provide capital expenditure for refurbishment and for equipment upgrading of science laboratories for the benefit of undergraduate SET students and for students on science teacher training (concurrent and consecutive) courses. Make a structured assessment of the physical infrastructure and equipment provision, and invite applications to the fund.

**(€30m capital)**



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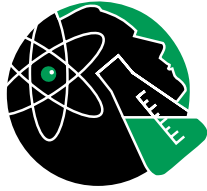
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Task Force *on the* Physical Sciences

## ***Chapter 1***

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### **The Work of the Task Force**



# The Work of the Task Force

## 1.1 Establishment

The Minister for Education and Science, Dr Michael Woods, announced the setting up of a Task Force on the Physical Sciences on 26 October 2000. This action was taken to address concerns about the declining levels of participation in the physical sciences at second level and in higher education and in recognition of the fact that the development of the skills base in the area of the physical sciences is central to sustaining Ireland's economic growth.

Dr Daniel O'Hare, President Emeritus of Dublin City University, was appointed as Chairman of the Task Force. Two National Strategy Coordinators were appointed to assist the Task Force in its work, one with a background in second level teaching in the physical sciences, and the other with a background in higher education teaching in the physical sciences.

## 1.2 Terms of Reference

The Task Force was asked to examine the issues surrounding the decline in take-up of the physical sciences and to report on its findings to the Minister for Education and Science along with a set of recommendations for action.

The terms of reference of the Task Force were as follows:

- Devise and recommend additional measures to address the issue of low take up rates.
- Consider how physics and chemistry can be most effectively promoted among students, particularly those at Junior Certificate and Transition Year.
- Review the impediments to the selection by students of the physical sciences as second level subjects and as options at third level.

The Task Force was also expected to address issues in the following areas:

- The support and promotion of high quality teaching provision in the physical sciences as well as awareness of the career opportunities open to students.
- The identification of how third level institutions can assist with the promotion of the subjects, skills-upgrading and in-service training of teachers.
- The support and promotion of a strengthening in the contacts between Physics and Chemistry Departments and Education Departments within universities and also their interaction with teachers and students in schools.
- The increase in involvement of industry in the promotion of physics and chemistry in schools and as career choices.

### 1.3 Membership

The Task Force consisted of 44 members, representative of a wide range of educational and industrial interests. The intention was that the Task Force could draw on the perspectives of a broadly based membership to canvass a wide range of opinion and expertise. A letter of invitation was circulated in early December 2000 to Department of Education and Science executive bodies, third level institutions, second level representative bodies, scientific and professional institutes, some science based industries and other relevant bodies, requesting nominations to the Task Force of a person within their respective organisation whose disposition towards the brief of the Task Force would be enthusiastic and informed.

There was recognition that the full complement of appropriate representation might not be established by this means and that the Task Force so formed could agree to invite additional members on to the Task Force as they would see fit. The full list of Task Force members and their affiliations is provided in Appendix I.

### 1.4 Submissions

A press advertisement invited interested parties to submit their views on issues relevant to the terms of reference of the Task Force. A full list of formal submissions received by the Task Force is provided in Appendix II. A significant number of the submissions have, with the agreement of the authors, been published on the Task Force website (<http://www.sciencetaskforce.ie>).

The Task Force website was designed with a discussion board inviting opinion, information and debate deemed relevant to its work.

A synthesis of the submissions revealed that many factors were perceived to be impacting on the take-up of the physical sciences. Many submissions referred to the complex and multi-factorial nature of the problem. A meta-analysis of the submissions identified 189 different issues which were considered to be either impacting on, or to have the potential to impact on, the situation.

### 1.5 Work Programme

Two small working groups were set up in April 2001, under the direction of the two co-ordinators. The First Level/Second Level working group dealt with concerns in relation to primary and post-primary science education. While the terms of reference of the Task Force required an emphasis on addressing needs within second-level schools, the group endeavoured to take appropriate account of concerns at primary level also because of the desirable relationship between the two levels.

The Third Level/Industry working group was concerned with the role of third level institutions and industry in contributing to a reversal of the decline in numbers of students taking the physical sciences. In addition, the group dealt with the factors relating to the success rate of students on science, engineering and technology (SET) courses at third level.

The work of the Task Force was divided into two distinct phases. The first phase was concerned with the gathering of data and a clarification of the issues surrounding participation in science education in Ireland, research into science education and intervention projects in other countries, the exploration of issues and the identification of focussed areas for action.

In the second phase, specific goals and detailed objectives for each of the action areas were defined and the policy recommendations were formulated. The development of an implementation plan was accompanied by a consultative process with stakeholders to ensure the appropriate accommodation of new actions within existing structures.

### **Consultation**

The co-ordinators sought to optimise their research into current practice in science education by availing of the opportunities provided by meetings, seminars and visits.

A range of meetings and consultations took place with representatives of many of the stakeholders within Irish science education including: American Chamber of Commerce Ireland; Deans of Science of the Irish Universities; Department of Enterprise, Trade and Employment; Department of Education and Science; Enterprise Ireland; Expert Group on Future Skills Needs; Heads of Schools of Science of the Institutes of Technology ; Irish Association of Science Education Lecturers; Irish Business and Employers Confederation; Industrial Development Agency; Institute of Engineers of Ireland; Physical Sciences Initiative (DES); Primary Curriculum Support Programme; National Council for Curriculum and Assessment; Science, Technology and Innovation Awareness Group; the Irish Council for Science, Technology and Innovation.

## **1.6 Research Commissioned**

Three major pieces of research were commissioned by the Task Force in order to provide additional insight into particular areas of interest. These are outlined in the following sections.

### **1.6.1 Survey of attitudes of students and parents**

This survey was carried out by MRBI between October and December 2001. The primary purpose of the survey was to elicit the views of students and parents in an effort to understand the factors contributing to their perception of science. An understanding of the environment and of the factors influencing student choice was obtained from a review of previous research, both national and international. This information was used, in consultation with MRBI, to construct a focus for research questions.

A total of 1,100 interviews were conducted with second level and third level students and parents of second and third level students. A sample of 57 schools was taken to represent the range based on size, type, gender and geographical location. A total of 411 students from first through to sixth year were interviewed.

Proportional samples of third level students from universities and the institutes of technology were selected for the third level student survey. A total of 436 students in first, second and third year - on science, engineering, computing and arts/business courses - were interviewed.

A total of 199 parents were interviewed, 40% with children at second level only, approximately 30% with children at third level only and 30% with children at both levels of education.

The results of the surveys are to be found on the Task Force website (<http://www.sciencetaskforce.ie>) and have been drawn upon in the analysis of issues in the Task Force report. Student responses have been used to test the validity of claims made in submissions regarding student perceptions.

The encouraging outcome of the survey is that Irish students, and their parents, have a positive response to the impact of science on society, its importance for Ireland's development, its contribution to improving health and living conditions and solving the world's problems. The task of promoting the study of science is made less onerous by virtue of these positive attitudes.

In common with trends among students in other developed countries, Irish students' enthusiasm for school science decreases between the beginning and the end of junior cycle. The challenge is to turn this phase of science education into a more positive one that encourages students to continue with the physical sciences into the senior cycle. Students have a poor and uninformed perception of careers in science and technology but yet it is on the basis of career information – as well as the experience of junior cycle science – that they make decisions for or against the physical sciences. This points to the need for Irish industry to raise the level of awareness among students and to advertise opportunities for interesting and rewarding careers.

Third level students are positive about the quality of lecturing on their courses but science and engineering students found the transition from school to college more difficult than their arts/business counterparts. They also generally find their courses more difficult, but are highly interested nonetheless. They have an interest in careers in a range of hitech industries but they are not satisfied with the level of guidance on careers from companies and industries. All students are unhappy with the level of feedback on progress during the academic year. Parents are generally informed about the science being studied by their children, but have a limited perception of the range of careers available to science graduates.

Overall, among students and parents there is a low level of engagement with science in the media – TV, radio, print or electronic media. This provides a challenge if Ireland is to belong to the scientifically literate community of the modern technological world.

The MRBI research summary is published on the Task Force website at [www.sciencetaskforce.ie](http://www.sciencetaskforce.ie).

### 1.6.2 Comparability of grading of Leaving Certificate subjects

The Task Force commissioned the Educational Research Centre (ERC), Drumcondra to carry out research on the grading of the Leaving Certificate Physics and Chemistry examinations.<sup>1</sup> The objective of the research was to ascertain whether Leaving Certificate candidates in the physical sciences (Physics and Chemistry) are treated unfairly by the examination system; that is, whether it is more difficult for candidates to achieve high grades in the physical sciences in comparison with other subjects. The preliminary report from this study is included as Appendix III to this Report; the full report from the ERC will be completed at the end of March 2002.

A methodology, Subject Pair Analysis (SPA), was used for the preliminary study. SPA relies on comparing the mean grade of students sitting a target subject with their mean grade on a comparison subject (or group of comparison subjects).<sup>2</sup> The Subject Pair Analysis carried out in this instance drew on the results of the Leaving Certificate examinations of 1996, 2000 and 2001.

The findings confirm that Leaving Certificate candidates are less likely to perform as well in Physics and Chemistry than in other subjects. Students sitting Higher Level Chemistry and Physics in 2000 and 2001 did consistently less well in these subjects than they did in the other higher level subjects that they sat. Comparison with the data from 1996 demonstrated that there was little improvement in performance in the physical sciences in relative terms in the last six years, in spite of improved mean grades in absolute terms.

These findings lend weight to the commonly quoted perception of students, teachers and guidance counsellors – and recurring observations in submissions to the Task Force – that the physical sciences are the "difficult" subjects.<sup>3</sup> This research highlights the need for an urgent review of the comparability of grading of Leaving Certificate subjects; specific action by the Department of Education and Science to rectify this damaging anomaly is both necessary and urgent.

---

1 This work has been led by Dr David Millar, Educational Research Centre, Drumcondra, Dublin.

2 For a particular target subject and comparison subject, a mean grade is calculated in each subject for the common group of students who take both subjects. A measure of relative leniency or severity of the one subject (relative to the other) can be derived from the difference between the two means. This procedure can be repeated for several subjects in a group of comparison subjects. Calculating the difference between the two sets of means can provide a general leniency/severity rating for the target subject.

3 The full ERC report, due in March 2002, will include the results of a second examination of the relative performance of Leaving Certificate candidates. This second methodology is based on relating student performance in Leaving Certificate subjects to overall performance in the Junior Certificate Examination.

### 1.6.3 Case Studies of schools with high science take-up

This study was undertaken by Dr Odilla Finlayson, School of Chemical Sciences, DCU and Dr Lynn Killen, School of Computer Applications, DCU. The purpose of the study was to explore issues around the science provision in a set of schools with a high take-up of the physical sciences at Leaving Certificate. A group of twelve schools, representative in size, type and gender, in the Dublin area were included for the study. Questionnaires were prepared to reflect the set of school factors to be investigated for their impact on the successful uptake of physical science e.g. science ethos, resources for science, science management and budget, junior cycle science, senior cycle science, the expertise and professional development of teachers.

Face-to-face or telephone interviews were conducted with the Principal, the Guidance Counsellor and the junior cycle science teacher in each school. The main findings were:

- Transition Year was compulsory in the majority of schools, and science was a compulsory module in Transition Year.
- Science teachers played an important role in guidance and science promotion.
- Resources for practical work were generally rated as high or reasonable; only three schools had technical assistance but all schools indicated a strong need for technicians/assistants.
- In two thirds of the schools there was a head of science or science coordinator position.
- 90% of science teachers were teaching the subject in which they had qualified at degree level.
- The Principals attributed the success with science in their schools to excellent, innovative teaching.
- Other "success" factors suggested were: providing junior cycle science as a core subject, a strong emphasis on Transition Year science, a strong school tradition of science and good resources.

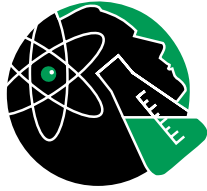
The recommendations from the schools for improving the teaching of science, generally, were:

- upgrading resources and facilities;
- provision of laboratory assistance;
- good training of teachers;
- more practical work in junior cycle science.

The full findings of this research are to be found as Appendix IV to this Report.







Task Force *on the* Physical Sciences

## ***Chapter 2***

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## **Participation in Science**



## Participation in Science

### 2.1 Participation in the Physical Sciences at School

#### 2.1.1 Primary

Science is being introduced to Irish primary schools as part of the implementation of the revised primary school curriculum. A new curriculum area *Social, Environmental and Scientific Education (SESE)* will provide primary pupils with exposure to learning in the physical sciences.<sup>4</sup> To date only approximately 5% of primary schools have had the opportunity to participate in the new programme.<sup>5</sup> Implementation of the programme in all schools will commence in 2003, following on from the provision of in-service training for all teachers during the 2002/2003 academic year.

#### 2.1.2 Take-up at Post-Primary Junior Cycle

Department of Education and Science statistics for the school year 2000/01 show that in only 5 of the 733 post-primary schools offering the Junior Certificate programme, were there no students enrolled in Science. Thus, out of a total of 180,998 students enrolled in the Junior Certificate programme nationally, only 110 students were enrolled in schools that did not offer Science.<sup>6</sup> The pattern of take-up of Science in the 733 schools that offer the Junior Certificate programme demonstrates that a large majority, 489 schools, operate with 90% or higher enrolments (Table 1). Indeed, 436 of the 489 schools have enrolments of 95% or higher.

**Table 1: Junior Certificate Science Enrolment (2000/01)**

% ENROLMENT	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-100
# SCHOOLS	5	1	1	15	18	21	51	60	72	489

In the school year 2000/2001 the overall participation rate was 88.4% (Table 2) with the consequence that over 21,000 Junior Certificate students did not study science during that year.

**Table 2: Enrolment in Junior Certificate programme during the period 1991 to 2001**

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total JC enrolment	203,377	207,904	210,262	208,917	205,417	199,571	192,944	187,068	183,883	180,998
JC Science enrolment	179,246	184,448	187,548	186,923	184,455	178,211	172,817	166,991	163,033	159,927
% Science enrolment	88.1%	88.7%	89.2%	89.5%	89.8%	89.3%	89.6%	89.3%	88.7%	88.4%

4 Although science is a new element in the revised curriculum, the 1971 curriculum did expose students to the biological sciences through a nature and environmental studies programme.

5 Only 207 schools participated in the science developmental project for the primary sector.

6 These were generally schools with a majority of enrolment at senior cycle or in post-leaving certificate programmes.

Figure 1 illustrates the decline in the number of students enrolled in Junior Certificate Science since the mid 1990s.

**Figure 1: Number of students taking Junior Certificate Science (1992-2001)**

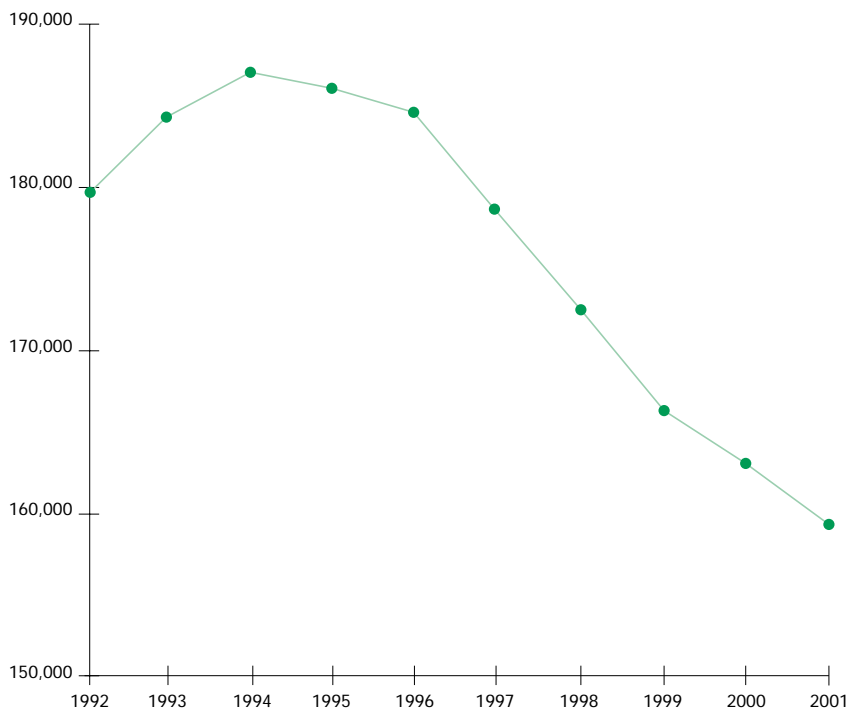
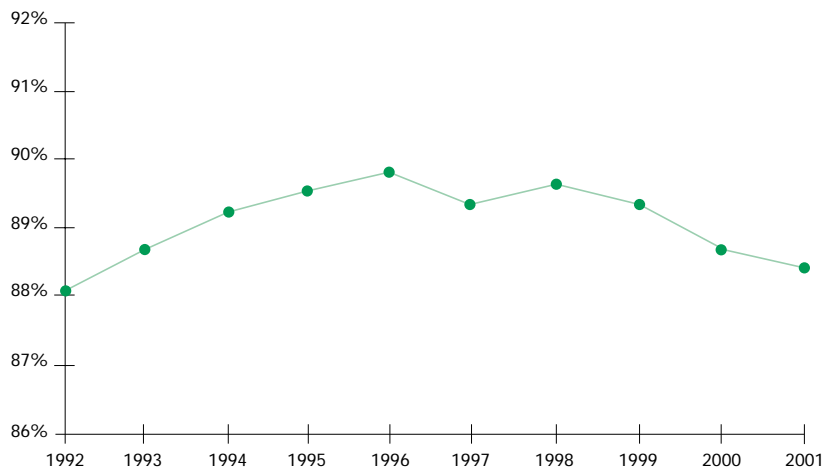


Figure 2 takes changes in the cohort size into account, by showing the proportion of the total Junior Certificate population enrolled in Junior Certificate Science in the period 1992-2001. While this shows that proportional enrolment has been relatively stable (ca. 89%), there are some concerns about what may be an emerging trend of decline in the take-up of Junior Certificate Science in recent years.

**Figure 2: Proportion of Junior Certificate students taking Science (1992-2001)**



### 2.1.3 Post-primary Senior Cycle<sup>7</sup>

There are three different Leaving Certificate subjects based on the physical sciences. These are (i) Physics (ii) Chemistry and (iii) Physics and Chemistry Combined. The number of students enrolled in these subjects during the academic year 2000/2001 is shown in Figure 3.

**Figure 3: Number of 5th & 6th Year students enrolled in Leaving Certificate physical sciences (2000/2001)**



In 2000/2001, Physics was taken by 16.4% of Leaving Certificate students, Chemistry by 12.0% and Physics and Chemistry (combined) by 2.0%. Table 3 shows the total number of students enrolled in the Leaving Certificate programme in each of the physical science subjects in 2000/2001, the most recent data available at the time of writing.

**Table 3: Number of 5th & 6th Year students and % of the cohort enrolled in selected Leaving Certificate subjects (2000/2001)**

	MALES	FEMALES	TOTAL	% COHORT
Physics & Chemistry (combined)	1,559	623	2,182	2.0%
Agricultural Science	4,847	1,297	6,144	5.7%
Engineering	10,260	677	10,937	10.1%
Technical Drawing	12,587	937	13,524	12.5%
Construction Studies	17,568	1,280	18,848	17.4%
Chemistry	6,105	6,894	12,999	12.0%
Physics	13,329	4,434	17,763	16.4%
Home Economics	4,761	31,777	36,538	33.7%
Biology	15,631	31,823	47,454	43.7%
Mathematics	52,404	55,947	108,351	99.8%

The changes in participation rates over time are demonstrated in Figure 4.

<sup>7</sup> Please note that the analysis throughout this section is specific to schools and students where the LC programme is provided (i.e. it does not take account of post-primary schools where there are no LC students). It is based on data for the academic year 2000/2001, the most recent available at the time of writing.

Figure 4: Proportion of student cohort taking Leaving Certificate subjects 1988-2001

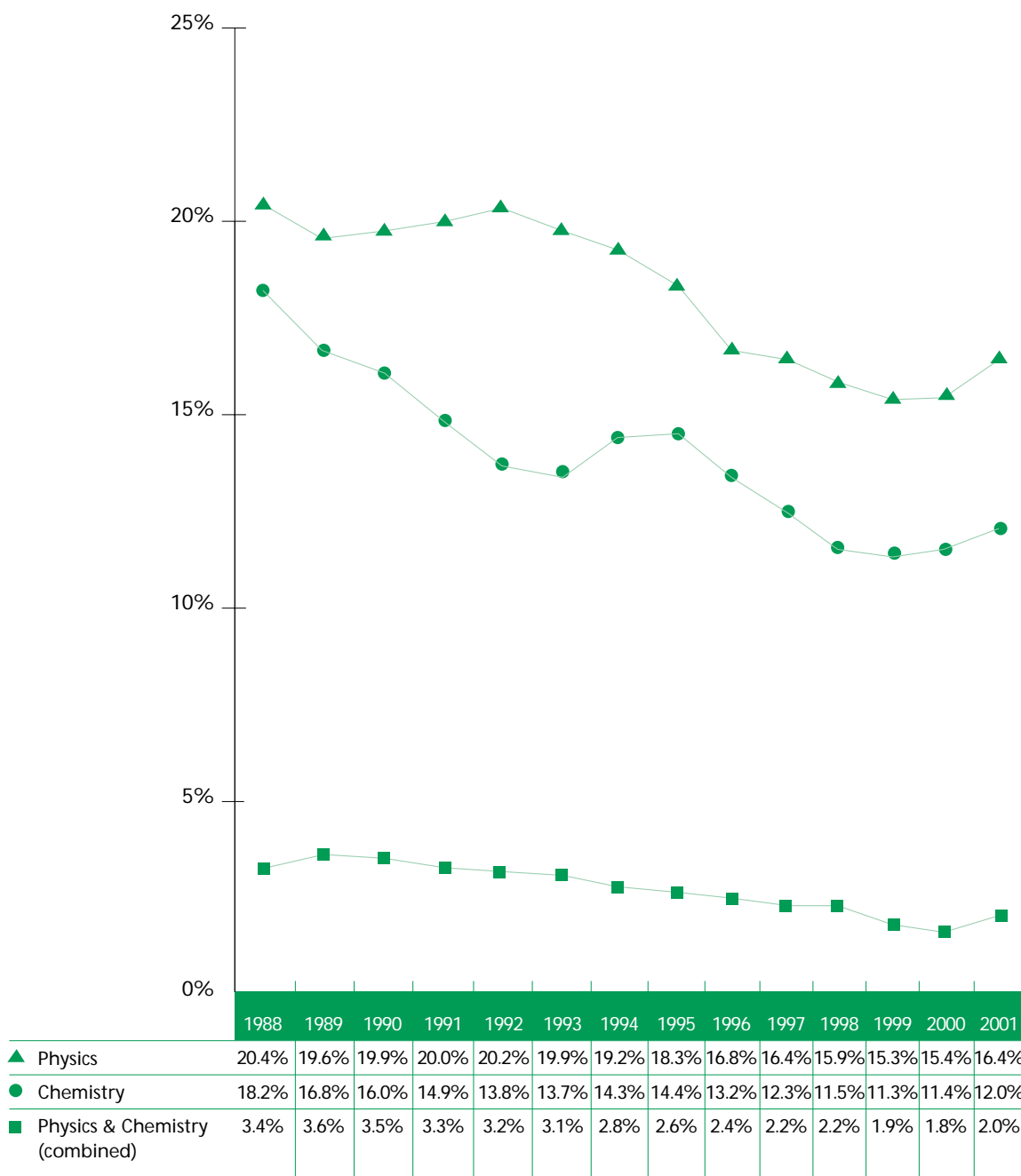
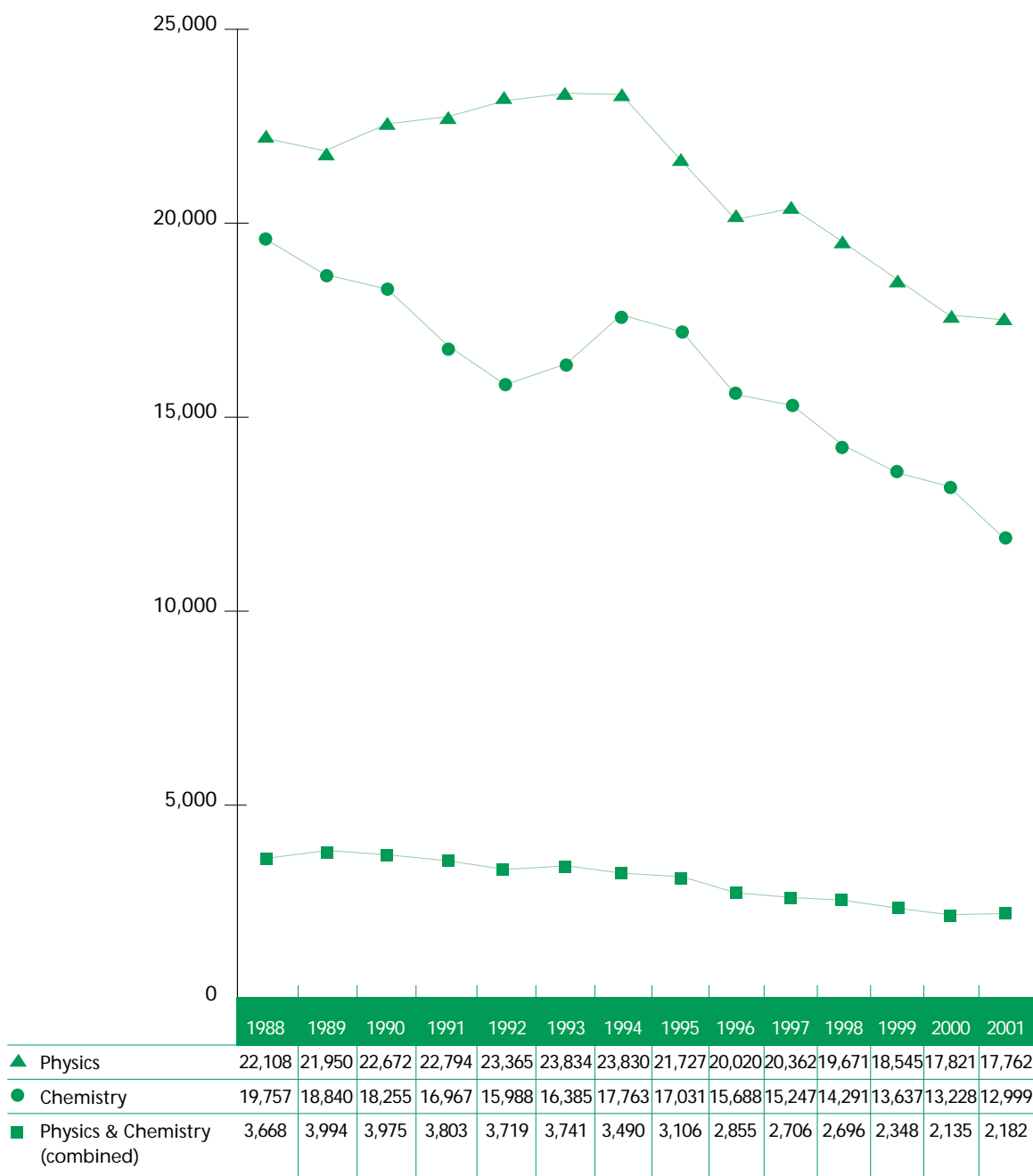


Figure 4 indicates an apparent recovery in participation in recent years. However the number of Leaving Certificate students opting to study the physical sciences has continued to decline during this period as shown in Figure 5.

Thus, while the proportion of students opting to study the Leaving Certificate physical sciences did show an increase in 2001, the actual number of students continued to drop. This is in line with the on-going decline in the total number of students enrolled in the Leaving Certificate programme as a whole (reflecting demographic changes in the Irish school-going population).

**Figure 5: Total number of 5th & 6th Year students taking Leaving Certificate subjects 1988-2001**



It has been suggested that one factor contributing to the relative decline of the Leaving Certificate physical sciences is that they are offered in fewer schools than previously. Figure 6 shows the number of post-primary schools with student enrolments in particular Leaving Certificate subjects.

**Figure 6: Number of post-primary schools with students taking particular Leaving Certificate subjects (2000/2001)**

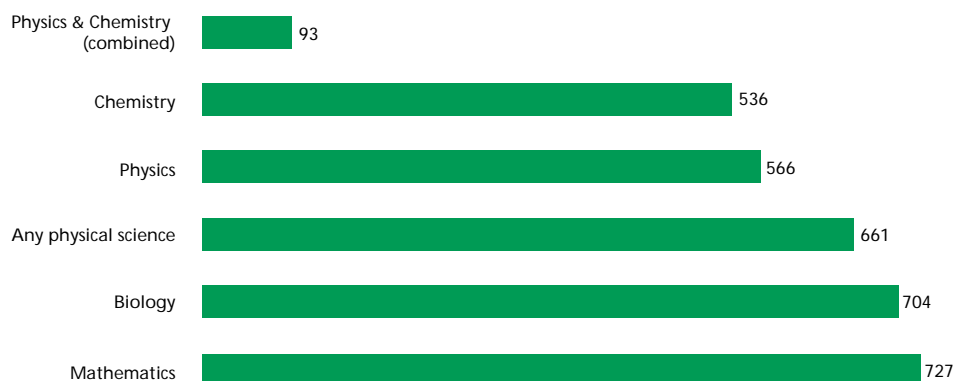
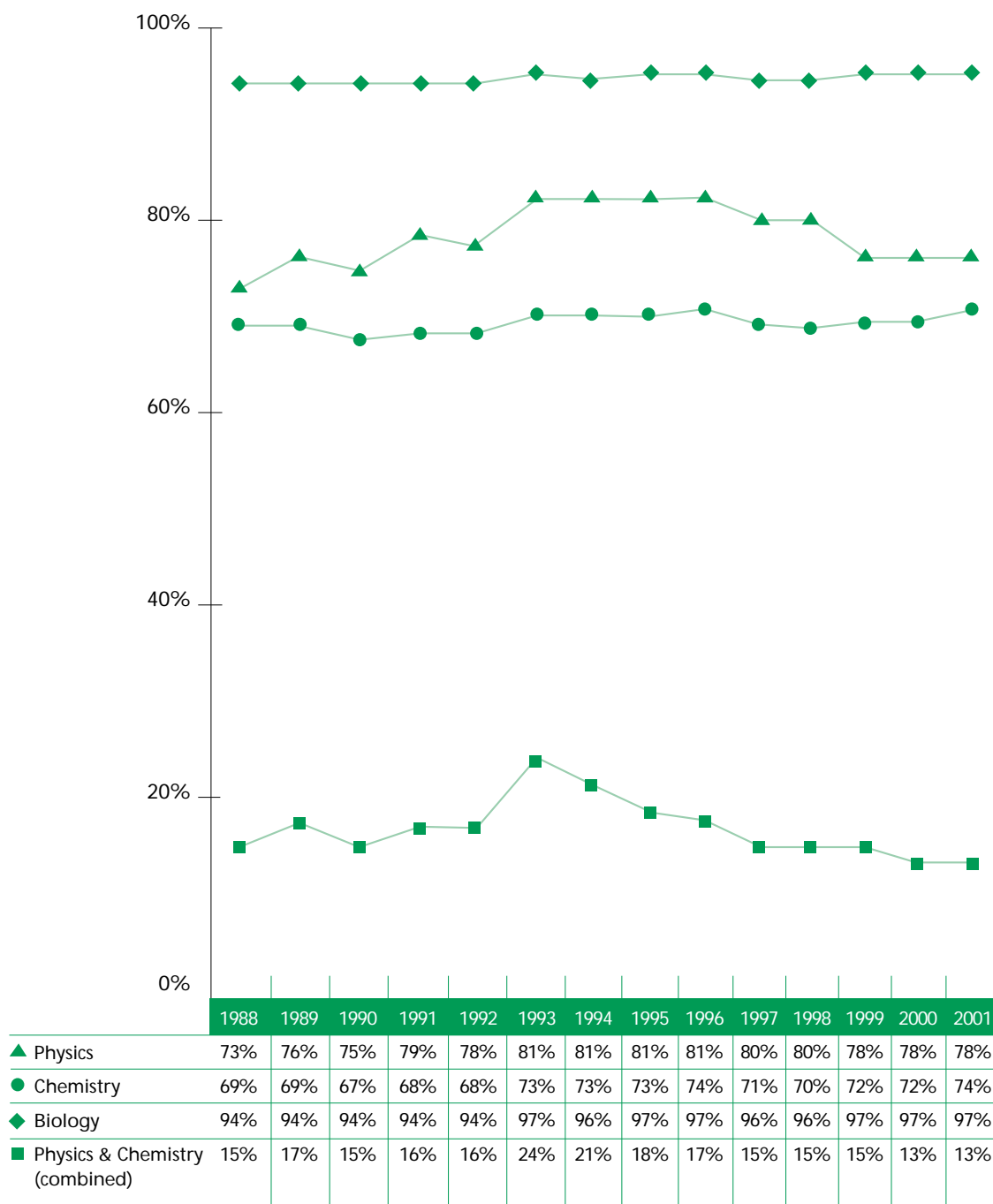


Figure 7 illustrates the trend in the number of schools offering the sciences during the period 1988 to 2001 and demonstrates that there was, on a proportional basis, more availability of Leaving Certificate science subjects in 2000/2001 than in 1997/1998.<sup>8</sup> Thus it does not appear that the decline in student numbers taking Leaving Certificate science can be attributed to schools dropping the science subjects from their curriculum.

<sup>8</sup> The set of schools offering a particular LC subject is those schools which demonstrate an enrolment of at least one LC student (5th or 6th year or repeat LC) in that subject.



**Figure 7: Percentage of post-primary schools offering Leaving Certificate science subjects (1988-2001) <sup>9</sup>**



<sup>9</sup> Academic year 1990/1991 to academic year 2000/2001; P=Physics; C=Chemistry; B=Biology; P&C=Physics & Chemistry (combined).

**BIOLOGICAL SCIENCES**

It is noteworthy that student take-up in the *biological sciences* has also shown a significant decline during the 1990s, both in proportional and absolute terms. The number of students enrolled in Leaving Certificate Biology has fallen from 56,087 (51.8%) in 1988 to 47,454 (43.7%) in 2001.

**2.1.4 Gender differences in science take-up in post-primary schools**

As Table 4 demonstrates, girls are much less likely to take Junior Certificate Science than boys.

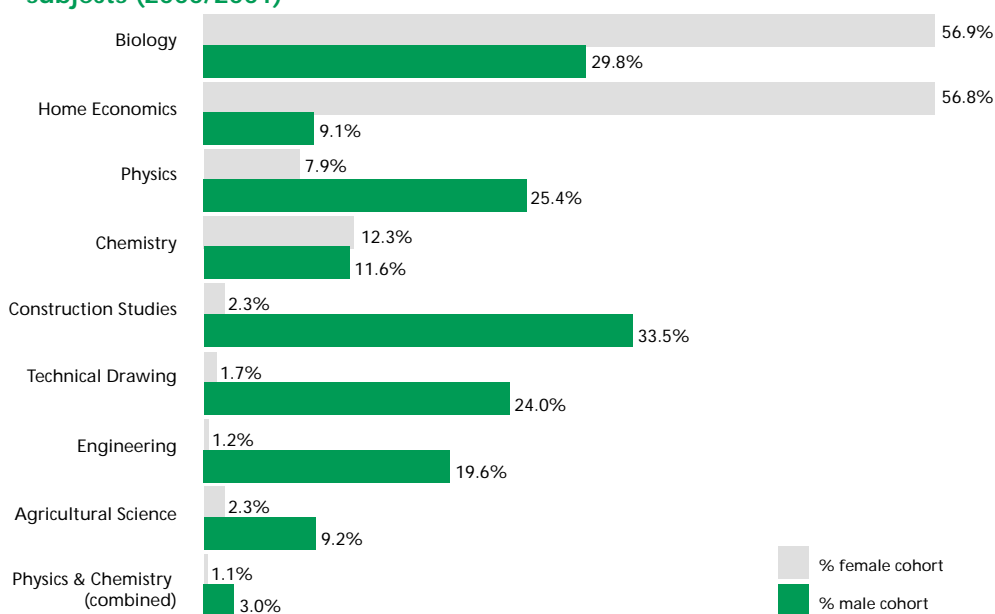
**Table 4: Enrolment in Junior Certificate Science by school gender classification (2000/2001)**

SCHOOL TYPE	BOYS	GIRLS	MIXED	ALL
JC Enrolment	31,202	42,693	107,103	180,998
JC Science Enrolment	30,009	34,018	95,900	159,927
% take-up of JC Science	96.2%	79.7%	89.5%	88.4%

This difference arises entirely from a lower take-up of science in girls-only schools. Girls (89.8%) and boys (89.3%) are equally likely to study Junior Certificate Science in mixed gender schools, whereas the participation rate in Girls Only schools (79.7%) is some 10% less.

The science and technology subjects also show marked differences in terms of take-up by male and female students. As Figure 8 demonstrates, Chemistry is the only one of these subjects demonstrating equitable take-up by gender.

**Figure 8: Proportion of gender cohort<sup>10</sup> taking Leaving Certificate subjects (2000/2001)**



<sup>10</sup> Participation rates computed using total numbers of male/female students taking LC maths to represent full cohort.

## 2.2 Participation in Higher Education Science, Engineering & Technology (SET)

There is concern that the level of participation in Science, Engineering and Technology (SET) courses in higher education may not meet the demands of the technological sector for skilled graduates (Expert Group on Future Skills Needs 2001; Gaffney 2001; NCEA 1999; HEA 1999).

The composition of skills available among all SET graduates, and the potential of these to meet the demands of the labour market, is the special concern of the Expert Group on Future Skills Needs. This group has identified the need for a continued supply of science graduates at certificate, diploma and degree level with Chemistry, Biology and Instrumentation/Applied Physics specialisms, as well as a continued supply of all types of IT/Computing and Engineering graduates (Expert Group on Future Skills Needs 2001).

The decrease in popularity of the more traditional applied science courses (in Physics, Chemistry and Biology) is more dramatic than revealed by enrolment trends as the decline is masked by the inclusion of the more highly sought-after courses in Health, Physiology, and Medical Laboratory Sciences in the classification of science courses. The Expert Group on Future Skills Needs has identified the importance of maintaining enrolment on science courses in Chemistry and Biology and Physics/Instrumentation, and particularly on sub-degree programmes in these areas of study, in order to ensure that Ireland is positioned to meet the demands of the chemical, pharmaceutical and biotechnology industrial sectors.

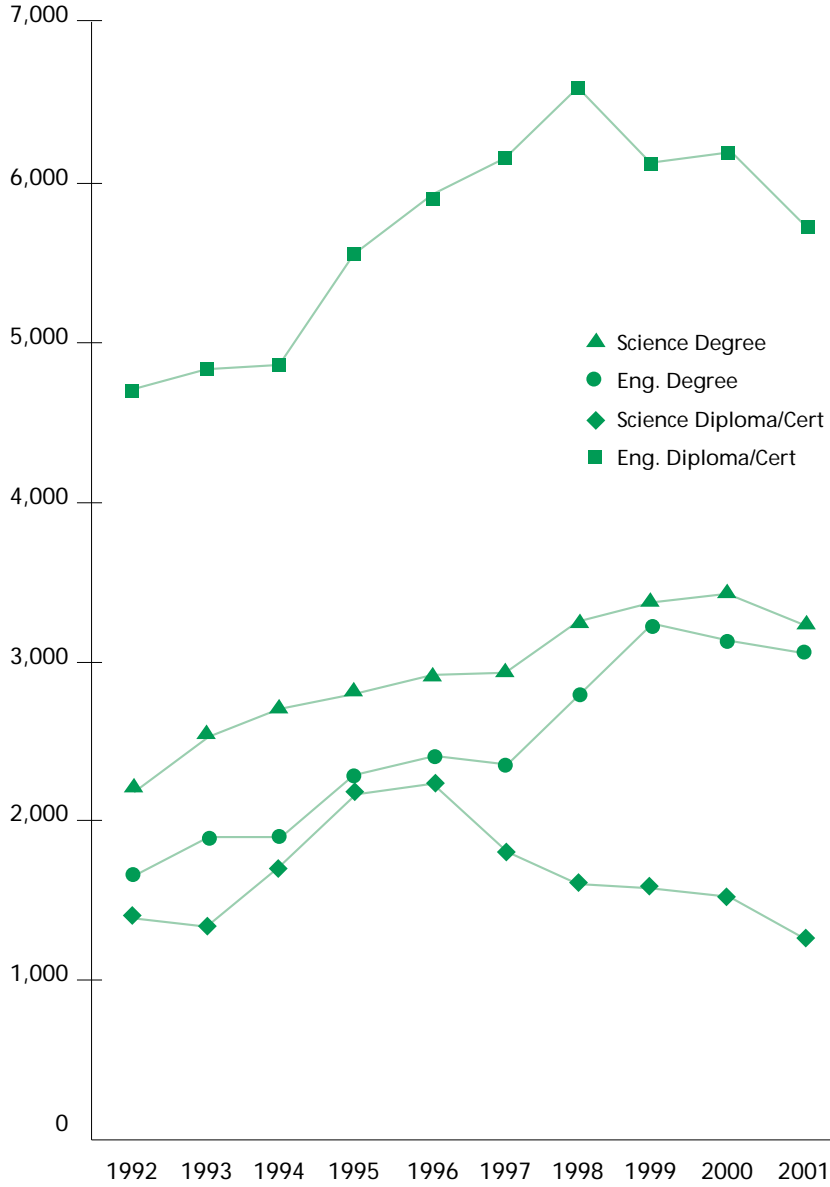
Ireland ranks in the top four OECD countries for its production of a high proportion of skilled graduates in science (OECD 2001a) and in 1999 boasted the highest number of science graduates per 100,000 people in the labour force of age category 25–34 years. Science graduates from tertiary type B education (generally described as equivalent to certificate and diploma courses) for Ireland in 1999 exceeded all other OECD member states by a minimum factor of three. This outstanding record of graduate output has contributed to the phenomenal growth in Irish based technology.

Trends in participation can be examined by looking at (i) enrolments and (ii) retention rates.

2.2.1 Enrolment on Science, Engineering and Technology Courses

A measure of total enrolment on all courses in science, engineering, technology and computing can be obtained from CAO acceptance data.<sup>11</sup>

Figure 9: CAO Acceptances by subject area and level



11 Computing/IT/Software Engineering courses are classified as either Science/Applied Science or Engineering.

**Table 5: CAO Acceptances by subject area and level (basis of Figure 9)<sup>12</sup>**

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Science Degree	2153	2509	2665	2713	2931	2963	3258	3306	3477	3283
Eng. Degree	1651	1837	1879	2266	2457	2419	2870	3258	3160	3080
Science Diploma/Cert	1485	1413	1625	2247	2268	1740	1591	1533	1500	1283
Eng. Diploma/Cert	4651	4890	4897	5520	5998	6206	6549	6080	6231	5866
Total	9940	10649	11066	12746	13654	13328	14268	14177	14368	13512

A number of factors contributed to a rise in acceptances in 1995<sup>13</sup> and 1996, including an increase in the number of places made available for science, engineering and computing courses across all higher education institutions. This period also corresponded to the peak in the demographics, with the highest number of Leaving Certificate candidates over the ten-year period presenting in 1997.

However the absolute numbers of acceptances on all programmes are demonstrating a decline. The most alarming decrease has occurred in science acceptances at diploma/certificate level. In 2001 there were only 1,283 acceptances, down 43% from the 1996 peak (2,268 acceptances). The downward trend has been accompanied by a lowering of points of entry on to diploma/certificate courses in science/applied science, with a significant number of courses now offering places to "All Qualified Applicants". Acceptances to engineering certificate/diploma courses have declined 10% from their peak in 1998. The onset of a decline in acceptances to degree courses in science and engineering has been more recent (2000 and 1999 respectively) and the magnitude of the decline has been less (5%). The net effect is the drawing off, by the universities, of applicants who previously would have gained places on diploma/certificate courses in the institutes of technology, and the exhaustion of the pool of applicants to the institutes of technology as the lowest threshold of entry (AQA) is reached.<sup>14</sup> If the above trend continues, the skills level of the graduate scientists/engineers will increasingly bias towards degree qualifications and enrolments in SET courses in the Institutes of Technology will decline further.

<sup>12</sup> Trends in acceptances into science and engineering degree and diploma/certificate courses (Data from CAO Board of Directors annual reports for the years 1992 to 2001; courtesy of Dr Martin Newell, Secretary, CAO). These numbers are an indication but not a direct measurement of student enrolments as 5% -10% of acceptances do not translate into registered enrolments.

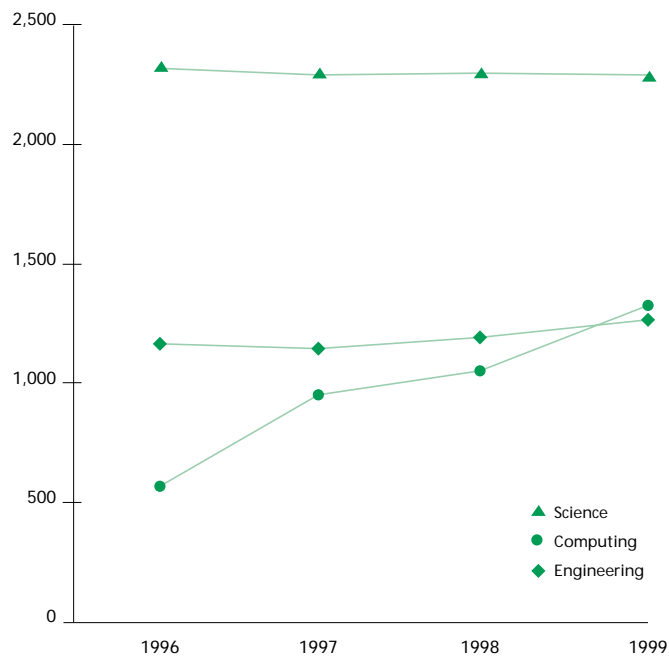
<sup>13</sup> 1995 = Academic year 1995/1996; 1996 = Academic year 1996/1997 etc.

<sup>14</sup> In 1996 total diploma/certificate acceptances exceeded degree acceptances; in 2001 they were about 75% of degree acceptances.

As well as the decline in absolute numbers on SET courses, a decline in science and engineering acceptances as a proportion of overall CAO acceptances has been seen in recent years; the science proportion of degree acceptances has declined from its maximum of 18% in 1996 to 16% in 2001; the engineering proportion of degree acceptances has declined from its maximum of 16% in 1999 to 15% in 2001. A more significant loss in market share has been experienced by the diploma/certificate courses: science has declined from 13% in 1996 to 8% in 2001; engineering has declined from 41% in 1998 to 37% in 2001.

A re-classification of science, engineering and technology courses has been undertaken in more recent years to reflect the emerging emphasis on Computing/IT courses of study. The shifting popularity of the three main component areas of SET (Science, Engineering/Technology and Computing) can be seen in plots of enrolments on these respective courses in Figures 10 and 11.

**Figure 10: Trends in First Year Intake to Science, Engineering and Technology programmes in the University sector**

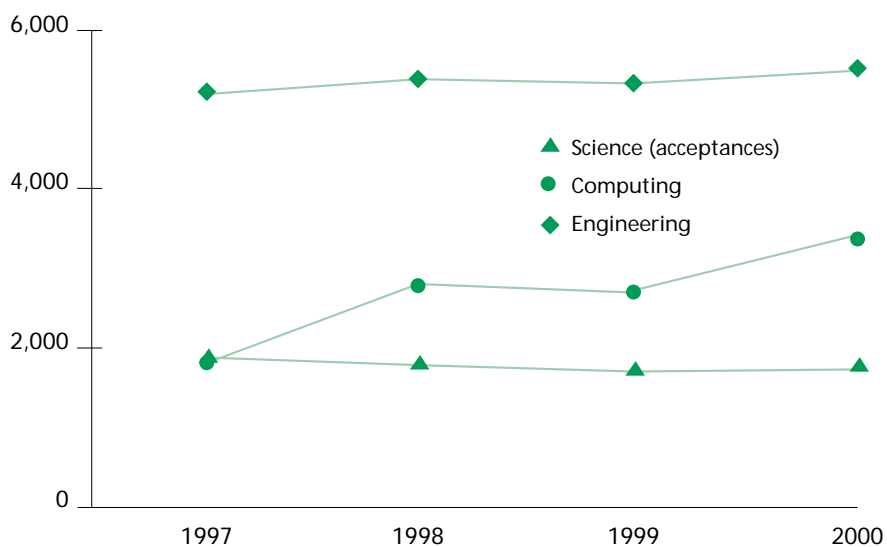


**Table 6: Trends in First Year Intake to Science, Engineering and Technology programmes in the University sector (basis of Figure 10)<sup>15</sup>**

	1996	1997	1998	1999
Science	2346	2315	2316	2308
Computing	614	900	1088	1394
Engineering	1234	1222	1258	1294
Total SET	4194	4437	4662	4996

While Figure 9 indicates a levelling off of total acceptances to all SET courses in 1999 and 2000, Figures 10 and 11 demonstrate that, prior to this, rising numbers on computing courses in both universities and institutes of technology were the main source of the overall rise in SET enrolment.<sup>16</sup>

**Figure 11: Trends in First Year Intake to Science, Engineering and Technology programmes in Institutes of Technology**



<sup>15</sup> First year undergraduate enrolments in science, engineering and computing courses (Data from HEA).

<sup>16</sup> It must be noted that direct comparisons cannot be made between the acceptance plots in Figure 9 and the enrolment plots in Figures 10 and 11, the former being divided along degree/diploma lines the latter two along university/institute of technology lines. No simple correlation can be inferred due to the emergence of new degrees in the institute of technology sector over recent years. Also acceptance numbers are not the same as enrolment numbers.

**Table 7: Trends in Intake to Science, Engineering and Technology programmes in Institutes of Technology (basis of Figure 11) <sup>17</sup>**

	1997	1998	1999	2000
Science (acceptances)	1945	1782	1736	1745
Computing	1895	3016	3034	3512
Engineering	5221	5312	5241	5325
Totals	9061	10110	10011	10582

Further insight into participation trends across the three subject areas will require clarity of definition of the three SET subject areas and the resolution of enrolment data into the three areas. It is important that the HEA and Department of Education and Science make available up-to-date data of this nature on student enrolment to aid future studies.

### 2.2.2 Retention (Non-Completion) on Science, Engineering and Technology Courses

The decline in participation in third level SET courses is dictated principally by two factors i.e. the decline in initial uptake of courses and the reduction on throughput due to high rates of non-completion.<sup>18</sup> Both factors operate together to generate an environment that reduces the attractiveness of the physical sciences and of science-related areas of study at third level.

The three subject areas of SET (Science, Engineering and Computing) exhibit among the highest non-completion rates across all subject areas in both the universities and the institutes of technology (Table 8).

<sup>17</sup> The 'science only' data is acceptance data for science excluding computing (from Timpson 1999 and from DES Statistics). The computing data is derived from enrolment data for 'science including computing' (DES Statistics) and the aforementioned 'science only' data. Allow for 5-10% discrepancy between acceptance and enrolment numbers.

<sup>18</sup> Definition as used in reports on retention/non-completion: non-completion of course of first registration.



**Table 8: Non-completion rates for the Higher Education Institutions<sup>19</sup>**

UNIVERSITY SECTOR					
Subject Area	Computing	Science	Engineering	Law + Health	(Arts, Bus, SS)
Overall Non-completion	26.9%	22.2%	19.6%	7%	11- 17%
Range	25 – 32 %	15 – 42 %	16 – 27 %	2.5 - 12%	6 – 9%
INSTITUTES OF TECHNOLOGY					
Subject Area	Engineering	Computing	Science	Business	Humanities
Overall Non-completion	50.9%	50.0%	39.7%	36.6%	32.3%
Range (Cert)	37 - 70	37 - 63	21 – 70	22 - 51	13 - 33
Range (Dip)	34 - 65		12 – 87	16 - 66	23 - 51
Range (Deg)	19 - 60		26 - 40	25 - 35	
DIT					
Subject Area	Computing	Engineering	Science	Business	Humanities
Overall Non-completion	53%	43%	43%	37%	29%

Despite variations in non-completion for different subject areas across institutions, the SET areas exhibit the highest non-completion rates in every university and every institute of technology. This represents a serious attrition of undergraduate students through withdrawal from, and exam failure in, the first year of SET studies, principally.

Initiatives to boost retention have been taken in all third level institutions, sponsored by the Higher Education Authority and the Department of Education and Science. Qualitative studies identifying the underlying reasons for non-completion are in progress; these will include a detailed investigation into non-completion in the SET areas of study. In a study of non-completion in three institutes of technology (Healy *et al.* 1999) some of the factors influencing non-completion were found to be: low grades in the Leaving Certificate, lack of guidance on course and career options, unsuitable course choices, difficulties with subject matter, as well as social and personal factors. These factors all have particular relevance to SET courses, because of the more recent dropping of points for entry to these courses, leading to an increasing proportion of less-well-prepared students in the intake.

<sup>19</sup> The maximum and the minimum percentages represent the variation across the different colleges in the sector. In the university sector, the overall non-completion rate was 16.8 %; in the institutes of technology the overall non-completion rate was 42.7%. In the DIT the overall non-completion rate was 39.5%. From: Flanagan *et al.* 2000; Finnegan and Russell, 2000; Morgan *et al.* 2001).



Task Force *on the* Physical Sciences

## ***Chapter 3***

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## **International Comparisons**



## International Comparisons

### 3.1 Decline in Science Take-up at School

A decreasing willingness to participate in the study of science has been experienced amongst students in nearly all developed economies. The critical implications of this decline for national economic and social well-being have brought it to the attention of policy makers at a national level as well as placing it on the policy agenda for bodies such as the OECD and the EU.

*Science, mathematics and technology are relatively unpopular parts of the school curriculum... Over the past ten or fifteen years, there have been frequent expressions of concern that so few pupils are taking up mathematics, science, technology and related subjects. (OECD Observer 1998<sup>20</sup>).*

A number of countries have recognized the problems and have endeavoured to initiate educational reform initiatives in this field. In addition to reviewing the general situation in other developed economies (including the US), the Task Force has taken a particular interest in initiatives in Scotland, Finland and Victoria (Australia).

The *American Association for the Advancement of Science* (AAAS) established *Project 2061* in 1985 with the aim of helping all Americans to become literate in science, mathematics, and technology. It has been described as the "single most visible attempt at science education reform in American history" (OECD 1996). More recently the National Commission on *Mathematics and Science Teaching for the 21st Century* reiterated the need to address change in this area,

*the Commission is convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically (Glenn Report<sup>21</sup>).*

Improving the quality of mathematics and science education has been adopted as one of the principal goals of the Bush administration (Bush 2001). The National Science Foundation (NSF) has launched a US\$100 million initiative to regenerate leadership in teaching and research in mathematics, science and technology by establishing *Centers for Learning and Teaching* throughout the country. These centres will encourage the development of new teachers and new materials to boost learning in kindergarten through 12th grade as well as to prepare post-graduate students in areas of critical national need to eventually assume leadership roles. The NSF has described this initiative as a "massive effort" to rebuild teaching leadership in science and mathematics.

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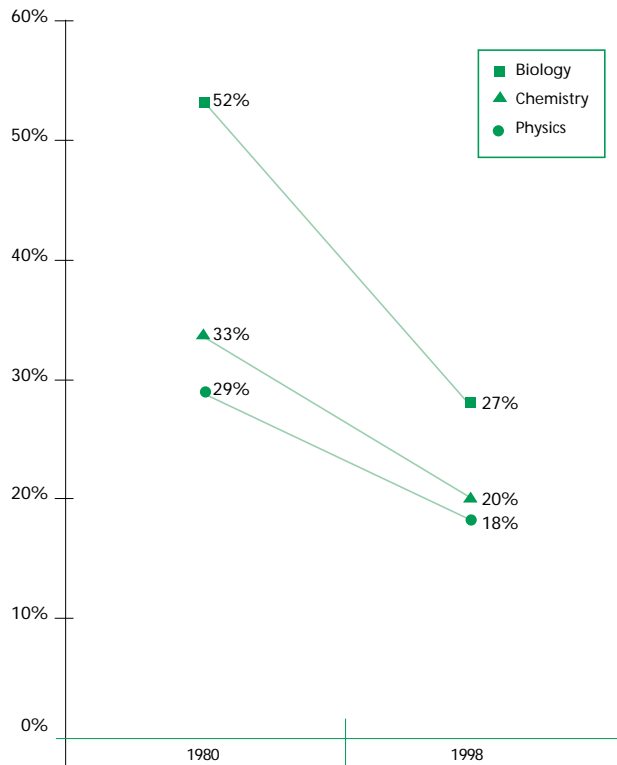
20 James (1998).

21 National Commission on Mathematics and Science Teaching (2000).

### 3.1.1 Australia (Victoria)

Science is a compulsory component of the school curriculum up to Year 10, the year in which students turn 15 years of age. Enrolment trends for Year 12 students are shown in Figure 12.

**Figure 12: Percentage of Year 12 Cohort Enrolled in Biology, Chemistry and Physics (Australia)<sup>22</sup>**



This decline in numbers undertaking the three primary science subjects was offset to some degree by increasing enrolments in newer alternative science subjects.<sup>23</sup> However the increase in the number of students taking "alternative" science has not been sufficient to offset the enrolment decline affecting the traditional discipline-based sciences. Whereas in 1980 the number of science enrolments exceeded the number of science students, in 1998 the situation had changed so that, on average, each student enrolled in less than one science subject (Table 9).

22 Goodrun *et al.* (2000: 20).

23 These include Environmental Science, General Science, Marine Science, Physical Science, Science for Life and Sports Science. In addition to this, a number of School Assessed Subjects (SAS) were introduced in the 1980s including Astronomy, Horticulture and Marine Studies.

**Table 9: #Year 12 Students and #Year 12 Science Enrolments from 1980 to 1998 (Australia)**

YEAR	TOTAL NUMBER OF YEAR 12 STUDENTS	TOTAL NUMBER OF YEAR 12 SCIENCE STUDENT ENROLMENTS	RATIO OF SCIENCE ENROLMENTS TO ALL STUDENTS
1980	89,038	115,535	1.30
1998	177,234	152,570	0.86

Gender take-up patterns for the different sciences are shown in Table 10.

**Table 10: Percentage of Science Subject Enrolments that Were Female (Australia 1980 and 1998)**

SUBJECT	1980	1998
Biology	65%	65%
Chemistry	37%	48%
Physics	25%	29%

Science occupies an important place within the secondary school curriculum in Victoria. All secondary schools in Victoria have a functioning science department with access to laboratory facilities, equipment, and laboratory support. A baseline survey commissioned by the Department of Employment, Education and Training confirms this picture,

*Secondary teachers mainly reported science equipment provision as adequate (58%) and laboratory technical support as excellent (58%), painting a reasonably healthy picture of science resource provision in Victorian schools (Gough et al. 1998).*

In spite of what would appear to be a generally satisfactory level of resource provision there remains "a crisis in secondary science education relating to increasing alienation of students to the formal science curriculum" (Tytler and Gough 2000:10)...

*In the area of science, a number of studies have shown a general decline in students' interest and enjoyment of science across the compulsory secondary school years. This decline in interest is greater for girls than boys.*

In 1998, as part of a broader government action on science and technology, the Victorian State Government identified science and technology as a major focus within its development strategy, and this led to a major set of initiatives on science in schools. *Science in Schools*

(SiS) was a key element of this strategy and included a number of strands of activity focussed on building the capacity of the school system in relation to science education. These included actions to build (i) the capacity of schools to plan for science (ii) professional development for teachers (iii) resources to support the teaching and learning of science (including access to on-line resources), and (iv) community partnerships to enable schools to work more closely with industry, parents etc. A recent review of these initiatives stated that:

*The experience of this project has convinced us that, to be effective, science education reform must be firmly positioned within a whole school change process (Tytler and Conley 2001).*

The authors imply that attempts to reform science education will not have maximum impact unless they link physical resources provision with the provision of support, professional development, and leadership at the school level.

### 3.1.2 Finland

The 1990s have been a period of reform in Finland including the introduction of a new curriculum framework in 1994 with a number of important consequences for science education. For example, all secondary students were required to include at least one physics course in their programme of study and all Finnish schools were required to provide students with access to a range of advanced physics options for further study (Ahtee 2000).

The curriculum changes have generally had the effect of emphasising the importance of practical work in science. While the study of chemistry, physics and biology is compulsory for all students, until age 15/16, there would appear to be some variability in the laboratory infrastructure to support this.

*The laboratories are generally well equipped. Practical work is usually carried out in small groups of 10-15 pupils (ICSTI 1999).*

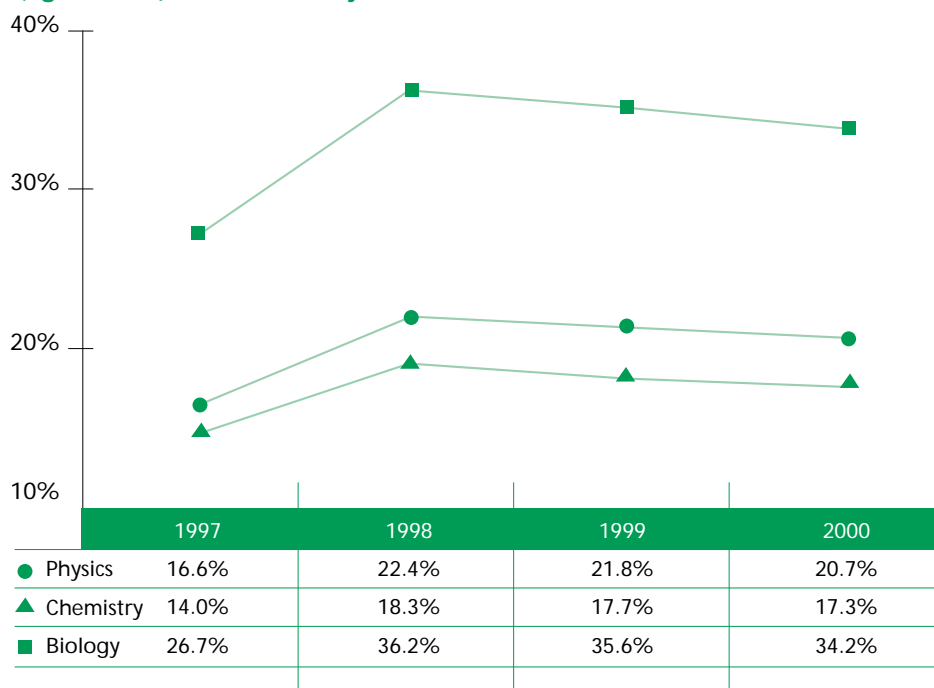
*...there can be 30 to 35 students in physics lessons. There are special laboratories for practical work in few senior secondary schools. That means that the experimental nature of physics is mostly shown in demonstrations or experiments carried out by the teacher (Ahtee 2000: 129).*

The Finnish Ministry of Education launched a development programme (LUMA) for mathematics and sciences in 1996. This programme was designed to address a number of concerns:

- too few pupils opting for physics and chemistry courses in school;
- the learning outcome is inadequate as regards experimental skills in these fields;
- too few subject teachers with majors in physics or chemistry;
- few women studying physics or technology;
- too few pupils opting for advanced courses in mathematics;
- the learning outcome in mathematics is inadequate, especially as regards application skills.

A full report will be published when the project concludes in 2002. However it would appear that the initial experience of LUMA has been positive in terms of its impact on student intake to school science courses (Figure 13).

**Figure 13: %Enrolment of Finnish upper secondary students (ages 16-18) in science subjects<sup>24</sup>**



The gender take-up has proved to be more resistant to change where the proportion has remained essentially unchanged from 1997 to 2000 (Table 11)

<sup>24</sup> Source: Finnish Ministry of Education (2002) *LUMA-PROGRAMME* Statistics. available online [http://www.minedu.fi/minedu/education/luma/statistical\\_data/stats\\_data/stats\\_pl\\_lukio.html](http://www.minedu.fi/minedu/education/luma/statistical_data/stats_data/stats_pl_lukio.html) (accessed February 2002).

**Table 11: Percentage of Science Subject Enrolments that were Female (Finland 1997 and 2000)**

	1997	2000
Physics	27%	28%
Chemistry	41%	42%
Biology	65%	68%

### 3.1.3 Scotland

General science is part of the core curriculum in Scotland up to age 14/15. Thereafter, the study of science is optional but throughout the 1990s science courses continued to be popular among secondary school pupils, with significant numbers taking Biology, Chemistry, Physics and Science courses (HMI 1999).

Thus, while concerns have been voiced around pupil attainment at primary and lower secondary levels, it would appear that science education in Scottish post-primary schools is generally in a healthy state. At lower secondary, practical work is a regular feature of most science lessons and is undertaken as a whole class activity with pupils working in small groups. This emphasis on practical work is facilitated by the fact that almost all classes are held in technician-supported laboratories with a maximum class size of 20. A recent report published by the Scottish Executive Education Department summarised the situation as follows:

*Accommodation and facilities for the sciences were very good in 20% of departments and good in a further 45% (HMI 2000: 19).*

In only 5% of schools were accommodation and facilities for science judged to be unsatisfactory while the management and planning of curriculum and resources is generally the responsibility of a "principal teacher".

*In most departments, resources were clearly catalogued, well-organised into kits and readily accessible to staff and pupils. Almost all departments gave careful attention to health and safety issues, including risk assessment of practical activities (HMI 2000: 19).*

The teaching of biology, chemistry or physics is normally carried out by specialists with an honours university degree or its equivalent in an appropriate subject (HMI 1994). In addition to this specialist teaching, most science teachers contribute to more general science courses for lower secondary students.

Recently there have been some concerns around a drop in uptake of science at "Higher" level (Jackson 2001). The Scottish branch of the Association for Science Education has commented on a decrease in the number of upper secondary science pupils thus:



*...our members report a disenchantment based on the idea that Science is "old-fashioned and out of date". A quick comparison of the 20-30 year old labs and Science equipment still in use in most of Scotland's schools with the new Technology and IT suites which have become commonplace over the last ten years will reveal where that misconception comes from (ASE 2001a).*

### 3.2 Higher Education – International Context

A general recognition of the impact of growing disenchantment with science among young people has motivated responses from third level science educators across the developed world. As far back as 1996, 28 countries (including 8 European) were represented at an International Conference on Undergraduate Physics Education (Redish and Rigden 1997). Though the objective of the conference was to explore the 'recalibration' of undergraduate Physics in the face of the changing needs of the contemporary employment market, many delegates cited dropping enrolments as an impetus for action.

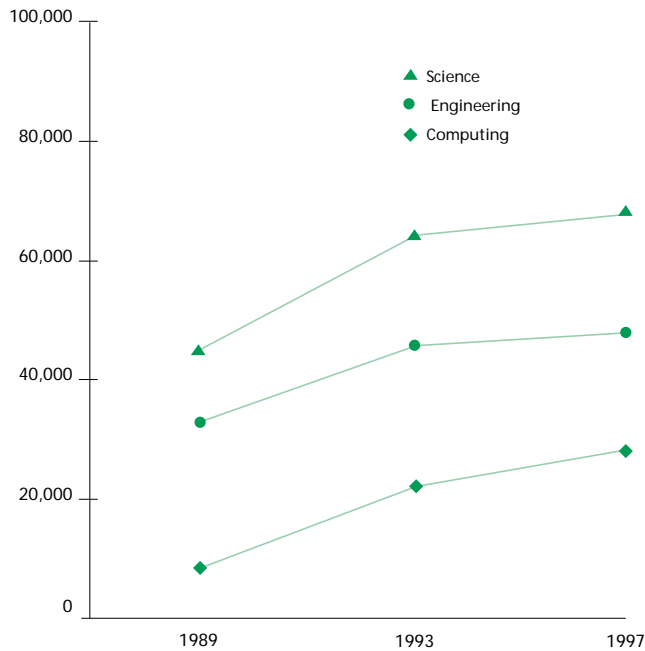
A communication from the Commission of the European Communities in December 2001, presented an action plan to achieve for Europe the position of the most competitive and dynamic knowledge-based economy in the world, based on promoting scientific education and culture throughout Europe. The Commission cited the threat posed to the labour market of the effects of a falling interest among young people in the study of science and the pursuance of scientific careers. This together with demographic trends, they noted, had the potential to jeopardise technological progress through the inability to supply qualified scientists and engineers to the workforce.

The particular concerns for the viability of science and science-related courses in higher education institutions in specific countries are not well documented. However there are citations of the difficulties in maintaining interest in the study of science (Sjoberg 2001; European Physical Society 1999). For instance, in the Netherlands there is a decline in interest in science and technology at university level, particularly in physics. In Japan a growing negative attitude on the part of third level students towards science and technology is expected to lead to a fall in recruitment to careers in the scientific/technological sector. The number of first year physics students in German universities fell by 50% between 1991 and 1998. Undergraduate physics degree awards in universities across the U.S. has fallen by 24% since 1989, in the same period in which overall bachelor degree graduate numbers have increased fourfold.

3.2.1 Australia (Victoria)

In a report produced by the Deans of Science of Australian universities (Dobson and Calderon 1999) concern is expressed about declining university enrolments in the "enabling" sciences.<sup>25</sup> The Victorian Tertiary Admissions Commission has compiled detailed statistics of student enrolment in universities in the state of Victoria between 1989 and 1997. Over this period there was an overall increase of 49% in enrolment on university courses (60% on bachelor programmes) because of policies related to university expansion. Over this same time science student numbers expanded by 57.9% and engineering by 47.6%. The broad field of study called science includes five major fields of study: general science, computer science, life science, physical science and mathematics.

Figure 14: Enrolments on science, engineering and computing courses in universities in Victoria



<sup>25</sup> The physical sciences, together with biology and mathematics are regarded as the "enabling" sciences, upon which are built the new sciences of information technology, biotechnology and nanotechnology.

**Table 12: Enrolments on science, engineering and computing courses in universities in Victoria (basis of Figure 14)<sup>26</sup>**

PROGRAMME	1989	1993	1997
Science	46,809	62,674	67,870
Engineering	33,178	45,715	48,958
Computing	13,897	21,004	27,991
Total	93,884	129,393	144,819

The majority of enrolments are on bachelor courses (science bachelor courses account for over 79% of enrolments). A small contribution (circa 5%) from diploma courses has dropped dramatically (by up to 50%) as such courses have been upgraded to bachelor.

The expansion of 57.9% in the broad field of study called science masks a much smaller growth of 28% in the physical sciences. In common with trends in Ireland, the major contribution to growth in science is the dramatically increasing participation in computing; in Victorian universities computing increased by 101% from 1989 to 1997. Data on first year enrolments are more effective in portraying trends in course popularity. These indicate a growth rate (during the same period) of 36.2% and 46.6% in engineering and science respectively, compared with a growth rate of 47.3% in total commencing enrolments. The contribution of computing to the figure for science is not available.

Data from Queensland and Victoria demonstrate that a large proportion of school leavers, well qualified to enter science courses in university, are choosing other subject areas instead. Engineering ranks slightly ahead of science as a higher education subject choice.

### 3.2.2 Finland

The gender specific objectives in the schools strategy of LUMA has led to an increase in the total number of enrolments onto third level science courses being mostly accounted for by the increased participation of women, particularly on physical sciences courses.

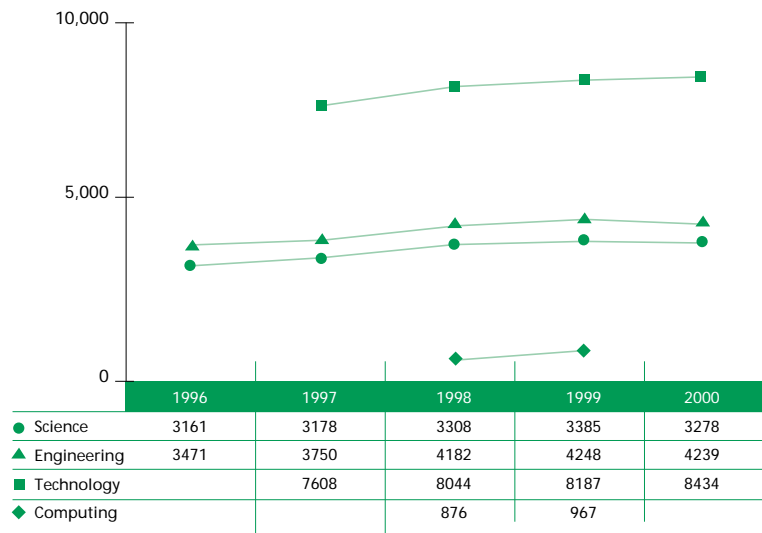
In higher education there are two parallel sectors, the universities and the polytechnics, divided along similar lines to the two higher education sectors in Ireland. Engineering and sciences account for the two largest fields of study in the universities, representing 21.3 % and 16.5% respectively of the total of new entrants (Patosalmi and Salenius 2000).<sup>27</sup> The emergence of computing courses has not adversely affected enrolment in the more traditional science subject areas. Engineering courses have not experienced a drop.

<sup>26</sup> The science and engineering plots represent 'broad fields of study'; the computing plot represents the portion of the science field of study that is accounted for by computing courses (source: Adapted from data on [http://www.acds.edu.au/TrendsInScienceEduc\\_CD.pdf](http://www.acds.edu.au/TrendsInScienceEduc_CD.pdf)).

<sup>27</sup> Corresponding figures for Ireland are 24.5% and 12.5% respectively (based on CAO acceptance data for the higher education sector for 2001).

The closest equivalent to the Irish engineering technician programme is the Technology and Transport programme in Finnish polytechnics; these courses have experienced an expansion of over 7.5% in enrolments since 1997.

**Figure 15: Entrants to science, engineering and computing courses in Finnish universities<sup>28</sup>**



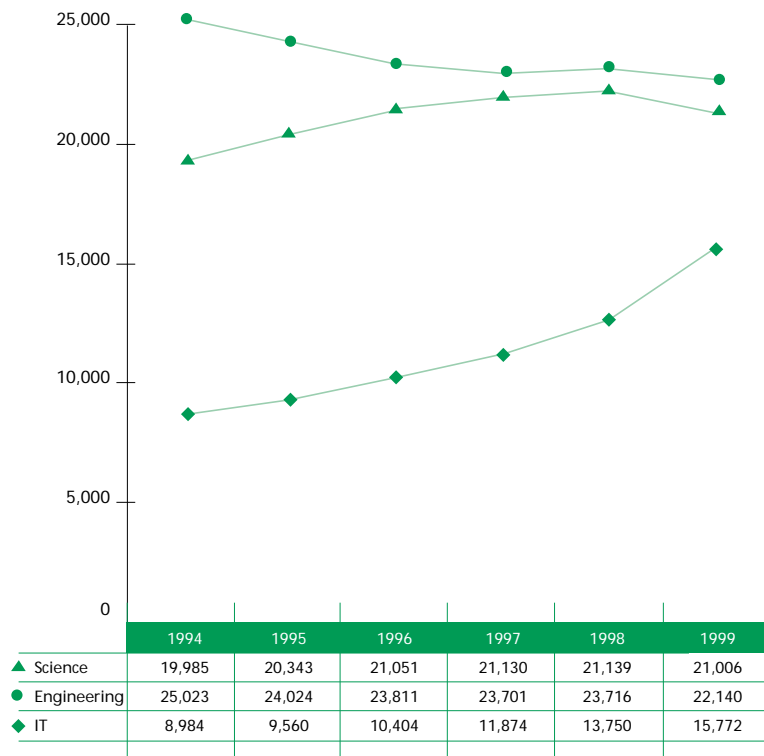
No decline is evident in the number of entrants to SET courses. Involvement in the LUMA project for the higher education sector is on a voluntary basis where individual institutions set targets for increasing participation in science, engineering and technology.

### 3.2.3 UK and Scotland

A review of supply and demand in respect of scientists and engineers within the UK (Roberts 2001) has revealed that numbers of students graduating in the physical sciences have fallen slightly in recent years; numbers graduating in engineering and technology have experienced a more marked decline. The review is in its initial phase and consultation with universities and industry is ongoing. A key issue will be the reassessment of the adequacy of the numbers of students enrolling on SET courses at third level. A survey carried out by the Undergraduate Physics Inquiry (Institute of Physics 2001) indicated that the demand for physics graduates was not matching supply, and recommended that government and its agencies should introduce inducements for students to study science subjects deemed to be important for national economic growth. The main concern was the severe shortage of physics teachers in schools and the loss of physics teachers from the profession; this crisis could have a serious impact on the future uptake of physics at third level.

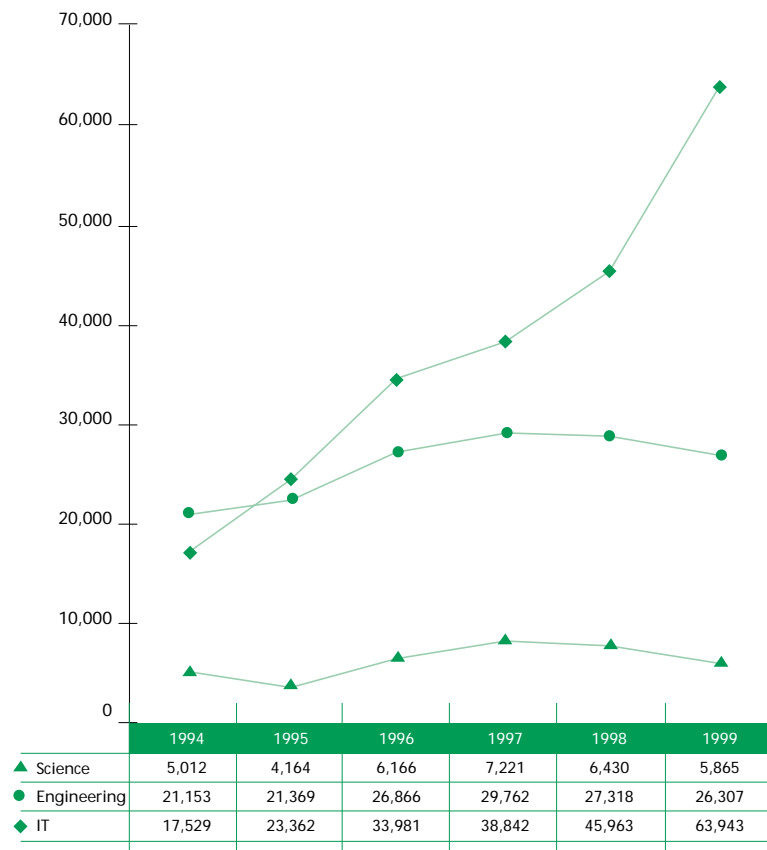
<sup>28</sup> Source: Finnish Ministry of Education (2002) LUMA-PROGRAMME Statistics. available online [http://www.minedu.fi/minedu/education/luma/statistical\\_data/stats\\_data/stats\\_pl\\_Jukio.html](http://www.minedu.fi/minedu/education/luma/statistical_data/stats_data/stats_pl_Jukio.html) (accessed February 2002).

**Figure 16: Total enrolment on Science, Engineering & Technology courses in Scottish universities<sup>29</sup>**



<sup>29</sup> Source: <http://www.scotland.gov.uk/stats/bulletins/00086-00.asp> (accessed February 2002).

**Figure 17: Total enrolment on Science, Engineering & Technology courses in Scottish institutions of further education<sup>30</sup>**

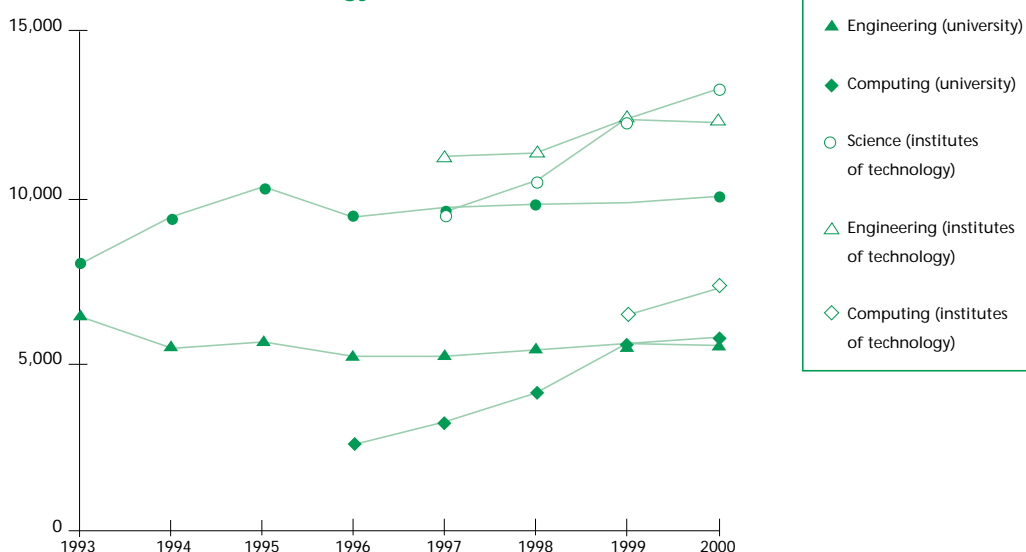


A study of trends in total students numbers in SET courses in Scotland demonstrates a marked expansion in numbers on computing courses.

This growth in computing in both higher and further education in Scotland is accompanied by a decline in engineering, particularly in the further education sector (which is equivalent to the institute of technology sector in Ireland).

For purposes of comparison the total (full-time) student numbers on third level SET courses in Ireland is provided in Figure 18. Comparison with Figures 16 and 17 indicates much similarity to the situation in Scotland in that the small changes in engineering and science enrolment contrast with a dramatic rise in computing enrolment.

30 Source: <http://www.scotland.gov.uk/stats/bulletins/00086-00.asp> (access February 2002).

**Figure 18: Total full-time enrolment on SET in universities and institutes of technology in Ireland<sup>31</sup>**


### 3.2.4 Participation by Gender

SET courses attract a significantly smaller proportion of female students than male. This disparity is predominant in engineering courses, less so in computing, and does not exist for the general science area of study. Participation by gender in Ireland is in line with that in the countries which were selected for comparative purposes.

**Table 13: Percentage of students on SET courses accounted for by women students<sup>32</sup>**

COUNTRY	ENG	COMPUTING	SCIENCES	PHYSICAL SCIENCES	BIOLOGICAL SCIENCES
Ireland (1st year Enrolment '99/00):					
Institutes of Technology:	14%	38%	61%		
Universities:	20%	31%	57%	51%	69%
Scotland (Total SET Undergraduate):	13%	29%		38%	64%
Finland (1st year Enrolment '99/00):	22%	24%		53%	78%
Victoria (Australia) '97 Total Enrolment:	14%		41%		

31 Data for universities from HEA: [www.hea.ie/pub\\_rep/Statistics/StatisticalReports.htm](http://www.hea.ie/pub_rep/Statistics/StatisticalReports.htm); Data for institutes of technology provided by DES Statistics section (note that science numbers here are inclusive of computing).

32 Scotland: Cronin *et al.* 1999; also <http://www.scotland.gov.uk/stats/bulletins/00086-09.asp>  
Finland: [http://www.minedu.fi/minedu/education/luma/statistical\\_data/stats\\_data/stats\\_ik\\_ala.html](http://www.minedu.fi/minedu/education/luma/statistical_data/stats_data/stats_ik_ala.html)  
Ireland: HEA; DES; also 3 university courses (600 students on each courses).



Task Force *on the* Physical Sciences

## ***Chapter 4***

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### **Issues**





## Issues

### 4.1 Take-up of Science in Schools

#### 4.1.1 Science at Junior Certificate

The review undertaken in the previous two chapters demonstrates two things in relation to science at the lower secondary stage of education:

- (i) *Ireland is unusual in not requiring students to study science at this stage of education.* In each of the three countries used as reference points by the Task Force (Finland, Scotland and Australia), science formed part of the core curriculum for this age group.
- (ii) *Girls are less likely to study science than boys, a difference which is attributable to school provision rather than student choice.* The most recent data available to the Task Force shows that the take-up rate for girls in single-sex schools is much lower than that for girls in mixed-gender schools, where it equals that of boys.

The Junior Cycle Review, conducted by the NCCA, proposed that all students should study either a Science or a Technology subject. Part of the rationale for allowing this element of choice would appear to derive from concerns about the level of resourcing of the system and...

*...a lack of facilities for Science and Technology across the post-primary sector. Ireland is one of the few countries which does not require a study of Science of all students at this stage of education. It may be necessary to re-visit this issue in the future when resources become available (NCCA 1999:25).*

At present a significant number of junior cycle students study neither Science nor a technology-based subject. In 2000/2001, for example, 12,133 students, (6.7% of the Junior Certificate cohort), were studying neither Science nor any of the technology-based subjects.<sup>33</sup>

The argument that Science should be included as a core component in the education of all students is strengthened by its inclusion as one of the three literacy domains examined by the OECD as part of the Programme for International Student Assessment (PISA).

*Scientific literacy is considered a key outcome of education by age 15 for all students, whether or not they continue to learn science thereafter. Scientific thinking is required by citizens, not just scientists. The inclusion of scientific literacy as a general competency for life reflects the growing centrality of scientific and technological questions. The definition used in PISA does not imply that tomorrow's citizens will need large reserves of scientific knowledge. The key is to be able to think scientifically about the evidence that they will encounter (OECD 2001b: 23).*

33 (i) Materials Technology (Wood), (ii) Metalwork, (iii) Technical Graphics, (iv) Technology.

Irish performance in PISA was relatively good; the mean scientific literacy score of Irish students was significantly higher than the OECD country average (9th overall). It is un-surprising that students who took Junior Certificate Science achieved a significantly higher mean score in scientific literacy than students who did not study science. However this result does point to the fact that the 11% of Irish students who do not take Junior Certificate Science are lacking "important scientific content knowledge" (Shiel *et al.* 2001: 19). It would appear that these students do not acquire sufficient "scientific literacy" from exposure to other curriculum areas such as technology.<sup>34</sup>

#### 4.1.2 Science at Leaving Certificate

An examination of trends in the take-up of science in schools shows a decline since the mid 1980s when, on average, each Leaving Certificate student took one science subject. As Table 14 shows this ratio fell to 0.8 science subject per candidate in 2001.

**Table 14: Total enrolments in Leaving Certificate science subjects relative to all Leaving Certificate subject enrolments (2001)**

LC STUDENTS	LC SCIENCE ENROLMENTS	RATIO OF LC SCIENCE ENROLMENTS TO ALL LC STUDENTS
108,542	86,542	0.80

Table 15 shows that, in 2001, the typical Leaving Certificate candidate sat an examination in:

- Mathematics;
- close to three subjects from the language group (typically Irish, English and another);
- a subject from the social studies group (History, Geography, Art, Music);
- and two subjects from the remaining three subject groupings i.e. Technology/Applied Science,<sup>35</sup> Business or Science.<sup>36</sup>

34 23.8% of girls in single sex schools who participated in the Irish node of PISA did not study science at JC level.

35 Home Economics, Construction Studies, Engineering, Technical Drawing, Agricultural Economics.

36 Physics, Chemistry, Physics & Chemistry (combined), Biology, Agricultural Science.

**Table 15: Relative numbers of Leaving Certificate candidates (all subject groupings)<sup>37</sup>**

LC SUBJECT GROUPING	1985	1990	1995	2001	CHANGE <sup>38</sup>
Languages	2.66	2.67	2.72	2.80	+14%
Social Studies	0.91	0.85	0.83	0.99	+8%
Mathematics	1.01	1.05	1.15	1.06	+5%
Technology/Applied Science	0.61	0.66	0.78	0.85	+24%
Business	0.74	0.88	0.66	0.69	-5%
Science	1.01	0.97	0.79	0.80	-21%

As Table 15 shows, during the period 1985 to 2001, the overall drawing power of science subjects relative to other subject groupings declined. Table 15 also suggests a re-distribution of candidates from the pure sciences to the technology and applied sciences subjects (although the tentative nature of this conclusion needs to be emphasised on the basis that there are significant annual variations between Leaving Certificate subject groupings).

This diminishing science uptake at Leaving Certificate is confirmed by an analysis of CAO applications. In 1999 for example, 29% of CAO applicants had not taken any science subject to Leaving Certificate, a deterioration from 23% of candidates in 1996 (Flanagan 2001).

#### 4.1.3 Relative popularity of different science subjects

There has been considerable discussion around the relative popularity of the physical sciences vis-à-vis the biological sciences. Table 16 summarizes the proportional popularity of the different science subjects with respect to the total population of Leaving Certificate science candidates.

<sup>37</sup> Number of examination candidates in LC subject grouping relative to number of candidates in LC English.

<sup>38</sup> Change relative to number of LC English candidates.

**Table 16: Relative Numbers of LC science candidates (base: all LC Science candidates)<sup>39</sup>**

LC SCIENCE SUBJECT	1985	1990	1995	2000
Biology	51%	54%	57%	58%
Physics	20%	21%	20%	19%
Chemistry	21%	17%	15%	15%
Agricultural Science	4%	4%	4%	6%
Physics & Chemistry	4%	4%	3%	2%

Table 16 demonstrates that, although the proportion of the Leaving Certificate science cohort taking Physics did not change much during the period under examination, the fractions taking Biology and Chemistry did show significant change. However it would not be correct to assume that Biology grew at the expense of Chemistry. In fact, in terms of appeal to Leaving Certificate students as a whole, the drawing power of nearly all of the science subjects fell during the period 1985-2000. As Table 17 shows, the popularity of Leaving Certificate Chemistry declined more rapidly than Leaving Certificate Physics which in turn declined more rapidly than Leaving Certificate Biology.

**Table 17: Relative numbers of LC science candidates (base: all LC candidates)**

LC SCIENCE SUBJECT	1985	1990	1995	2000
Biology	52%	52%	52%	46%
Physics	21%	20%	18%	15%
Chemistry	21%	17%	14%	12%
Agricultural Science	4%	4%	4%	5%
Physics & Chemistry	4%	4%	3%	2%

Table 18 shows participation rates calculated with reference to the number of students who are in schools where the relevant science subjects are provided. As might be expected these rates are higher than the rates usually quoted which are based on the entire student cohort (and which are calculated without regard to whether students may actually be "offered" a subject).

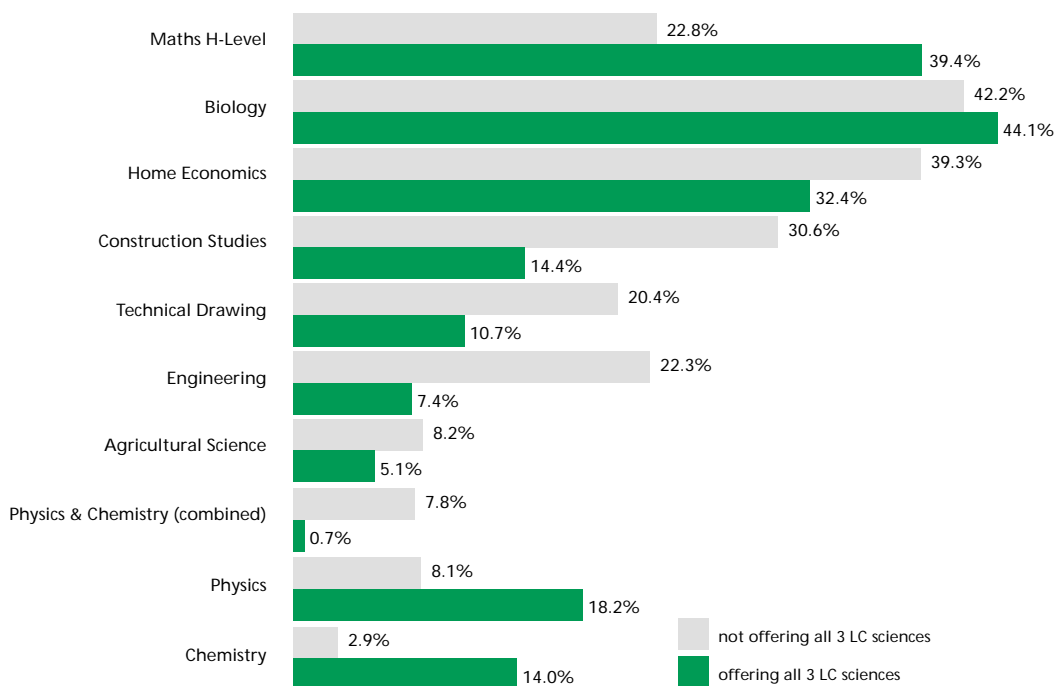
<sup>39</sup> Number of candidates in LC science subject relative to total number of examination candidates in all LC science subjects.

**Table 18: Take-up of 3 principal Leaving Certificate science subjects (2000/2001)**

	Basis for calculation of take-up rate (number of schools shown in parentheses):		
	LC pupils in all post-primary schools	LC pupils in schools offering subject	LC pupils in schools where all 3 sciences available <sup>40</sup>
LC Biology	43.7% (727)	44.2% (704)	44.1% (487)
LC Chemistry	12.0% (727)	13.9% (536)	14.0% (487)
LC Physics	16.4% (727)	18.5% (566)	18.2% (487)

Figure 19 shows a comparison between the 240 schools that do not show take-up in the 3 major Leaving Certificate science subjects and the 487 schools that have students enrolled in each of Leaving Certificate Physics, Leaving Certificate Chemistry and Leaving Certificate Biology.

**Figure 19: Curriculum take-up comparison on basis of whether schools offer all 3 Leaving Certificate sciences**



As Figure 19 demonstrates, schools that do not offer the three sciences as separate subjects tend to have higher student uptakes in the technology subjects i.e. Construction Studies, Engineering and Technical Drawing. It can also be seen that the lower take-up of students in mainstream Leaving Certificate Physics and Leaving Certificate Chemistry, is offset to some extent by higher numbers of students enrolled in Leaving Certificate Physics & Chemistry (combined).

<sup>40</sup> There is a total of 88,807 LC students in the 487 post-primary schools that offer LC Physics, LC Chemistry and LC Biology.

#### 4.1.4 Provision of Leaving Certificate physical science subjects in schools

Table 19 illustrates how the non-availability of the three principal science subjects impacts on schools and students. At first glance it appears that Leaving Certificate students are significantly less likely to have access to the study of physics and chemistry relative to biology. On a relative basis, there are few Leaving Certificate students in schools which do not offer Leaving Certificate Biology (1,197) relative to the numbers of students in schools which do not offer Leaving Certificate Physics (12,296) or Leaving Certificate Chemistry (15,129).

**Table 19: Relative availability of principal Leaving Certificate science subjects (2000/2001)**

	BIOLOGY	PHYSICS	CHEMISTRY
# schools offering subject	704	566	536
# LC students in schools offering subject	107,345	96,246	93,413
# schools not offering subject	23	161	191
# LC students in schools not offering subject	1,197	12,296	15,129
% LC students in schools not offering subject	1.1%	11.3%	13.9%

However this analysis ignores the availability of the third Leaving Certificate physical science subject i.e. Physics & Chemistry (combined). Although the combined subject is offered in a relatively small number of schools, the fact that these are generally schools where neither Leaving Certificate Physics or Leaving Certificate Chemistry are available does have the effect of significantly extending student access to the physical sciences. And, similarly, although take-up of Physics & Chemistry (combined) is low on a national basis (2.0% of all Leaving Certificate students), the take-up rate in those schools where the subject is provided, at 17.7%, is comparable to the take-up of Leaving Certificate Physics or Leaving Certificate Chemistry (Table 20).

**Table 20: Take-up of Leaving Certificate Physics & Chemistry (combined)**

	PHYSICS & CHEMISTRY (COMBINED)
# schools offering subject	93
# LC students in schools offering subject	12,339
# LC students taking subject	2,182
% take-up of subject in schools offering subject	17.7%

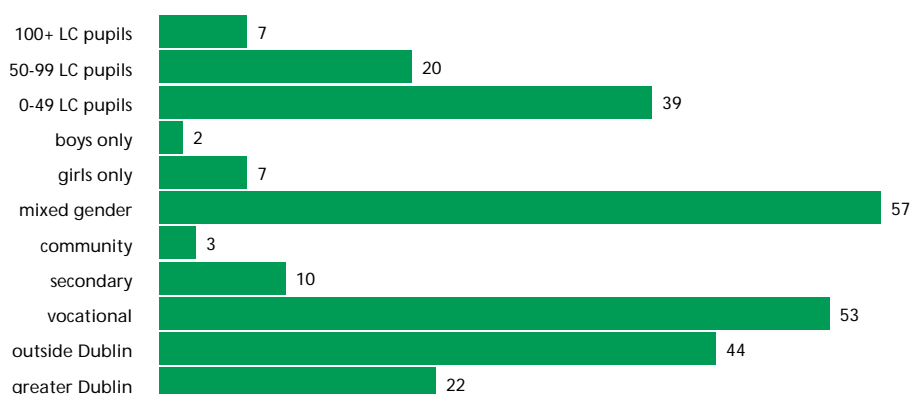
Thus nationally, only 3,332 students, representing 3.1% of the Leaving Certificate cohort, are enrolled in schools where none of the three physical science subjects is available (Table 21).

**Table 21: Provision of any Leaving Certificate physical science subject**

	ANY LC PHYSICAL SCIENCE SUBJECT
# schools offering	661
# schools not offering	66
# LC students in schools offering	105,210
# LC students in schools not offering	3,332
% LC students in schools not offering	3.1%

As Figure 20 illustrates, schools with no physical science uptake are typically small mixed-gender vocational schools located outside the greater Dublin area.

**Figure 20: Profile of 66 post-primary schools with no physical science take-up<sup>41</sup> at Leaving Certificate (2000/2001)**



<sup>41</sup> Physical science take-up is defined as students enrolled on any of the three physical science subjects i.e. (i) Physics, (ii) Chemistry or (iii) Physics and Chemistry (combined).

## 4.2 Student Attitudes

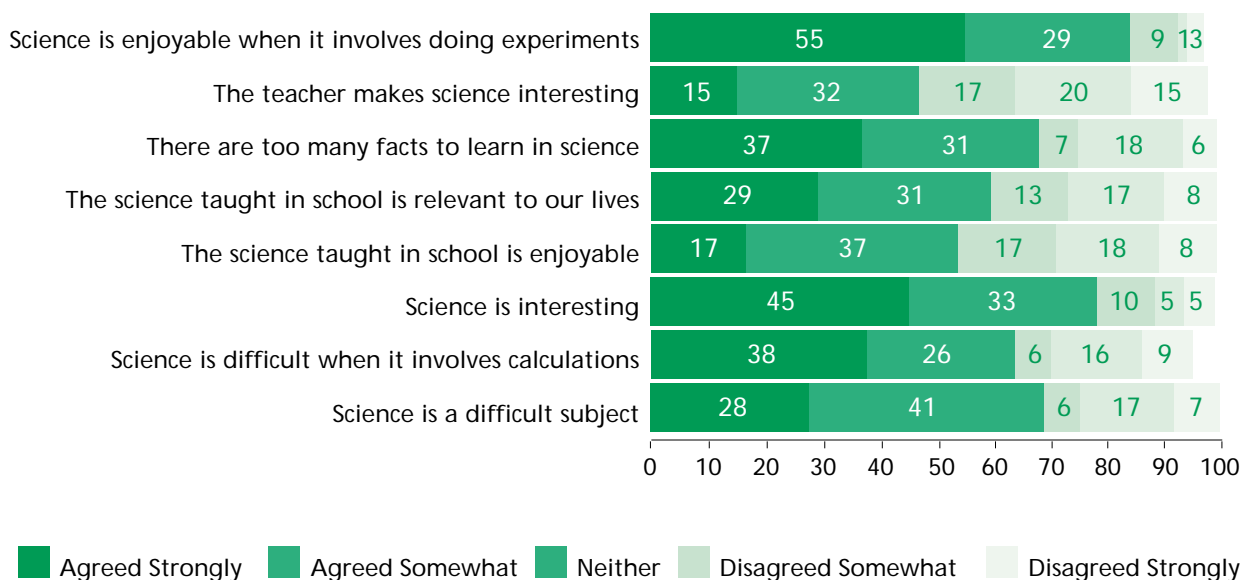
### 4.2.1 Student Attitudes towards Science in Society

The Task Force survey shows that Irish students generally have very positive attitudes about the contribution that science makes to society. Nearly all pupils, from first year to sixth year, believe that science makes the world a better place, improves people's general health and is important for Ireland's development. It is interesting that these positive attitudes exist, irrespective of whether students have chosen to study science or not. However a difference in opinion does manifest itself in relation to perceptions as to how useful or otherwise science is for solving everyday problems. Students who are not studying the physical sciences to Leaving Certificate do not hold the same strength of belief in its usefulness.

### 4.2.2 Student Attitudes towards School Science

Attitudes towards science become less positive as students get older. This decline manifests itself in the development of more negative views around science in schools. Students at the end of the Junior Certificate Science programme, while still agreeing that science is interesting, are less likely to agree that the science taught in school is enjoyable. They are also more likely than first year students to agree that science is a difficult subject (Figure 21).

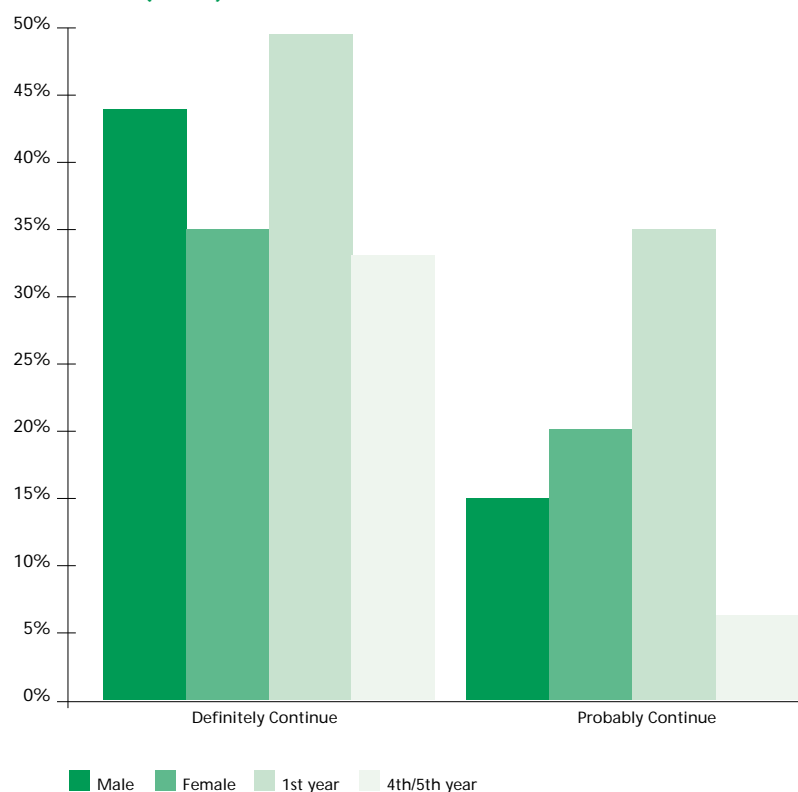
**Figure 21: Student perceptions at end of Junior Certificate Science (4th/5th years, n=143)**



The fact that attitudes are formed at an early age is illustrated by the results of a survey question on whether students would, given the choice, continue to study science. As early as term one in first year, 8% of students state that, given the choice, they would definitely not continue to study science.



**Figure 22: Students' interest in continuing the study of science (MRBI)**



The survey responses to this question also demonstrate the decline in interest during the course of the Junior Certificate. In first year, 83% of the cohort indicate that they will either "definitely" or "probably" continue to study science. By the time students have completed Junior Certificate Science, interest has declined to the extent that only 39% of the cohort indicate that they will continue to study science (Figure 22).

These results were confirmed by another survey question that asked students to rank science in relation to their other school subjects. 31% of students at the end of Junior Cycle did not rank science within their top four subjects, in comparison with 18% of students starting Junior Cycle. There was also a gender difference evident where 32% of girls did not rank science in their top four subjects, in comparison with 20% of boys.<sup>42</sup>

These findings are in line with those identified outside Ireland, as illustrated by the following observation from Australia.

*The decline in interest in science is particularly sharp, however, across the primary – secondary school transition. This decline in interest in the early years of secondary school is particularly of concern, since it is in these years that attitudes to the pursuit of science subjects and careers are formed (Tytler and Gough 2000:10).*

<sup>42</sup> It was however interesting to note that science was more likely to be ranked as favourite subject by girls (11%) than boys (7%), and 4th/5th years (11%) than 1st years (5%).

### 4.2.3 Reasons for not choosing Science

The Task Force survey asked students in the senior cycle<sup>43</sup> about the importance of different factors on subject choice. The responses were generally highly consistent, regardless of the student year (i.e. Fourth Year, Fifth Year, Sixth Year), or the subject (Physics, Chemistry or Biology) or whether the students were studying the subject or otherwise (Figure 23).

**Figure 23: Student perception of factors in choosing/not choosing Leaving Certificate science subjects<sup>44</sup>**

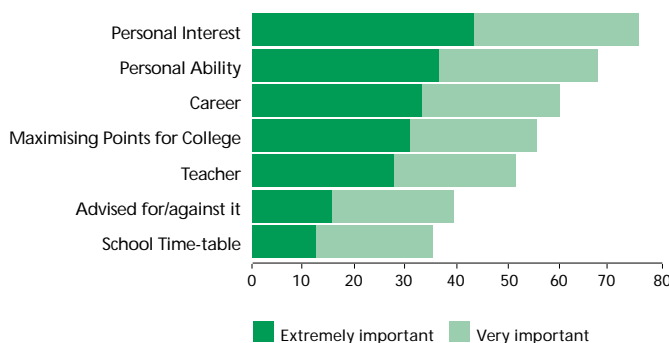
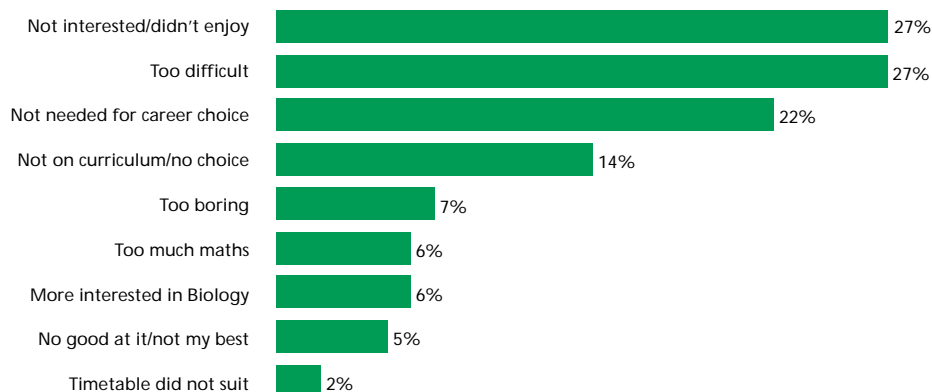


Figure 23 indicates that the principal factors influencing post-primary students in their subject choice for Leaving Certificate are: (i) personal interest, (ii) personal ability and (iii) perceived need of the subject in terms of college course or career. This conclusion appears to be confirmed by responses to another open-ended question directed at students who had not chosen a physical science subject for Leaving Certificate. This sample of students were most likely to say that they did not choose Physics or Chemistry for Leaving Certificate because of the difficulty of the subjects, or because they weren't interested in or didn't enjoy the subjects. The third most likely reason identified was that they didn't need the subjects for their chosen career (Figure 24).

**Figure 24: Reasons for not choosing Physics or Chemistry (6th year students, n=101)**



43 The senior cycle cohort is made up of students enrolled in the Transition Year and the Leaving Certificate programmes.

44 Based on 738 responses from 315 students (students were questioned on factors in relation to more than one leaving certificate subject).

Clearly many of these students have arrived at the conclusion that they do not enjoy or are "not good at" the physical sciences. A large proportion of students (73%) indicate that Junior Certificate Science had some impact on their decision not to study physics or chemistry to Leaving Certificate. Interestingly, experience of Junior Certificate Science was much more likely to be identified as having had a negative impact on their decision by girls (51%) than by boys (18%). There are also gender differences in perceptions of difficulty: more girls (35%) than boys (18%) state that physics and chemistry are "too difficult".

Students agreed that they would be more likely to choose the physical sciences subjects if it was *easier to get good grades* (50%) and if the subjects had *less mathematics and calculations* (40%). The survey findings indicate that these changes are more likely to influence students than including *practical work in the exam* (32%) or *more practical work in class* (34%). Only 18% of students say that they would be more likely to choose a physical science subject if they had a different teacher.

### 4.3 Differences between Schools

The first results from PISA 2000 identified some school resource factors, school policies and classroom practices that appeared to make a difference to student performance.

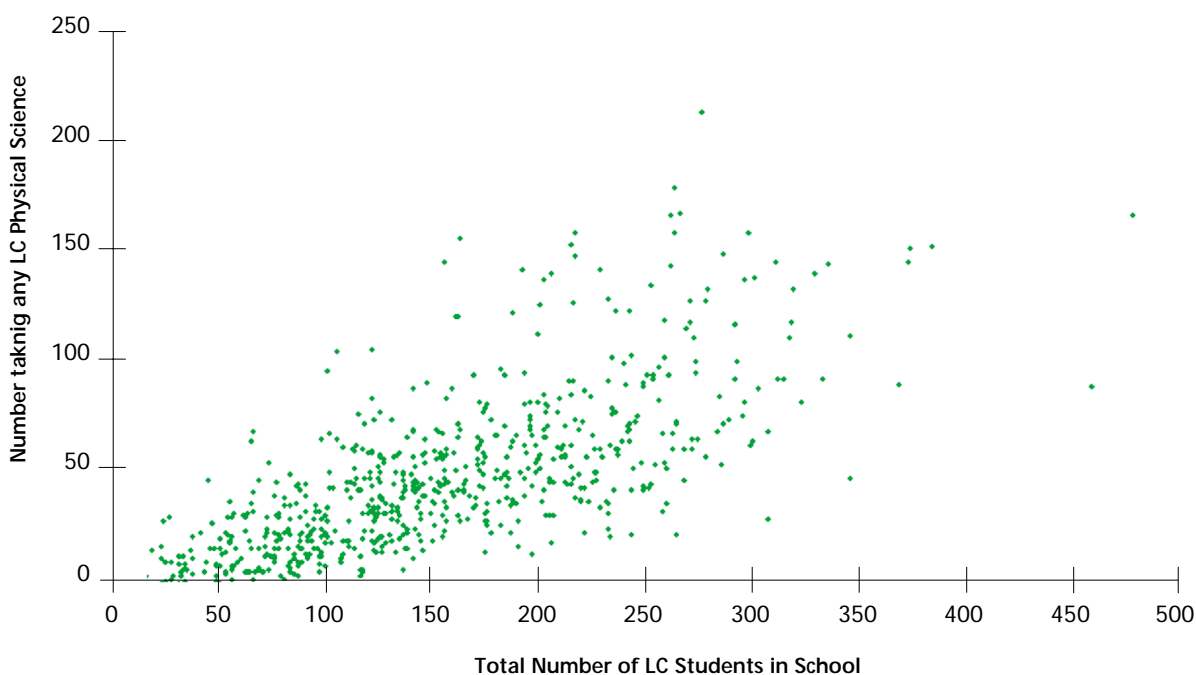
*The extent to which students make use of school resources, and the extent to which specialist teachers are available, can both have an impact on student performance (OECD 2001b: 212).*

It is, however, important to bear in mind the proviso that successful performance in PISA was attributable to a constellation of factors, including school resources, school policy and practice, and classroom practice. The impact of school- and system- level factors will be explored in greater detail in a series of thematic reports to be published by the OECD in 2002 and 2003.

Examination of subject take-up data for each of the different Leaving Certificate sciences confirms that large differences exist between post-primary schools. Schools with the same number of Leaving Certificate students show large variations in the numbers of students taking the physical sciences.<sup>45</sup> This is illustrated in Figure 25 where each data point represents an individual school.

<sup>45</sup> The same level of inter-school variability exists when physical science take-up is plotted against the number of students taking LC higher level Mathematics (2000/2001).

**Figure 25: Variability in take-up of Leaving Certificate physical sciences between schools (2001)**



Research conducted by the ESRI has demonstrated the strong influence of schools on subject take-up even when controlling for differences in student intake (Smyth 1999). Other work indicates that school Principals consider school policy to be an important factor, second only to needs of students, in determining the subjects offered to students

*Primary school headteachers have overall responsibility for the curriculum, which includes making decisions about when science should feature on the school development plan. They have an important role to play (NCCA 1999:17).*

It is interesting to disaggregate pupil responses to the Task Force survey on the basis of whether pupils are in schools with high or low science take-up rates. In both sets of schools students not choosing the physical sciences identified "personal ability" and "personal interest" as the principal reasons for not choosing the subjects. However, Leaving Certificate students in "low science" schools identified "school timetable" and "teacher" as being of next greatest importance (from the five remaining factors). In comparison, students in schools with high enrolments in the physical sciences ranked "school timetable" and "teacher" as being the least important out of the seven factors.

Thus the Task Force survey would seem to suggest that, while the main inhibitors of science take-up are students' self-perceptions of interest and ability, teaching and timetabling can also be important influencers. These findings indicate that school-level action is needed in tandem with other actions aimed at influencing student choice and perceptions of ability.

The twelve schools included in the Task Force Case Studies demonstrate a commitment to teaching science as a practical subject.

*In all of the schools, the teachers considered practical work as being crucial at Junior Certificate level. The teachers stated that they spent approximately half of their time doing practical work, though sometimes more in first year and less in third year (Finlayson & Killen 2002).*

The level of laboratory provision within the twelve case study schools was found to be greater than the national average and thus would tend to support the belief that there is a significant emphasis on practical work. However, there was no attempt made to establish whether the level of practical work within these schools is above the norm for all post-primary schools.<sup>46</sup> In-depth case study research to examine factors that operate "on the ground" to facilitate or constrain the take-up of specific subjects has been completed by the Economic and Social Research Institute (ESRI) and is likely to be published during early 2002. The level of "emphasis on laboratory-based work" is one of the factors examined in this research.

#### 4.3.1 Classroom Practice

Submissions to the Task Force suggest some consensus as to what constitutes desirable practice in school science. These views are exemplified by the following quotation summarising findings from international research conducted in schools across Germany, the Netherlands, USA and Sweden. This research suggests a number of practices associated with effective science teaching,

*a high level of student involvement and enthusiasm; increased student initiative in the learning process; a lot of group work and interaction; teaching involving stimulation and facilitation; increased variety of resources (materials and objects) and experiences; extensive integration of science topics with project-oriented activities over a long period; and a lot of emphasis on process skills for exploration, learning to learn, and attitudinal goals such as curiosity, precision and perseverance' (van den Akker 1998, p.426).*

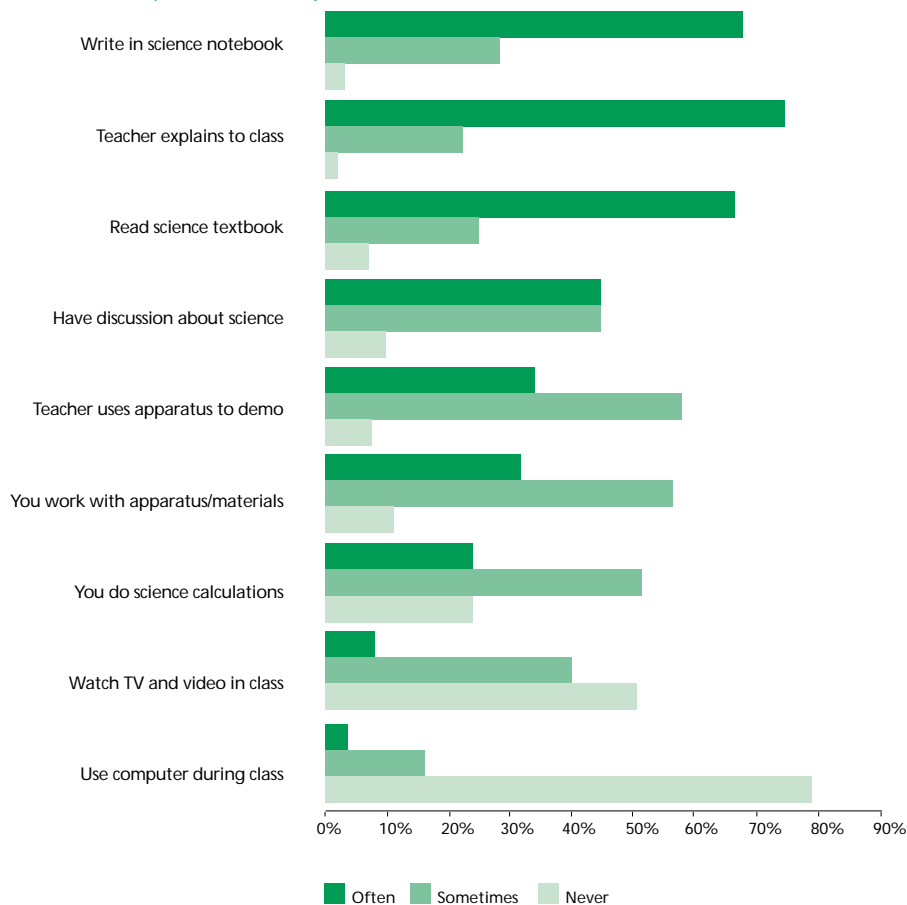
Another submission points out the need for quantitative information on what actually takes place in Irish science classrooms.

*There is little real information on teaching and learning practice at both second and third level, although there is plenty of anecdotal evidence. It would be useful to identify innovative Irish practice anywhere, review it and disseminate it to teachers at the appropriate level (DLIADT Science 2001).*

<sup>46</sup> It is regrettable that there is no definitive picture of the extent of practical work in Irish schools. The Task Force survey does provide some baseline data although this is based on student response rather than classroom observation.

The absence of this sort of comprehensive baseline data, while understandable within the context of limited resources of time and manpower, is regrettable.

**Figure 26: How frequently students engage in activity in science class (MRBI, n=348)**



As part of its survey of student attitudes the Task Force has sought to capture student perspectives on classroom activities in science. The results (Figure 26) indicate that the most frequent activities are (i) teacher explaining to class (ii) students writing in notebooks and (iii) students reading science textbooks. Thus the findings are in line with the views of the Irish Council for Science Technology and Innovation (ICSTI) which has commented on classroom practice in Ireland in the following terms:

*Traditionally science teaching in Ireland has been largely didactic (formal presentation) with teachers and students performing clearly defined experiments as prescribed. The 'cook book' metaphor for experimentation is apt (ICSTI 1999:20).*

At the same time it would also seem that practical work is more frequent than is sometimes supposed. Around 50% of science students report that they "do experiments in the laboratory" on a weekly basis. This finding seems to be fairly consistent across different age groups, i.e. there is little change from first year to sixth year.

It also seems to be the case that, for some students, science is taught without any opportunity for practical "hands-on" learning. Responses from around 10% of science students indicate that they never work with apparatus or materials. This finding appears reasonably stable from first year to sixth year.

Table 18 shows the results when MRBI asked students to classify classroom activities on the basis of how enjoyable they found them. The results indicate that, more than anything else, students enjoy practical work in science; and again this finding is consistent from first year (entry) to sixth year (leaving) of second-level schools. Even sixth year students who are not studying a physical science subject identify practical work as enjoyable, based on their experience at lower secondary level.

**Table 22: How enjoyable students find activities in science class (MRBI, n=348)**

	MEAN SCORE <sup>47</sup>
Use computer during class	2.4
Watch TV and video in class	2.5
You do science calculations	1.9
You work with apparatus/materials	2.7
Teacher uses apparatus to demo	2.4
Have discussion about science	2.5
Read science textbook	1.9
Teacher explains to class	2.1
Write in science notebook	1.9

The MRBI finding, that students find practical work enjoyable, is in line with research findings outside Ireland. A review of research on good practice in science teaching summarised the situation in relation to practical work thus:

*On the whole, pupils enjoy practical work and develop positive attitudes to it (Watson 2000:59).<sup>48</sup>*

Further support is provided by the findings of a review of science in over 700 UK schools:

*Pupils' attitudes are most positive when they are involved in practical work (OFSTED 2000).*

<sup>47</sup> higher score=more enjoyable.

<sup>48</sup> Of course the assertion that students enjoy practical work needs to be qualified. Watson (2000:59) points out that "what appears to be important is not whether pupils do practical work but the kinds of practical work used".

## 4.4 Curriculum and Assessment

### 4.4.1 Curriculum Outcomes

An effective science curriculum must address the needs identified by many different stakeholders. Primarily it must challenge and engage students. It must do this in the context of learners who may have different needs, abilities and goals. It must provide students with sufficient knowledge and skills for active participation as citizens in a technology-rich world. It must offer a framework within which teachers can work in an effective and creative manner. It must provide linkages, impetus and progression to further study and employment in the science-based industries.

There are a significant number of positive outcomes associated with the present science curriculum in schools. These include,

- strong performance of Irish students in the recent PISA (OECD) study of levels of scientific literacy;
- positive attitudes of many students towards practical work in schools;
- high importance attached by all students to a school education in science and the contribution of science to society;
- high "subject satisfaction" ratings evident in the survey responses of many upper secondary students of the physical sciences;
- high levels of student participation and enthusiasm demonstrated in events such as the Young Scientist Exhibition and local science fairs and the strong performance of Irish students in international science fairs and Olympiads.

While recognising these strengths, the consultation and research carried out by the Task Force - most particularly the survey conducted by MRBI - has pointed to the need for action in relation to the curriculum.

### 4.4.2 Science as General Education

There is a general consensus on the need to move away from descriptions of curriculum, typified by listings of factual knowledge, towards models of provision which emphasise skills, particularly skills related to building a capacity for future learning.

*Education, at the end of the 20th century, no longer prepares individuals for secure, lifelong employment in local industry or services. Rather, the rapid pace of technological change and the globalisation of the marketplace have resulted in the need for individuals who have a broad general education, good communication skills, adaptability and commitment to lifelong learning (Millar and Osborne 1998).*



An education in science can make an important contribution to inculcating and developing life-long learning skills.

*Over the past 25 years "learning to learn" has become the only policy common to all countries seeking to transform science education (OECD 1998).*

Thus while an education in science can be perceived as having a direct vocational benefit in terms of enhancing employability, it can also help to inculcate important generic skills which help to build a capacity for future learning.

*Curriculum reform for the Information Age is to provide citizens with higher order thinking skills, intellectual adaptability, and the ability to manage knowledge... The generic work skills sought are those associated with the access, processing, and utilization of knowledge. These skills are also primary goals of education in the sciences (DeHart Hurd 2000).*

In the Irish context, the revised primary curriculum has identified the part that subject-related curriculum areas can play in developing generic skills...

*...such as creative problem-solving, critical thinking, interpersonal and intrapersonal skills, and the importance of helping children to investigate, to question, to observe and to make informed judgements. The development of these higher-order thinking skills is incorporated in every curriculum area (NCCA 1998).*

This thinking (i.e. that a generic framework should inform the development of curriculum at the subject-level) also informs the curriculum design process within other national systems. In Australia, the National Goals for Schooling provide an agreed curriculum framework operating at the national level. These national goals are defined in terms of broad generic outcomes,

*When students leave school, they should have the capacity for, and skills in, analysis and problem solving and the ability to communicate ideas and information, to plan and organize activities, and to collaborate with others (DETYA 1999).*

At the same time it is important to acknowledge that a gap can exist between the curriculum as planned and the reality as implemented in the classroom as illustrated by the following observation (Tytler 2001).

*In Western Australian (and presumably Victoria)... 'teaching tends to be a headlong rush through the crowded curriculum with little time for higher order thinking skills' (Chadbourne, 1995, p.4). These demands drive the teaching strategies that are turning these students off in the lower secondary school.*

### 4.4.3 Curriculum Goals

Many commentators outside Ireland have expressed the view that the existing science curriculum, as implemented within their own national systems, has emphasised preparation for further scientific study at the expense of a broader curriculum. The following quotes are from the UK and Norway respectively.

*Our view is that the form of science education we currently offer to young people is outmoded, and fundamentally is still a preparatory education for our future scientists (Millar and Osborne 1998).*

*Although very few pupils will pursue further studies in science, preparation for such studies seems to be a guiding curriculum principle. There is often repetition, where the same concepts and laws are presented year after year. Such curricula and textbooks often lead to rote learning without deeper understanding (Sjoberg 2001).*

Several submissions to the Task Force have drawn attention to similar issues in an Irish context.

*The new syllabus in physics is a considerable improvement on what it replaced. But problems remain. Much was made during the introduction of the new course of what was referred to as STS (science and technology in society). The newer textbooks have clearly made an effort to reflect this. But many highly abstract topics remain central to the course....(Tierney 2001).*

The NCCA has outlined the challenge in the following terms,

*Clearly, a new kind of Junior Certificate syllabus and course is required, one that concentrates less on factual content and puts greater emphasis on key concepts in science and technology, but which also catches the imagination, providing opportunities for students to engage with great ideas and the lives of great scientists and technologists, to talk about these and to explore possible future developments in science and technology. Understanding of the key concepts can be supported through practical investigations that emphasise the process skills required to solve relevant problems (NCCA 2000).*

#### 4.4.4 Curriculum Content

The Task Force has been pleased to note that new primary science curriculum gives appropriate attention to the balance between the physical sciences and the biological sciences.

Concerns have been raised about curriculum imbalance between physical and biological sciences at lower secondary level, however.

This issue of curriculum balance was explored in the Case Study research commissioned by the Task Force.

*When asked how the time spent on practical work was divided between biological/life sciences and physical sciences, the majority indicated a one third to two-thirds split in favour of physical sciences, though in one school (school F), the time split was equally divided between these two areas, and in another school (school A), it was 80% in favour of physical sciences (Finlayson and Killen 2002).*

It is also the case that relative performance by post-primary students in physics, chemistry and biology was broadly similar in the 1998 Junior Certificate Science examination, the most recent year for which an Examiner's Report is available.<sup>49</sup>

However the above data does not present a comprehensive analysis of the situation. The Case Study schools are not a nationally representative sample as they were selected on the basis of demonstrating high take-up within the physical sciences.

Similarly, while the recent examiners' reports do not appear to support the argument of curriculum imbalance, it is clear that examination performance may not provide the full picture. It has been suggested that the wide range of choice afforded to students in the Junior Certificate Science examination "has compounded the under-emphasis on Chemistry and Physics" (Shiel et al. 2001:139).

It seems likely that the new Junior Certificate Science syllabus will address this issue of balance between the different sciences.

*The NCCA is at present undertaking a review of the Junior Certificate Science syllabus in the light of concerns that elements of physics and chemistry are under-represented in the core and the applied science extensions. Under this review, the present syllabus is being restructured and a framework that will give equal emphasis to its three components – biology, chemistry, and physics – is being considered (NCCA 2000:16).*

<sup>49</sup> Overall performance was computed as Physics=67.6%, Chemistry=64.7%, Biology=68.0% and is based on student performance on questions 1-9. Performance on the Applied Science questions (10-15) has not been included.

Another concern is that the content of the present Irish science curricula may be out-dated. This is illustrated by a recent comparative analysis between OECD PISA questions and the Junior Certificate Science curriculum, which demonstrated that much of the PISA content would be unfamiliar to students who had taken Junior Certificate Science (Shiel et al 2001). As a consequence, the Irish syllabus does not appear to map well onto the concept of "scientific literacy" as defined by the OECD.

#### 4.4.5 Assessment

There is a need to clearly identify the expected outcomes of a science education, and to ensure that assessment is matched to these outcomes. Many submissions to the Task Force point to deficiencies in the present assessment system. There is a belief that, in common with criticisms of science curricula outside Ireland, the present assessment models do not promote higher-order skills.

*This type of superficial understanding of science can still allow pupils to do well in terminal exams but fails to engage them in any meaningful way (McElwee 2001).*

The Task Force recognises that while it is not difficult to point out existing deficiencies, it is more challenging to clarify precisely how best to remedy them in the context of a high-stakes assessment system. That is not to say that action should not be taken.

There is one issue on which the submissions to the Task Force demonstrate an almost universal consensus, namely the need to assess practical work. However, it is recognised that a necessary prerequisite to introducing practical assessment, is the need to achieve some consensus on what the intended outcomes are of undertaking practical work in science. It has been suggested that these are not well defined at present.

*... there is little or no discussion about the nature of the practical work and whether or not it achieves the aims outlined in the curriculum (DLIADT Science 2001).*

This clarification is something which needs to be achieved both at a national level, in terms of the work of bodies such as the NCCA, and at schools level. The following observation from Scotland illustrates the point.

*Practical work forms an essential component of science provision in both primary and secondary schools. Pupils enjoy doing practical work since it gives them opportunities to be active in different ways and to interact with their teachers on a less formal basis than normal...Because practical work is expensive of time and resources, teachers need to be very clear about the learning outcomes which are intended. Practical work should be structured and purposeful, with clearly defined goals for pupils to achieve (HMI 1999: 13).*

Clarity on the rationale for practical work can provide the basis for the development of an appropriate assessment model or models. Submissions to the Task Force show that there is clearly a desire that these should be as flexible as possible. Suggestions have included,

*....A requirement of a student portfolio of practical work (investigations, projects field work etc) along with a practical test of experiments and techniques could be used as a starting framework....Outside activities such as participation in science exhibitions or competitions could also contribute to the 'practical profile' that students assemble during school years (Royal Irish Academy Working Group 2001).*

#### 4.4.6 Comparability of Grading

Many of the submissions to the Task Force have drawn attention to the difficulty of obtaining high grades in Physics and Chemistry vis-à-vis other Leaving Certificate subjects. This issue is perceived to be an impediment to the selection by students of the physical sciences subjects at second level. The following quotation is representative of the concerns raised.

*One major contributor to the low uptake of physical science subjects at Leaving Certificate level is the comparative difficulty of achieving high grades in the physical sciences. This is pupil, parent, and teacher perception, but one which is grounded in reality. Failure to pay adequate attention to this factor has probably been a major contributor to decline in uptake of the science subjects (TUI 2001).*

A longitudinal study on student performance in the 1996 Leaving Certificate Examination (LCE) provided evidence of the variation in grading patterns across subjects. It did this by relating overall performance in the Junior Certificate Examination (JCE) with performance at Leaving Certificate level.

*....candidates were more likely to be awarded low grades in the science subjects and History than in Art, Construction Studies or Geography. This is in spite of the fact that the candidates sitting History and the sciences tended to have performed better in the JCE. The findings suggest that a review of how grades are awarded in the LCE is required (Millar et al. 1998: 204).*

The report of the Commission on the Points System also recommended that research be undertaken to identify the cause(s) of the variation in existing patterns of grade allocation across subjects.

To address the concerns raised, the Task Force commissioned the Educational Research Centre (ERC) to conduct research on the comparability of grading at Leaving Certificate. At the time of writing (February 2002) this research is still ongoing but a preliminary report has been prepared and is included in Appendix III. The analysis undertaken to date...

*...would appear to support the view that candidates sitting the physical sciences are generally less likely to perform as well as those sitting other subjects. Students sitting Higher level Chemistry and Physics in LCs 2000 and 2001 did consistently less well than they did in other Higher level subjects that they sat (Millar and Murphy 2002).*

These findings are illustrated by Table 23 which compares the mean grade obtained by LCE 2001 Physics higher-level candidates with the mean grade obtained by the same candidates in the other 15 most popular Leaving Certificate subjects.

**Table 23: Subject Pairs Analysis for HL Physics, LC 2001 (Millar and Murphy 2002)<sup>50</sup>**

	SUBJECT	MEAN GRADE IN SUBJECT	MEAN GRADE IN PHYSICS
1	Accounting	4.4	6.0
2	Art	5.2	7.5
3	Biology	4.2	6.0
4	Business Organisation	5.2	7.4
5	Chemistry	5.0	5.1
6	Construction Studies	3.7	8.4
7	English	5.6	6.6
8	French	5.8	6.0
9	Geography	5.6	7.4
10	German	5.2	6.3
11	Home Economics (S&S)	5.2	7.2
12	History	5.1	7.3
13	Irish	5.3	6.0
14	Mathematics	4.7	5.8
15	Physics	-	6.7
16	Technical Drawing	4.2	7.2
	Mean (all subjects)	5.0	6.7

<sup>50</sup> The values assigned to the various grades were A1 – 1, A2 – 2, B1 – 3, B2 – 4, B3 – 5, C1 – 6, C2 – 7, C3 – 8, D1 – 9, D2 – 10, D3 – 11, E – 12, F – 13, NG – 14. Therefore a higher number indicates a lower grade. For example the first row in Table 23 shows the mean grade obtained by the set of students who sat both Accounting and Physics in LC 2001 at H-level. The mean grade obtained in Accounting was equivalent to 4.4 (i.e. between B2 and B3 grade) while the mean grade obtained by these same students in Physics was 6.0 (i.e. C1).

The data show that the mean grade awarded to candidates in Physics was lower than the mean grade awarded in each of the other 15 subjects.

The authors conclude that these findings are in line with the earlier NCCA longitudinal study and also point out that there has been little improvement in performance in the physical sciences in relative terms in the last six years (in spite of improved mean grades in absolute terms).

Questions have been asked about whether this type of comparison between subjects is defensible (and some of these concerns are articulated within the ERC report to the Task Force). However, regardless of the theoretical rationale underlying such comparisons, it remains the case that students, teachers and parents make them on a frequent basis. As a research report completed on behalf of the School Curriculum and Assessment Authority (UK) puts it: "whether or not it makes sense to compare grades across subjects, it is common practice to do so" (Fitz-Gibbon & Vincent 1994). Indeed the operation of the CAO system itself is based upon the rationale that subject grades are not just comparable but completely equivalent.

#### 4.4.7 Curriculum Change

Submissions to the Task Force have pointed to the need to critically examine the existing structures for curriculum development in schools. A number of issues require attention. The submission by the Irish Council for Science, Technology and Innovation (ICSTI), while acknowledging the principal strength of the present structures, namely the "partnership model", presents the challenge in the following terms:

*How to develop and implement science, technology and mathematics education policy on a time-scale that meets the rapidly changing needs of an emerging knowledge-based society, while continuing to meet individual students' long-term needs and ensuring a high level of ownership among the social partners. Consideration of the individual's needs and involvement of the social partners are strengths of the Irish system. However, it is important that the pace of and procedures for consultation should not prevent timely policy decisions and implementation (ICSTI 2001).*

The high-stakes Leaving Certificate has militated against a creative approach to curriculum development at senior cycle. A comparison has been made with the UK where it seems that greater flexibility has allowed for more curriculum innovation.<sup>51</sup>

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<sup>51</sup> For example there are four different A-level chemistry syllabuses, a situation which David Waddington, professor at York University, has said allowed for the development of the advanced level Salter's chemistry course.

The NCCA committed itself in September 2000 to a programme of action on science that established targets across a number of key areas as follows:

- the Junior Cycle Review will ensure that any revised curriculum at this level will provide all students with experiences in science and technology education;
- the revised syllabus for Junior Certificate Science will be completed on schedule to meet the target date of 2001 proposed by the NCCA for its implementation in schools;
- an impact study to determine the feasibility of introducing a new, general science subject at Leaving Certificate level will be undertaken in 2001;
- the NCCA will prioritise action in establishing provision for the assessment of practical work within the sciences, particularly at Leaving Certificate level;
- the Leaving Certificate Physics/Chemistry (combined) syllabus, to be titled Physical Science, will be completed on schedule to meet the target dates proposed by the NCCA for implementation in schools (2003);
- ongoing, rolling reviews of senior cycle programmes, in particular the NCCA review of the Transition Year, will examine ways in which the profile of science and technology can be improved within the programmes;
- the NCCA will introduce a system of rolling reviews of subject syllabuses and programmes from 2000/2001.

While the publication of targets in this manner is to be strongly welcomed, it is regrettable that slippage has occurred. This is a particular concern in relation to the implementation of curriculum change at junior cycle, a period which is crucial in terms of the formation of attitudes towards science. The early adoption of the revised Junior Certificate Science syllabus must now be a priority.

The NCCA has itself publicly commented on the time-lag of many years between initialisation and implementation for the curriculum reform process. In this regard it is essential that the rolling review of science syllabuses should be fast-tracked to achieve the desired impact:

*This will result in increased levels of monitoring, on an annual basis, of curriculum and assessment arrangements, of student achievement in the public examinations, and of subject/programme uptake by students (with particular reference to gender issues in the case of science and technology). The review will take into account appropriate baselines and the results of other relevant studies, for example the Programme for International Student Assessment (PISA), and will aim to keep syllabuses up to date with developments within subjects and*



*beyond. It will result in more frequent, small-scale changes to subject syllabuses and educational programmes than in the past. In turn, this will ensure greater levels of responsiveness to changes in culture, in society and in the economy and to developing insights into learning and the applications of learning as these evolve (NCCA 2000:37).*

The Task Force has considered the issue of provision of a general science subject at Leaving Certificate, a proposal contained within a number of submissions.

*It is recommended that a General Science programme building on the current Junior Certificate programme should replace the current Physics and Chemistry (combined) Leaving Certificate course. This new programme should then become the minimum entry requirement for a wide range of 3rd level courses. This should not dilute the key position of maths, physics and chemistry as an entry requirement for science and engineering studies (IDA 2002).*

There is concern that such a change might compromise the present enrolments in Leaving Certificate Physics and Leaving Certificate Chemistry. The Task Force believes this and other issues should be examined in an impact study (as originally planned by the NCCA for completion in 2001) and that this study should proceed as quickly as possible.

There is a belief that the present curriculum review process in relation to Physics & Chemistry (Combined) could provide a subject with the potential to broaden take-up vis-à-vis the physical sciences. This opportunity should not be missed.

It is also recognised by the Task Force that other Leaving Certificate subjects, namely those within the technology and applied science grouping, offer the potential to build experience and student exposure to content related to the physical sciences. The opportunity should be taken to highlight these aspects as part of the ongoing curriculum review process.

#### **4.4.8 Transition Year and Leaving Certificate Applied**

There is some concern about the exposure to science amongst students outside the standard Leaving Certificate programmes.

*Science education needs greater emphasis in the Transition Year and the Leaving Certificate Applied programmes (ASTI 2001).*

The revision of the Leaving Certificate Applied (LCA) to include elective modules in science is welcomed. The Task Force is anxious that any future evaluation of the LCA programme should examine the science exposure of LCA students in general, and also ensure that content relating to the physical sciences is appropriately represented across the available elective choices.

Similar evaluations are necessary in relation to the Transition Year programme. The outcomes of the Task Force Case Study research appear to confirm the position of Transition Year as an important influencer in schools.

*Generally, the science teaching in Transition Year was done by the Leaving Certificate science teachers. In most schools science modules were offered in each of Physics, Chemistry and Biology, and in these schools, all students either took all three modules or had to take two of the three. In other schools, "interesting" science courses were given in Transition Year, again by the Leaving Certificate teachers. Some of the teachers were quite innovative in what they taught in Transition Year. Teachers considered the exposure of the students to science in Transition Year was extremely beneficial and gave the students some knowledge of the subjects. ....In all of the schools except for one, the students chose their Leaving Certificate subjects during or at the end of Transition Year (Finlayson & Killen 2002).*

A number of Task Force submissions have identified the importance of the student experience of science within Transition Year and made the case for curriculum innovation in relation to science within the Transition Year programme. In the opinion of the Task Force this offers an opportunity to stimulate participation by teachers in curriculum development in science. Experience demonstrates that a locally-driven model of curriculum innovation can provide significant benefits at the individual, institutional and national levels.<sup>52</sup>

Table 24 shows an analysis based on Transition Year timetables in schools for the academic year 2000/2001.

**Table 24: Analysis of Science in Transition Year Programme (DES Timetable Database 2000/2001)**

	% of total classes
All Science	7.3%
General Science	3.3%
Physical Science	2.2%
Biological Science	1.8%

It is a concern that the proportion of Transition Year classes devoted to any form of science is very small (7.3%). Thus only around 1 in 14 Transition Year classes are in "science" subjects a classification which, apart from the traditional science subjects, would also include, for example, botany, geology, electronics, etc.

<sup>52</sup> National initiatives such as the Schools Integration Project (SIP) strand within IT2000 demonstrate how such models can work in practice.

#### 4.4.9 Co-ordination of Provision

There needs to be a co-ordinated approach to curriculum provision across the education system in its entirety. There is evidence from other national systems that unless this is managed effectively it can lead to problems,

*There is good evidence that secondary science teachers are still failing to recognize the strengths of science in the primary schools. In addition, the hierarchical nature of the subject means that many topics will be revisited, albeit in a more complex and sophisticated form (Osborne & Collins 2001).*

The issue of lack of connectivity between the different levels of the system is one that has been well documented by the inspectorate in Scotland:

*Pupils' prior experience and knowledge of science was not often fully exploited in the upper stages of primary schools or at S1/S2. Science topics sometimes repeated content covered at earlier stages and the pace of pupils' learning was often too slow (HMI 1999).*

The integration of science into the curriculum of every primary school during 2002/03 has raised similar concerns in an Irish context. It is essential that careful attention is given to co-ordination across the phases (i.e. primary and post-primary) by all those individuals and institutions who are in a position to positively influence the situation i.e. schools, teacher trainers, curriculum bodies, the inspectorate etc.

#### 4.4.10 Professional Development and Curriculum Change

It is clear that there is significant on-going or planned curriculum development which is impacting on science. All of these initiatives are dependent upon access by teachers to appropriate professional support and development.

*The task of preparing for the implementation of new and revised curricula is taken very seriously in Ireland. Many teachers at both primary and second level are now facing, possibly for the first time in their careers, the introduction of new and revised STM (Science, Technology, Mathematics) curricula. The benchmarking study indicates strongly that the training and support needed to ensure the smooth introduction of such curricula is generally underestimated. This was clearly the case during recent reforms of STM education in New Zealand (ICSTI 1999).*

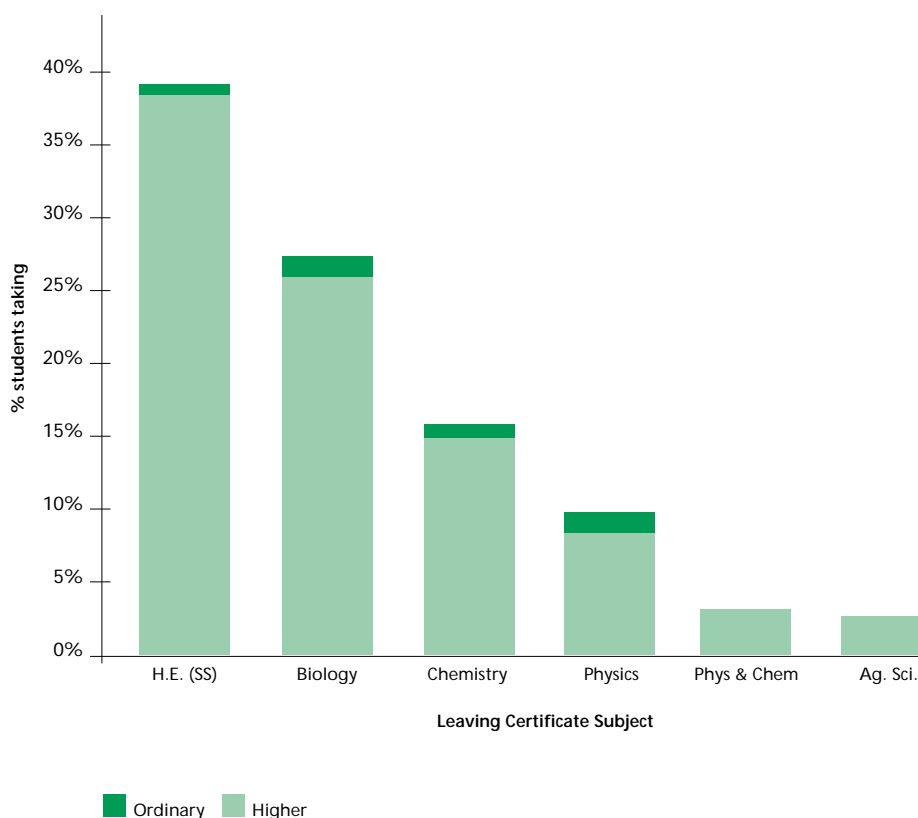
## 4.5 Teaching Science

### 4.5.1 Pre-service Training (Primary)

Prior to the introduction of the revised primary curriculum in 1999, there was little emphasis on the physical sciences within teacher training. The typical three year pre-service programme leading to the BEd degree must provide prospective primary teachers with knowledge and skills related to the general curriculum in addition to pedagogic training. In general, course entrants have a stronger background in the humanities than in the sciences.

The science background of students entering primary teacher training is indicated by data provided to the Task Force on the first year cohorts in two of the five teacher training colleges in the state (Figure 27).

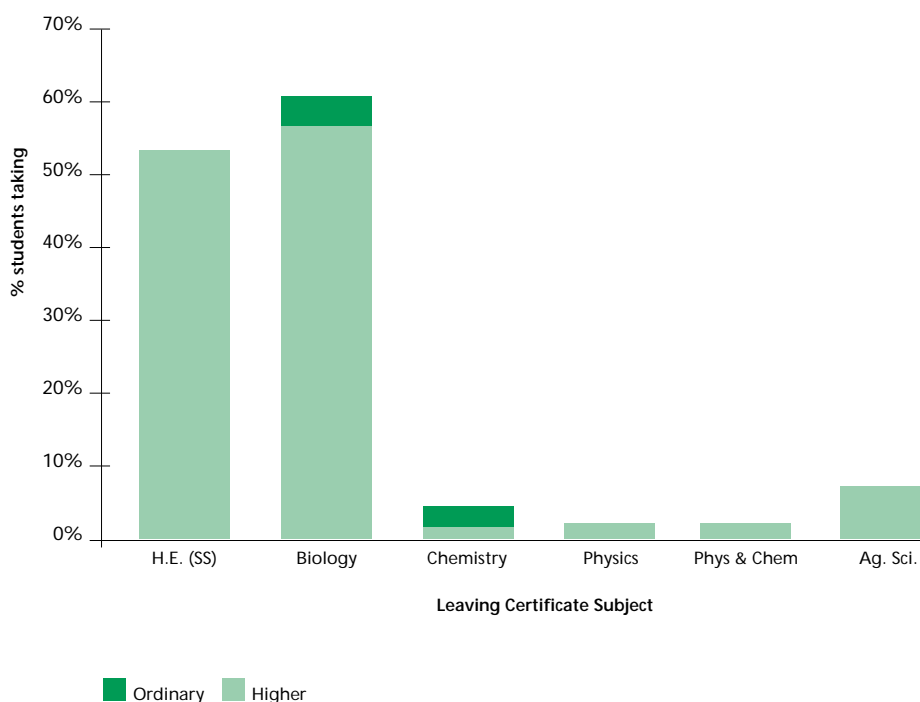
**Figure 27: Leaving Certificate science background of BEd students in St. Patrick's College, Drumcondra**<sup>53</sup>



The physical sciences background of students entering St. Patrick's College, Drumcondra, is typical of students entering Arts degree courses.<sup>54</sup> However, this may provide a better representation of the situation than that which applied on a national basis. For example, the physical sciences background of teacher training students entering the BEd programme in Marino Institute of Education is not as strong, as Figure 28 illustrates.

<sup>53</sup> BEd Year1 (2001/2002) (n=164; data supplied by McCloughlin T., Murphy, C. and Kilfeather, P.)

<sup>54</sup> See Flanagan 2001.

**Figure 28: Leaving Certificate science background of BEd students in Marino Institute of Education, Dublin** <sup>55</sup>

Thus in Ireland, as in other countries, only a minority of primary teachers have taken a physical science subject to upper secondary level. The limited time available for science education within the typical pre-service programme is also a concern.

In Finland, under the LUMA programme, there has been an effort to emphasise the physical sciences in teacher training, both by favouring for admissions purposes candidates with mathematics and science grades in the school Leaving Certificate, and through increasing the amount of mathematics and science in the core curriculum of teacher training programmes.

The Task Force believes that the variable science background of candidates points to the need for urgent action to ensure that all newly qualified teachers have adequate preparation and support to address the physical sciences component within the primary curriculum.

#### 4.5.2 Pre-service Training (Second-Level)

There are two modes of entry for those wishing to teach science in secondary schools - the consecutive mode in which science graduates complete a one year Higher Diploma in Education (HDE) and the

55 BEd Year 1(2001/2002) (n = 95; data supplied by Colaiste Mhuire, Marino)

concurrent mode in which undergraduates take courses in both science and education leading to a BSc in Science Education.<sup>56</sup>

Science graduates entering the higher diploma programme are unlikely to have a background that prepares them to teach all three sciences to Junior Certificate. However in many cases this will be expected of them in practice.

The establishment of the Teaching Council will create a structure whereby all teachers in publicly funded schools will be registered and an account taken of the qualifications of each teacher. It is essential that this system will be sufficiently rigorous to establish the exact status of the supply of science teachers and their teaching subject areas.

### 4.5.3 Teacher Supply at Second-level

Teacher shortage in the physical sciences is a critical issue in many developed economies. A serious threat exists to the viability of science at second level in a number of countries due to the lack of interest in a career in science teaching.<sup>57</sup> A clear picture of the issues around supply and demand of science teachers in Ireland requires ongoing study, but based on the information available to the Task Force, there does not appear to be a system-wide shortage at this time (although certain pockets of demand may exist).<sup>58</sup> Indeed, the relatively steady number of applicants to the Higher Diploma in Education (HDE) programme suggests that the level of interest in science teaching has remained reasonably stable in recent years (Figure 29).

This data also provides some indication of the numbers qualifying via the HDE route to teach each of the different sciences. Thus, of those accepted onto the HDE programme in 2001/2002, 36 identified Physics as a teaching subject compared with 101 selecting Chemistry and 158 Biology. As each HDE applicant normally undertakes two teaching methods courses, it is unlikely that any more than half of these would have studied the selected teaching subject as the primary subject of their undergraduate degree. Thus 18 of 36 HDE applicants may have Physics as the primary subject in their degrees while another 18 may have taken Physics as a subsidiary subject.<sup>59</sup>

56 Typically, students on the HDE programme choose two teaching subjects; this prepares the graduate to teach these two subjects to Leaving Certificate level. Students on the 4-year concurrent programmes are prepared to teach two science subjects to LC level. UL has two BSc (Education) programmes: one leading to a qualification in Biology together with a physical science; the other qualifies the graduate to teach the two physical sciences. DCU offers a BSc (Science Ed) whose first graduates in 2003 will be prepared to teach both LC Physics and Chemistry. UCC introduced a BSc (Ed) in the Physical Sciences in 2001 whose graduates will be equipped to teach both Physics and Chemistry. Prior to 2001, the only concurrent programme graduates were from the BScEd (Biological) course in UL, which supplied an average of 12 graduates per teaching subject per year for both Physics and Chemistry.

57 (i) <http://folk.uio.no/sveins/NOT-%20Appendix.html> (ii) *Physics-Building a Flourishing Future*, report of the inquiry into undergraduate Physics, Institute of Physics, 2001. (iii) *Before It's Too Late, A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century* U.S., 2000

58 Teacher shortage would appear to be an concern for some schools as indicated by responses to a survey carried out by the National Association of Principals and Deputy Principals (NAPD).

59 This correlates with data obtained directly from the universities for the number of Physics graduates entering the HDE programmes in 2001/2002 (NUIM 0, TCD 3, UCC 5, UCD 4, UCG 5).

Figure 29: Trend in Applicants to the Higher Diploma in Education <sup>60</sup>

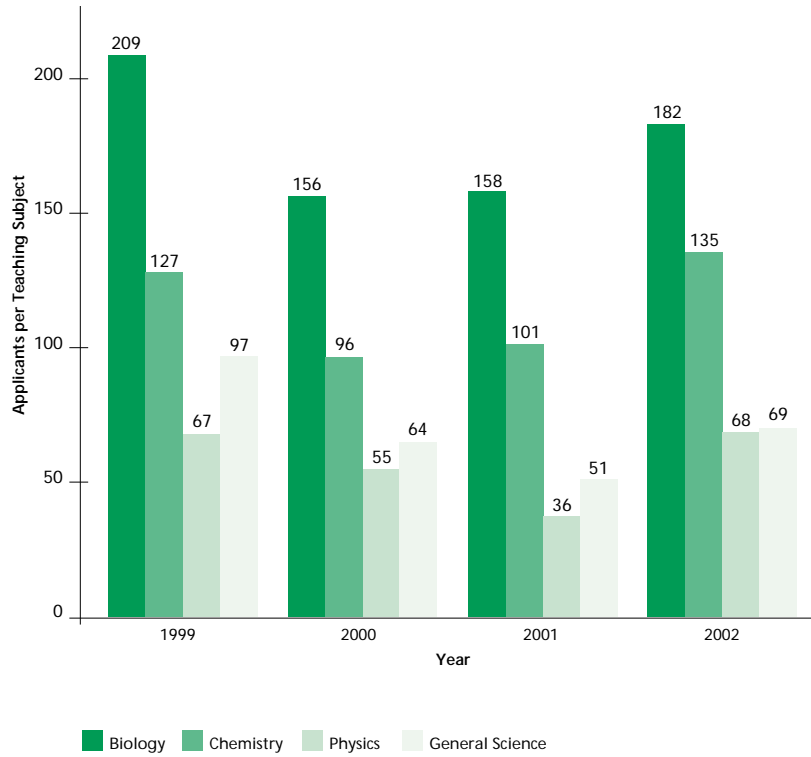
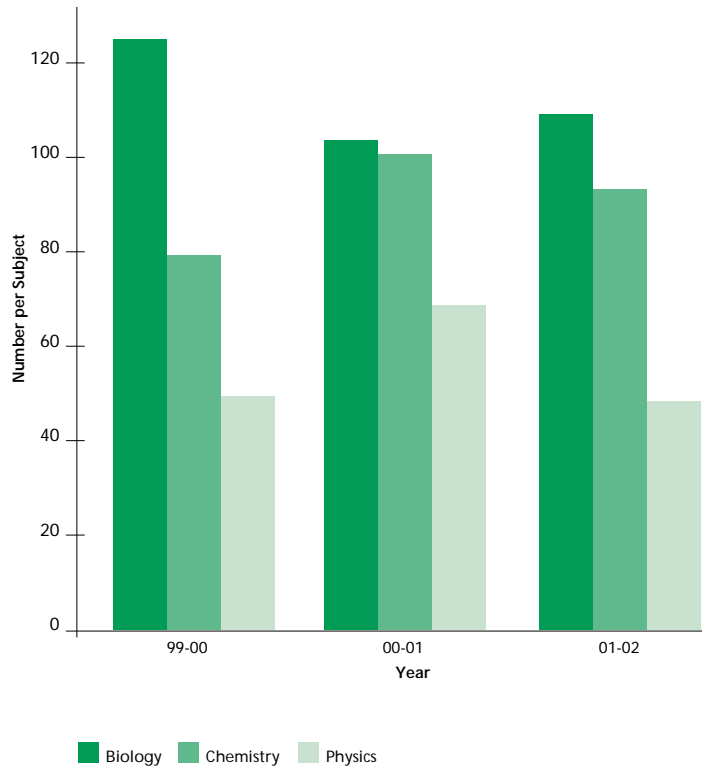


Figure 30: Students entering Teacher Training in Ireland by subject <sup>61</sup>

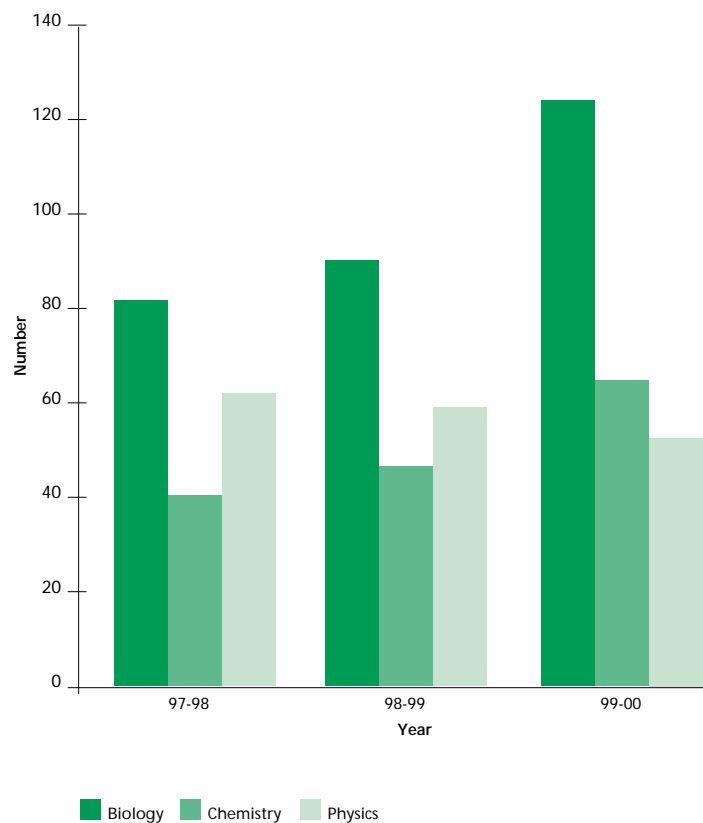


<sup>60</sup> Number of applicants per teaching subject to HDipEd programme for academic years 1999/2000 to 2002/2003. Data for 1999/2001 courtesy of Seamus Mac an Ri, CAO Postgraduate Applications, Galway; provisional data for 2001/2002 from Irish Independent 09/01/02.

<sup>61</sup> Numbers based on HDE acceptances plus first year enrolment on concurrent programmes. These numbers do not include students who have chosen general science as a teaching subject.

Total relative numbers of subject specialists can be gauged from combining data on both consecutive and concurrent programmes (Figure 30). A comparison with the equivalent teacher supply in Scotland (Figure 31) does not reveal a marked difference (other than a reversal in the Chemistry to Physics ratio).

**Figure 31: Relative Numbers on Initial Teacher Training courses in Scotland<sup>62</sup>**



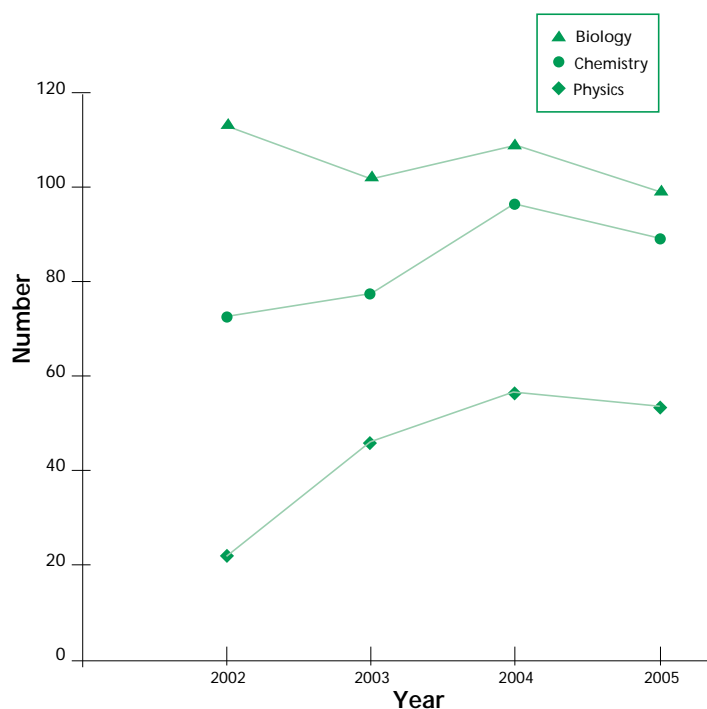
Short-term projections on teacher supply can be made by adding the numbers expected to graduate from the consecutive (HDE) programme<sup>63</sup> to the expected yield from the concurrent programmes. A narrowing in the gap between the number of teachers qualifying in biology and physics or chemistry is anticipated as the output of new concurrent programmes comes on-stream (2003 onwards).

62 Relative numbers of students on initial teacher training courses in Scotland (Source: Scottish Executive, Further & Higher Education Statistics <http://www.scotland.gov.uk/stats/bulletins/00086-26.asp>)

63 Three assumptions: (i) projected numbers on the HDE programme are the average number per teaching subjects over previous 4 years (ii) 100% retention of enrolment on all programmes and (iii) a 3:1 ratio of choice of Chemistry: Physics teaching subjects on the part of the 29 BSc Ed(Biol) students currently in first year in University of Limerick.



**Figure 32: Projected supply of senior cycle science teachers up to 2005**



#### 4.5.4 Background of Science Teachers

A significant number of submissions to the Task Force have identified concerns around teacher background in relation to the physical sciences. In particular there has been an anxiety about the teaching of the physical sciences in the junior cycle.

*There is a significant lack of junior cycle science teachers qualified in physics or chemistry. Undoubtedly this will affect the influence placed on science students and probably explains the higher numbers choosing biology at Leaving Certificate level (IBEC 2001).*

Comprehensive data on teacher qualifications is not held within existing Department of Education and Science databases. The DES Teachers database does not hold information on the specific degree qualifications of teachers. Neither does the DES Timetabling database hold usable information on the degree background of teachers teaching science at junior cycle. In short, simple answers to questions around teaching capacity for the physical sciences within the present system are not readily available. It is not possible to give a direct answer to the relatively straightforward question posed in another submission to the Task Force.

*In an ideal world the Physical Sciences need to be taught by graduates in Physics and Chemistry, and H. Dip. Ed. programmes should particularly seek to recruit such people. However, baseline data is needed on the science background currently possessed by teachers, at both Junior and Leaving Certificate level. For example, to what extent is Physics being taught by Physics graduates (National Commission for the Teaching of Physics 2001).*

At the same time it has been possible to obtain a snap-shot of the profile of Junior Certificate Science teachers during 2000/2001 based on the other subjects taught by these teachers. Table 25 suggests that a Junior Certificate Science pupil has an approximately equal chance of being taught by a Leaving Certificate Physics or Chemistry teacher but is more than twice as likely to be taught by a Leaving Certificate Biology teacher as by either of these.

**Table 25: Leaving Certificate subjects taught by Junior Certificate Science teachers (2000/2001)** <sup>64</sup>

No. of JC science teachers	2843
No. of JC science teachers teaching LC Science	2214 (78%)
LC science subjects taught by JC science teachers	#JC teachers
Biology	1282 (45%)
Mathematics	943 (33%)
Physics	529 (19%)
Chemistry	577 (20%)
Computer Studies	159 (6%)
Agricultural Science	143 (5%)
Physical Education	142 (5%)
Religious Education	91 (3%)
Physics & Chemistry	90 (3%)

Thus it would appear that, while two thirds of the Junior Certificate syllabus content is drawn from the physical sciences, there is evidence to support the contention that the principal qualification background of Junior Certificate Science teachers relates to the biological sciences.

There is no evidence to suggest that the Leaving Certificate physical sciences are being taught by teachers lacking a significant qualification in the subject. As with Junior Certificate Science, the Department of Education and Science holds no comprehensive data on teacher

<sup>64</sup> It should be emphasised that these figures refer to one particular year and that, while the proportion (78%) is likely to remain relatively constant from year to year the actual personnel are likely to change and that most of the remaining 22% will have taught a Leaving Certificate science subject in other years. In support of this assumption it may be noted that the numbers of Junior Certificate science teachers teaching Physics and Chemistry represents approximately 60% of the numbers currently attending in-service courses in these subjects.

qualifications in this area. However the Task Force has arrived at its position based on data acquired from a number of sources. The response to the 2001 survey carried out by the National Association of Principals and Deputy Principals (NAPD) suggests that, within the science teaching cohort in second-level schools, 27% of teachers have Physics to degree level and 29% have Chemistry to degree level. A snap-shot of the qualifications of those attending in-service for the revised Chemistry syllabus at one Dublin centre (n=81) showed that 91% had taken either Chemistry or Biochemistry to degree level (Finlayson & Killen 2001).

It is regrettable that there is no data held on the age profile of science teachers. Concerns are evident in some other countries in this regard.<sup>65</sup>

The Task Force believes that effective educational planning is dependent upon the Department of Education and Science having access to a comprehensive profile of the science teaching cohort including data on age, degree qualifications etc.

#### 4.5.5 Recruitment and Retention of Teachers

There are concerns about employment opportunities for newly-qualified science teachers; it is clear that, in common with teachers in other subject areas, graduates of physics and chemistry find it difficult to obtain full time permanent positions.

*The main problem is not lack of demand or the quality of students (both very high), but the lack of teaching jobs in the Irish second-level system when they graduate. There is no absolute shortage of science teachers in schools, contrary to many statements that have appeared to the contrary....Production of more, well-qualified science teachers will not solve the existing problems unless the proportion of Physics and Chemistry teachers increases. This is not possible at present because there is a shortage of full-time and permanent jobs in the schools, due to the age profile of the teaching profession, contracting rolls, government job quotas etc. A valuable resource for revitalising Irish science teaching is being wasted because new science education graduates cannot get jobs. As a consequence many of them retrain for other jobs, leave the country etc. Science graduates with their range of transferable skills are highly employable and many are lost to the teaching profession, because the employment opportunities are not available at present (University of Limerick Working Group on Science Education).*

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<sup>65</sup> The Forfas benchmarking study indicated that the age profile of teachers of science, mathematics and technology is in line with that of teachers in general.

A report in the Irish Independent (09/01/02) stated that 26.4% of science graduates who were enrolled on the HDE programme in the academic year 2000/2001 are presently working outside teaching. The HEA annual graduate survey gives the corresponding figures for 1998 and 1999 as 22% and 14% respectively.<sup>66</sup> According to the Association on Secondary Teachers of Ireland only 1 in 20 HDE graduates obtains a full-time permanent position on graduation.

The Task Force believes that it is essential that more employment opportunities are created to attract physical science graduates into teaching. This would be of benefit not only to the existing cohort of graduates but also to mature science graduates who may have valuable experience in industry and research.

There is a critical need to ensure that the teaching of science is, both in appearance and in reality, an attractive, challenging and rewarding occupation. While Ireland presently appears to be in the fortunate position of having well qualified graduates who wish to teach the physical sciences, this situation cannot be assumed to continue indefinitely. The Task Force survey of Leaving Certificate students found that teaching is not nearly as attractive a career option for candidates in the physical sciences as it is for others. A number of commentators have suggested that consideration should be given to applying a quota system for entry to the Higher Diploma programme.

*We recommend that there should be a separate entry quota for science graduates (and in particular in the physical sciences) into the Higher Diploma in Education programmes in the universities. At present entry is based simply on the ranking of an applicant's degree results regardless of the discipline and this has meant that, on a number of occasions, there has been no trainee science teachers at a university in a particular year (Deans of Science of the Irish Universities 2002).*

Thus, at present the CAO route for entry to the Higher Diploma programme takes no cognisance of subject background.<sup>67</sup>

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<sup>66</sup> In terms of comparison, these figures are slightly more than Arts/HDip graduates and considerably less than Commerce/ HDip graduates in both of these years.

<sup>67</sup> A quota system has been applied in the past in relation to shortage subjects.

#### 4.5.6 Career Guidance

The main impediment to effective guidance in schools is the seriously inadequate staffing level. The pupil: teacher ratio in relation to guidance counselling is 500:1. An Audit of Guidance in Post-Primary Schools carried out by the National Centre for Guidance in Education (NCGE 2000) showed that the provision of guidance is inadequate to the need. The audit revealed that there is little guidance happening in the junior cycle. However it is now well established that second level students begin to make their career choices before the end of junior cycle and that "educational and occupational aspirations will already be relatively fixed by the time students enter senior cycle" (Smyth and Hannan 2000). This is reinforced in NCGE's commentary on the audit findings:

*Junior Cycle career decision making has shown that between 40-50% of junior cycle pupils have definite career ideas by the end of junior cycle. There is also evidence that girls are earlier career decision makers than boys, and that careers education to counter gender occupational stereotyping is most effective with the 12-15 age group (NCGE 2001).*

Access to guidance is therefore important for junior cycle students as they enter the phase of making subject and career choices.

Changes in the role and functioning of guidance in schools have accelerated in recent times with changing social conditions and the introduction of a guidance element into school programmes such as the Leaving Certificate Applied, the Leaving Certificate Vocational Programme and Transition Year. Also, guidance counsellors spend a considerable portion of their time on subject and career advice for Leaving Certificate students. The volume of work to be done to facilitate this has grown enormously because of the complexity of career choices, and increased academic opportunities. The Task Force survey indicates that students rank guidance counsellors as the most useful source of information at this stage. Appropriate guidance, however, also needs to be available for students in the junior cycle, when they are beginning to formulate career decisions.

*To restrict access to guidance to 6th year pupils—as is frequently done to cope with the lack of guidance counsellors—disadvantages pupils, and means that when many pick their subjects for Leaving Certificate they have had little or no guidance on the implications of those choices. Guidance counselling tends to be focused on pupils at senior cycle, especially during the months leading to the completion of the CAO form, often with little support or information available to pupils in junior cycle. The major decisions on subject options which need to be made in the junior cycle and at the beginning of senior cycle could best be made by pupils and their parents with the support of a guidance and counselling service (TUI 2001).*

## 4.6 Resources for Practical Science

### 4.6.1 Existing Level of Laboratory Provision

The Department of Education and Science carried out an audit of laboratory resources in post-primary schools in 1999 and received replies from 628 schools (82%), of which 595 had at least one science laboratory (Table 26).

**Table 26: Laboratory provision (DES Laboratory Audit)**

#LABS	#SCHOOLS	TOTAL LABS	#STUDENTS	#STUDENTS PER LAB
1	169	169	38214	226
2	213	426	85482	201
3	150	450	72908	162
4	46	184	25695	140
5	13	65	9656	149
6	3	18	1941	108
8	1	8	1550	194
	595	1320	235446	178

Thus the survey indicates a level of provision nationally of c. 200 post-primary students per school laboratory<sup>68</sup>. A 2001 survey conducted by the National Association of Principals and Deputy Principals (NAPD) found a provision of 199 students per laboratory.

**Table 27: Laboratory provision from NAPD 2001 Survey (n=278)<sup>69</sup>**

#SCHOOLS	TOTAL LABS	#STUDENTS	#STUDENTS PER LAB
278	674	117470	199

<sup>68</sup> Table 26 shows a ratio 178 students per laboratory but does not include student numbers in the 33 schools with no laboratory provision.

<sup>69</sup> Results based on verified sample of 278 schools. A number of replies were excluded on the basis that the data on student numbers could not be confirmed.

#### 4.6.2 Quality of Existing Laboratory Space

The 1999 Department of Education and Science audit quantified many of the deficiencies in relation to the laboratory accommodation existing at that time. Approximately 50% of existing laboratory stock was provided prior to 1980 and, while laboratories built since then are of a reasonable standard, it is generally accepted that those built prior to that date are of variable quality.<sup>70</sup> It would appear that a significant proportion of classes is accommodated in rooms that were not designed for practical science and that lack basic requirements such as gas points, fume cupboards, power distribution points etc.

The response to the NAPD survey supports the contention that a significant proportion of the existing laboratory stock is of poor quality (Table 28).

**Table 28: Perception of Laboratory Needs 2001 (NAPD Respondents)**

REFURBISHMENT	RE-EQUIPPING
76%	82%

It is evident that health and safety considerations are contributing to the need for upgrading laboratory provision. A further impetus is provided by the need for access to new technologies and consequent new teaching requirements (e.g. internet access, interactive whiteboards, computer networking). Some of the deficiencies in the present level of provision in this regard are shown in Table 29.

**Table 29: Access to Technology by Chemistry Teachers (2001)<sup>71</sup>**

Have access to computer(s) in lab	58%
Have access to computer(s) in school	74%
Have access to data projector	20%
Have access to Internet connection	14%

#### 4.6.3 Quality of Laboratory Equipment

It is not possible to present a definitive picture of the standard of existing equipment provision in schools. The situation in 1999, as captured through the Department of Education and Science audit, was that 85% of schools had inadequate equipment for the teaching of Leaving Certificate physical sciences. However it would appear that the additional funding provided as part of the Physical Sciences Initiative (PSI) has had an impact. The National Association of Principals and Deputy Principals, based on the findings of their 2001 survey, came to the conclusion that "40% of school laboratories are not equipped to an acceptable standard" (NAPD 2002).

<sup>70</sup> The 1999 DES audit indicated that 46% of laboratories had been built since 1980.

<sup>71</sup> Report of Chemistry Co-ordinator to Physical Science Initiative Steering Committee (September 2001).

**Table 30: Perception of standard of existing laboratory equipment (NAPD Respondents):**

POOR	FAIR	REASONABLE	HIGH
18%	22%	38%	23%

Similarly the 58% of chemistry teachers with access to a computer in the laboratory in 2001 is an improvement on the "77% of schools do not have a computer available to the laboratory" reported in the 1999 DES audit.

The Irish Science Teachers Association, while welcoming the additional grants<sup>72</sup> made under the Physical Sciences Initiative has pointed out that more funding is urgently required.

*Whilst teachers of physics and chemistry in Ireland have one single computer available to them, our colleagues in the UK and USA have an average of 6 – 10 computers available to them for carrying out student practical work and teacher demonstration experiments (ISTA 2001).*

#### 4.6.4 Funding of Equipment and Consumables

The 1999 Department of Education and Science audit asked school principals for an estimate of the average annual budget over the preceding three years (1996 to 1998) in relation to the renewal and replacement of science equipment and consumables. While the median figure is in the £1000-£1999 range, the results demonstrate a large variation in reported expenditure (Table 31).

**Table 31: Estimated science budget (1999 DES Audit) <sup>73</sup>**

BUDGET IR£	# SCHOOLS	%	BUDGET IR£	# SCHOOLS	%
< 1000	231	41%	7000 to 7999	4	1%
1000 to 1999	138	24%	8000 to 8999	5	1%
2000 to 2999	101	18%	9000 to 9999	5	1%
3000 to 3999	42	7%	10,000 to 10999	5	1%
4000 to 4999	16	3%	> 10,000	4	1%
5000 to 5999	13	2%	Total responding	569	
6000 to 6999	5	1%	No response	59	

<sup>72</sup> £4,000 in April 2000 for the purchase of one computer and general items of laboratory equipment and £6500 in December 2000 for the purchase of data-logging and other equipment for the physical sciences.

<sup>73</sup> Respondents estimate of average annual budget over the preceding three years (1996 to 1998) in relation to renewal/replacement of science equipment and consumables.



Some basis for comparison is provided by a 2001 survey in Scotland which found an average school expenditure of GBE1,936 on physics equipment and consumables (ASE 2001). Assuming a multiplier of 3 (i.e. that expenditure on physics equates to one third of total science expenditure), this equates to school expenditure on science of GBE5,808 (equivalent to €9,460<sup>74</sup> at the time of writing).

While the Department of Education and Science provides funding for the equipping of new laboratories at post-primary level, or an initial capital grant for the purchase of science equipment at primary level, thereafter it is expected that a school will allocate a portion of its annual block grant to fund the renewing of science consumables. The Irish Science Teachers Association has commented on the situation at post-primary thus:

*Up to 1985, money for the renewal and replacement of science equipment in voluntary secondary schools was raised by a grant of 75% of expenditure from the Department of Education. The remaining 25% came directly from the school's own resources. This applied to all voluntary secondary schools, whether or not they had been equipped to the specifications of the Building Unit of the Department of Education and Science. In June 1985 school managers were informed (circular M17/85) that this system of grant aid was being replaced by a new system. This new system of grant aid meant that instead of the renewal and replacement grants issued for designated subjects, a block grant would be paid to schools and this grant would be distributed by the school managers among various subjects in each school (ISTA 2001).*

Similar changes in the funding model have taken place at primary level.

If a decentralised model is to function effectively then an appropriate portion of centrally provided funds must be allocated for curriculum purposes at local level. Concerns have been expressed to the Task Force that this may function less effectively in some schools than others.

While the Task Force has sought information on the local apportionment of expenditure, it has not been readily available. It is regrettable that audits of school accounts do not seek to capture this type of curriculum-related information.

A study carried out by the inspectorate in Scotland found that the proportion of per capita funds allocated to science departments varied between about 10% and 20% of the total available to the school (HMI 1994). Another recent Scottish schools study found that over 70% of schools apportion funds either wholly or partially on a per capita basis

<sup>74</sup> While the average Scottish post-primary school is larger than its Irish equivalent, it also needs to be borne in mind that this recorded expenditure on schools physics is significantly less than the optimum as determined by the Scottish Schools Equipment Research Centre (SSERC). The SSERC calculates that funding requirements for school physics range from GBE7,168 (1 laboratory) to GBE20,305 (6 laboratories) per annum. It should be noted that a significant portion of this would be consumed on non-equipment costs such as photocopying, text-books etc. (<http://www.sserc.org.uk>).

with an appropriate weighting to offset the higher costs associated with the practical subjects (ASE 2001b).

While not wishing to undermine the strong argument for promotion of local decision making and autonomy, there remains a concern that adequate financial resources may not be available at the curriculum level. The Task Force believes that some form of monitoring, as opposed to control, needs to be put in place.

#### 4.6.5 Optimum level of Laboratory Provision

Laboratory allocation for a particular school is determined on the basis of a number of factors, principally the projected long-term enrolment and the planned curriculum provision<sup>75</sup>. The Department of Education and Science has provided the laboratory allocation made in relation to a number of recent capital projects (Table 32).<sup>76</sup>

**Table 32: Provision of Science Laboratories for recent DES building projects**

Location of school	Long term projected enrolment	No of science labs	Location of school	Long term projected enrolment	No of science labs
Kerry	1000	5	Dublin	650	3
Cork	550	3	Cork	1000	6
Meath	825	4	Galway	500	3
Donegal	750	4	Wicklow	560	3
Limerick	400	2	Galway	625	4
Limerick	800	4	Dublin	600	3
Cork	350	2	Dublin	600	3
Mayo	220	1	Tipperary	550	2
Galway	550	3	Clare	600	3
Louth	350	2	Sligo	675	4

The fact that the appropriate laboratory provision is not determined through the application of a strict mathematical formula, is demonstrated by the fact that some of the schools on this list have the same projected enrolment (550 students) but a different laboratory allocation. At the same time it is accepted by the Department of Education and Science that the student:laboratory ratio is a useful benchmark for planning purposes. The data provided for the 20 schools gives an overall allocation of one laboratory for 190 students.

The data provided by the National Association of Principals and Deputy Principals (NAPD) from its survey have proved helpful in considering the appropriateness of the present level of allocation. Two samples were

<sup>75</sup> These are determined by the DES in consultation with the school management authority.

<sup>76</sup> Either in advanced stages of planning, or on site or have been recently completed.

selected from the 278 verifiable replies using the criterion of combined enrolment of students in Junior Certificate and Leaving Certificate science subjects. The "high science" sample consists of the schools (n=59) showing highest science enrolment and the "low science" sample (n=62) based on the schools with lowest rankings on this criterion.

The Leaving Certificate science enrolment rates for the two samples are shown in Table 33. This table also shows the science enrolment rates for the NAPD sample as a whole. It seems reasonable to surmise that the NAPD sample is representative of the post-primary system as a whole on the basis that these rates are in line with those computed for all post-primary schools.

**Table 33: Take-up rates for school samples selected from NAPD response**

Leaving Certificate Subject	Low Science	All Replies	High Science
Physics	11.8%	17.2%	21.9%
Chemistry	8.2%	12.7%	16.8%
Physics & Chemistry	1.1%	2.1%	4.0%
Biology	37.5%	43.9%	49.0%
Agricultural Science	0.8%	5.6%	10.8%

The distinction between the samples, and the typicality of the full NAPD sample, is also demonstrated by Table 34. The Leaving Certificate science enrolment ratio is in line with that calculated for the Leaving Certificate population nationally (0.80). Table 29 also shows that on average, each Leaving Certificate student in the "High Science" sample takes one (1.03) Leaving Certificate science subject, whereas the ratio is only 0.60 for the "Low Science" sample.

**Table 34: Ratio of Leaving Certificate Science Enrolment to Total Leaving Certificate Enrolment (NAPD Sample)**

Low Science	All Replies	High Science
0.60	0.82	1.03

Table 35 demonstrates that the "High Science" schools report a higher level of laboratory access, namely 178 students per laboratory, than the "Low Science" sample (209 students per laboratory).

**Table 35: Laboratory provision (NAPD Sample)**

SAMPLE	#schools In Sample	total #labs in Sample	Total #students in Sample	average #students per lab
All Replies	278	674	134,419	199
High Science	59	139	24,810	178
Low Science	62	132	27,539	209

However there was no difference between the proportions of respondents within each sample group identifying laboratory shortage as the critical factor in relation to low student uptake (17% for all 3 groups).

An analysis of the responses to the NAPD question on whether schools have a need for additional laboratory space is provided in Table 36. The sample of schools identifying a need for additional laboratory space has a student/laboratory ratio of 228 while those indicating adequate laboratory facilities show a ratio of 170 students per laboratory.

**Table 36: School differences in perceived need for laboratory facilities (NAPD Survey 2001)**

	Student/ Laboratory Ratio	LC Science Enrolment Ratio
respondents (n=278)	199	0.82
need additional labs (n=149)	228	0.82
don't need additional labs (n=149)	170	0.81

Another indication of an appropriate target for laboratory provision is provided by the Task Force Case Studies where the average provision for the twelve schools was 156 students per laboratory.

In conclusion, on the basis of the data examined in this section, it would appear that with regard to the overall national stock of school laboratory accommodation, minimum additional provision of c.20% is required. This is a conservative figure, when compared with the level of provision applying in some other education systems (e.g. Scotland). In the opinion of the Task Force, it should therefore be regarded as a minimum target and one that may need to be revised upwards in the light of experience.<sup>77</sup>

<sup>77</sup> This would have the effect of lowering the average student:laboratory ratio from c. 200:1 to 170:1 (compared with c. 100:1 in Scotland).

#### 4.6.6 Management of Resources

##### COORDINATION OF SCIENCE AT THE SCHOOL LEVEL

Many submissions to the Task Force have identified a need for the co-ordination and management of science at the school level. In the majority of the Case Study schools (ten out of twelve) one science teacher had the role of 'Head of Science' or 'Science co-ordinator'. A number of different arrangements facilitating a collegial approach to planning were evident.

*School G had an interesting structure whereby the 'Head of Science' rotated between the science teachers every two years. This seemed to give rise to a very good team effort in their approach also to science teaching in this school. This spirit of team work was also evident in school A, with the team being responsible for managing resources. ... In three of the schools (A, C and K) the science teachers planned resources as part of an informal team. In only two schools (D and I) did individual teachers make decisions on resources. All of the remainder had some element of formal team structure ranging from weekly planning meetings to once per year (Finlayson & Killen 2002).*

##### TECHNICAL ASSISTANCE

Table 37 shows the results of a survey question, relating to the introduction of the new Leaving Certificate Chemistry syllabus, given to 81 chemistry teachers participating in in-service. Lack of technical assistance is identified as a key inhibitor to practical work in schools.

**Table 37: Barriers to practical work identified by sample of Chemistry teachers (Finlayson & Killen 2001)**

Lack of laboratory assistants	67%
Lack of time	55%
Lack of laboratory equipment	55%
Lack of laboratory facilities	45%
Lack of relevant experiments	25%
Lack of laboratory skills	24%

The Task Force Case Studies also illustrate the demand for access to technical support,

*Only three of the schools had a laboratory technician when we visited them. Two of these were private fee-paying schools and in each case the laboratory technician was funded out of school funds. The third school (Community) had employed a technician under a Community Employment Scheme. Some of the other schools indicated that they had had laboratory assistants in the*

*past (funded under the above-mentioned scheme). In all of the schools the teachers (and Principals also, in some schools) stated their desire for laboratory assistants. Generally, they felt that even having a laboratory assistant for part of the week, perhaps shared over a number of schools in a locality, would have a very positive effect in their schools. This desire was particularly strongly expressed in the larger schools. It was apparent in all of the schools in this study that there was a lot of emphasis on practical work and these schools were requesting the help of an assistant in the laboratory. They stated that even the presence of an assistant was considered to be extremely valuable. It should be noted that two of the private schools had actually employed a qualified technician. The laboratory technician in both of these schools had a major role in stock control and maintenance of equipment as well as in setting up laboratories for practical work (Finlayson & Killen 2002).*

Comparative data collected by the Task Force indicate that Ireland is out of step with other national systems in terms of the level of technical assistance available to schools. For example, UK data indicates that schools have two laboratory assistants on average (Table 38).

**Table 38: Level of Laboratory Assistance in UK (Source: ASE/RS)<sup>78</sup>**

	NO. OF PUPILS	NO. OF LABS	TECHNICIAN HRS	TECHNICIAN FTE
Average for all schools:	900	7.8	77	2.1

The comparative data from Australia (Victoria) also showed that "all secondary schools have a functioning science department with access to laboratory facilities, equipment, and laboratory support" (Tytler 2001).

The case for technical support in relation to laboratory work has also been made to the Task Force by school Principals, both in an individual capacity and through the National Association of Principals and Deputy Principals. It has been stated that the provision of a "technical support" role in the school may need to be considered in the light of other areas of demand within the school i.e. the support needs associated with information technology, audio-visual, and art and craft subjects.

## 4.7 Promotion

### 4.7.1 Range of Promotional Activities

There are many individual initiatives country-wide for the promotion of science. Some are state funded, some sponsored by professional bodies, some run by industry. These programmes have a great diversity of scale, of objectives, of presentation/operational styles, of target audiences, of geographical cover, and have very different operational budgets.

<sup>78</sup> Survey of laboratory technicians undertaken by the Royal Society together with the Association for Science Education. (Royal Society & ASE 2001).

Because of the great diversity of activities in operation, and the varying levels of advertising employed by them, it is not possible to make an accurate inventory nor to be fully inclusive in a description of them. However an impression of their range and scope is indicated by Figure 33.

**Figure 33: Examples of Promotional Activities aimed at Schools<sup>79</sup>**

#### **Participative/Spectator events**

Pfizer Science Bus (DCU); Science Works (Tralee); Schering Plough Introduction to Science (Bandon); STEPS roadshow (IEI); Tyndall Lecture Series for Schools (IOP); the Cork Industry Electronic Association Careers Initiative; summer schools and Transition Year programmes run by third level colleges.

#### **Competitions**

Young Scientist and Technology Exhibition (Esat); Paper-clip Physics; Irish Science Teachers Association Science Quiz; Physics on Stage; Life in the Universe; Health Matters Competition, Science (chemistry) quizzes; Olympiad (physics, chemistry, mathematics and computing); scholarships (e.g. Intel); essay competitions.

#### **Resources for schools and teachers**

Schools Information Centre of the Irish Chemical Industry (SICICI): based in University of Limerick, funded by the Irish chemical industry, this centre develops promotional material, promotes chemistry in schools, produces the CheMystery magazine, provides a directory of resources for chemistry teachers, operates a video library for schools, organises industry-study tours for chemistry teachers.

**CD-ROMs and websites:** provided by third level institutions, professional institutes (e.g. "Think Again" video produced by Institute of Physics/Intel), Fas ("Careers in Science" video and CDROM), Forfás (National Skills Awareness Programme website and Science, Technology and Innovation Awareness programme website).

**Classroom visits/talks:** "Physics in Person" lecturer-to-schools service provided by the Institute of Physics; STEPS volunteer programme for practising engineers to go into schools; IBEC Business and Education Links programme.

**Site Visits:** Intel site tours; IBEC company visits.

<sup>79</sup> This list is not intended to be exhaustive but rather to serve as an illustration of the range of promotional initiatives. (Initiatives undertaken by third level institutions are described separately).

**Seminars/Conferences/Workshops for teachers:** Irish Science Teachers Association Conference; ChemEd-Ireland Annual Conference for chemistry teachers; Royal Irish Academy (National Commission for the Teaching of Physics) annual seminar/workshops for physics teachers; Intel Career Guidance workshops; STEPS career guidance workshops; seminars and workshops for guidance counsellors run by science departments of third level institutions.

**Publications for students and teachers:** Chemistry in Action (Institute of Chemistry of Ireland); Technology Awareness Programme for Schools (IT Tallaght).

**Career Events:** Higher Options; Opportunities fair (e.g. Opportunities 2002); careers events in third level institutions and careers evenings in schools.

It is important, when evaluating the extent of promotional initiatives, to distinguish between those that operate at a local/regional level and those that have a broad/national focus. The examples included in the detailed descriptions below illustrate the difference.

*The Schering-Plough Introduction to Science Programme*

This programme operates at a local/regional level. It involves the 19 primary schools in the catchment area around St. Brogan's vocational school in Bandon. Eight schools are selected each year to nominate approximately ten 6th class students to participate in a two-day programme of science experiments and a site tour of the company plant. The follow-up includes the writing of a report by the students and a plenary session, involving parents and teachers, when the General Manager of Schering-Plough presents certificates to the participants.

*The Science, Technology and Innovation (STI) Awareness Programme*

STI is a national programme run by Forfás on behalf of the Office of Science and Technology. The aim of the programme is to raise the awareness of the value and contribution of science and technology to the well-being of the Irish people. Target audiences include business, the public and students. There are a number of strands to appeal to the range of audience; for example the National Innovation Awards for the business sector. The most visible platform for student/public awareness is National Science Week, which takes the form of a wide range of events hosted by schools, colleges, communities around the country and coordinated, centrally advertised and given a high media profile by the programme. The emphasis of the schools' awareness programme is



towards primary schools and the lower cycle of secondary. The Science, Technology and Innovation Awareness programme periodically conducts a survey to ascertain the changing public perception of science. The programme hosts a website within the Forfás website.

#### *National Skills Awareness Campaign*

This is another national programme, also run by Forfás on behalf of the Department of Enterprise, Trade and Employment. It was set up to promote the work of the Expert Group on Future Skills Needs to a national and international audience. The campaign aims to improve awareness of career opportunities available in the Irish software, electronics and tele-service industries. This campaign is directed at students, teachers, guidance counsellors, parents, as well the unemployed and the general public. Resources directed at schools (including literature, video) are currently being expanded and re-focussed. Skills Awareness also operates a website within the Forfás website. The management team and boards of these two latter programmes (Skills Awareness and STI) coordinate their activities in areas of common interest.

#### *Science, Technology and Engineering Programme for Schools (STEPS)*

This programme is organised in partnership by the Institution of Engineers of Ireland, the Department of Education and Science, Forfás, FAS and a range of sponsors from the high technology sector. The aim of the programme is to promote careers in engineering to students in school. The programme operates a number of elements including: (i) a roadshow which travels to different regions, setting up in host school and drawing in students from neighbouring schools to participate in exploring information stands 'manned' by practising engineers and engineering lecturers from third level colleges, supported by careers seminars; (ii) a schools-industry partnership scheme to facilitate site visits for students and teachers to engineering plants; (iii) careers seminars for teachers and guidance counsellors; (iv) a volunteer database to put practising engineers in contact with schools; (v) a website, resource material, competitions and publications.

#### *International Comparative Comment*

In the OECD policy document on "Promoting Public Understanding of Science and Technology" (OECD 1997) a summary is provided of the range of activities employed across the 29 member countries to address the problem of a decline in interest in science: "Countries tend to use a similar range of instruments. The main ones are: encouragement of events, such as science weeks or days; development of infrastructures for diffusing science and technology information, such as science museums and centres; competitions and awards for scientists and innovators....establishing links between schools and scientists..." This is the scenario represented by the description of promotional initiatives in Ireland above.

### PROMOTION BY HIGHER EDUCATION INSTITUTIONS

A wide range of schools-directed activities has been developed in practically all Physics and Chemistry departments in third level institutions around the country. These operate to provide support for science teaching and learning at second level, and to encourage second level students to consider future studies and careers in SET. These activities are labelled "Schools Liaison". The extent of these activities has expanded in recent years due to the declining numbers of applicants for third level SET courses and the growing need for institutions to market their programmes. The activities are generally initiated by individual departments or schools within the third level institutions, but, as the profile of the activities rises throughout the second level science teaching sector, some approaches are made by teachers to local colleges for their cooperation. The organisation of activities within colleges varies from ad hoc arrangements with individual science staff to fully resourced liaison programme supported at departmental level.

The activities of Schools Liaison fall into several categories including:

- Visits by second level students to college science departments for: open days, career talks, Science Week activities, laboratory tours, interactive displays, lectures, demonstrations, use of laboratories for conducting Junior Certificate and Leaving Certificate experiments.
- Visits by science lecturers to schools: demonstrations, lectures, careers evenings.
- Support from college staff for other promotions: facilitation of regional heats of competitions; hands-on stands at the Young Scientist Exhibition; preparation of students for participation in Olympiads; cooperation with Royal Irish Academy in seminars for teachers; involvement in outreach programmes to disadvantaged schools.
- Teacher support: workshops and hands-on laboratories for teachers; workshops for guidance counsellors; lectures at science teachers' conferences; teacher resource (equipment loan) centre.
- Transition Year: specially designed lecture and practical projects for Transition Year students; work experience placements.
- Material: websites, brochures, promotional literature from professional institutes (Institute of Physics in Ireland, Institute of Chemistry of Ireland).

Representatives from the majority of Physics departments in the university sector have recently taken measures to collaborate on the sharing of best practice to building a common approach to promotion that enhances the perception of science both for its intrinsic value and for career opportunities. The Association of Heads of Schools of Science of the Institutes of Technology recommend the formation of a

promotional unit for science in the institute of technology sector.

*Cooperation is essential also in terms of marketing and promotion of careers in science. Further, such cooperation and collaboration is now clearly in the interests of all levels of the education system, as well as being in the interests of students and the nation (Association of Heads of Schools of Science of the Institutes of Technology 2001)*

The Deans of the universities in a discussion document to the Task Force (Deans of Science 2001) have drawn attention to the potential for the development of web-based learning programmes for schools and continuing education, including the development of computer-based 'virtual experiments'. A number of submissions to the Task Force have set out proposals for Transition Year modules.

#### 4.7.2 Role of Industry

*The interdependence of education and industry is now widely recognised. By working together, maximum benefit can be gained from the contribution that each makes to the community. Partnership with industry enables education to reflect modern technological society more closely. It also provides opportunities for teachers to add an extra dimension to their own knowledge and experience and to enhance their teaching with appropriate examples and applications from industry. Learners can benefit by gaining insights into the world (ASE 1998).*

This quotation captures the sentiment expressed in many submissions to the Task Force that highlighted the lack of collaboration between industry and science educators. These submissions identified that there is no collective action by educators and industry in Ireland to promote the importance of the physical sciences at second level for opening up routes to a wide vista of science-related careers. Contact between schools and industry is seen to be limited in its reach and effectiveness. The submission to the Task Force from the National Association of Principals and Deputy Principals (2001) calls for "more interaction between schools and industry and the need for industry to support in a meaningful manner the teaching of the physical sciences". Another common observation is illustrated by the following extract,

*There is no coherent industry-wide policy to support science education nationally and the funds that have been committed to this activity in the past are relatively small (University of Limerick Working Group on Science Education 2001).*

The third level sector sees the need for a strong input from Forfás, Enterprise Ireland, other public bodies and from Irish industry in a promotional strategy.

*There needs to be a strong input from Irish Industry in the promotion strategy. The importance of the Physical Sciences should be strongly promoted by industry on a country wide basis" (Committee of Heads of Irish Universities Chemistry Departments 2001).*

A view expressed quite frequently in submissions is that industry in Ireland is neglecting to impact on the perception of science among students. This is expressed in one instance in the following quote:

*These industries have to shoulder some of the criticism regarding the low up take rate in the Physical Sciences. They are simply too low key and below the public awareness horizon. There is a perceived skills shortage in these industries yet the general public are unaware of such and are much more aware of the computer industry (Murray 2001).*

There is some recognition of a problem with localisation of promotional activities that could have a much wider geographical reach. The Association of Secondary Teachers of Ireland call for "Regional and county competitions/exhibitions along the lines of the Young Scientists Exhibition" (ASTI 2001). This recommendation for regional equity is repeated elsewhere:

*Regional Science Fairs or regional heats of the Young Scientist Exhibition be held in ITs / Universities throughout the country. These competitions which would be sponsored by local industry would provide early contact for first and second level students with their local third level colleges. We believe that such platforms would promote the activities of the colleges and industry to future prospective students /employees (IDA 2002).*

*The ESAT Young Scientist Exhibition to be extended to run in ten venues around the country at the end of November, as local exhibitions. The finals to be held as normal in the RDS in Dublin in January. In this way, more students and their teachers would get to see the projects at their local level, and the celebration of science investigations is brought to a much wider audience (Simmie 2001)*

A recurring theme is that of school-industry links.

*All science-based companies should be encouraged to develop stronger links with their local schools, primary and second-level, in liaison with other companies in their area. The company should send staff into schools to talk to students, should give or lend equipment, and should provide work experience for Transition Year students during term-time and paid work experience for teachers during their vacations (University of Limerick Working Group on Science Education 2001).*

*More state support for the School-Industry links already in existence, and a programme similar to the Altramas programme, run by IBEC, where a local science related industry "adopts" a school. If the good careers are there, then the science teachers and their students need to be made aware of them (Simmie 2001)*

This concept of local schools-industry links has gained wide acceptance in other countries. In Finland industrial organisations and research institutes promote the sciences primarily through schools links. An objective of the LUMA programme is to intensify school-industry cooperation through the development of materials, the facilitation of visits and the involvement of industry in competitions (Ministry of Education, Finland 1999)

In Victoria, Australia, there are a number of strands to the Science in Schools (SiS) initiative of the Department of Education, Employment and Training; these are aimed generally at the promotion of science. One of these, the Community Partnership strand, provides for collaboration between industry, third level and schools to facilitate science partnerships (students into science workplaces and also scientists and engineers into schools). A senior project officer runs each element and grants are channelled to schools to participate on the basis of proposals.

Another variation of this type of scheme is the community based Teacher Scientist Network (TSN)<sup>80</sup> in the Norfolk region of the UK, funded by a range of research councils and centres. The TSN involves a group of 100 science teachers, approximately 80 working scientists and 20 other people with backgrounds in science and in education. The core activity centres around 'partnered' scientists and teachers, workshops for two-way communication on education and the latest scientific research, and the production of resource material for curriculum support.

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80 [www.tsn.org.uk](http://www.tsn.org.uk).

One example of a highly developed programme for education-industry cooperation is the Chemical Industry Education Centre (CIEC) at the University of York<sup>81</sup> which works on building partnerships between schools and the chemical industry. Among the many activities of the centre are: the production of a training pack for primary schools in collaboration with the chemical industry (to link curriculum with site visits); the hosting of a website to introduce best practice in industry-education partnerships; the conducting of an audit on behalf of industry groups on their support for science education.

### 4.7.3 Careers Awareness

#### PERCEPTION OF CAREERS

The Task Force survey of second level students indicates that, although Irish students do not have the negative images regarding the contribution of science to society, identified by some international commentators, they do have a negative view of working as a scientist. If promotional efforts are to impact positively on subject take-up, it is important that Irish industry address the negative perception of careers in science. The ranking given to interest in a career as a scientist actually drops between first year and 4/5th year in school. There is a perception of the work of a scientist as being difficult, complicated and boring, as well as being poorly paid. Also Irish students' appreciation of the link between science and scientific careers in industry is not well developed at the critical stage when they are making subject choices based on career aspirations. The reason put forward by the Deans of Science for this poor image of careers, is that there is no concerted effort on the part of industry to provide information to students to challenge their perception.

Many submissions refer to the absence of clear information on career structures, promotional prospects and salaries, and the inertia to deal with the negative imagery associated with the working scientist (e.g. Keary 2001; Cawley 2001; Faculty of Science and Health, DCU 2001). Based on the relatively high priority that students surveyed by MRBI gave to the importance of high salaries (second, following "interesting/enjoyable work") as a consideration in their career choice, the advertising of careers in science will require to be accompanied by such information if they are to be taken seriously by modern students. The submission from the Institution of Engineers of Ireland states:

*Unless students are aware of the highly attractive and rewarding careers which can be pursued by those who have a good level of mathematics and science subjects at Leaving Certificate, they are less likely to take up such subjects (IEI 2001)*

The Task Force survey of students revealed a very poor rating for a career in engineering by female students. This is further evidence of the need to address stereotyping of careers and the need for awareness programmes to be developed appropriately for different target

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81 [www.york.ac.uk/depts/chem/seg/seg.html](http://www.york.ac.uk/depts/chem/seg/seg.html)

audiences. The submission from IBEC (2001) refers to the importance of "real scientists" and role models to effect change in students' attitudes.

### ROLE OF GUIDANCE COUNSELLORS

The main requirement of guidance counsellors for effective promotion of science in schools is to have available inclusive, comprehensive information on courses and careers, and to have this well-packaged and easily accessed (National Centre for Guidance in Education 2001). The present collection of individual, worthy but disconnected events and resources fragments the message. A quote on this topic from Gaffney (2001) states "career guidance people and schools generally are fed up with industry after industry approaching them with separate initiatives. There is a need to concentrate resources." The National Association of Principals and Deputy Principals calls for focused information for guidance counsellors.

The National Centre for Guidance in Education observes that the development of science career information by Irish industry is lacking: most good quality career information used by guidance counsellors in Irish schools originates in the U.K. or is drawn from the print media in Ireland (submission from National Centre for Guidance in Education, 2001). The survey of students indicated that guidance counsellors, together with parents, are relied most heavily on for career advice by students at second level. This creates an imperative for the provision of effective resources to guidance counsellors in order that appropriate careers counselling can be undertaken by them. Various mechanisms for providing these resources to guidance counsellors have been suggested, including the creation of a liaison structure, setting up of awareness programmes, induction courses in industry, the establishment of "specific training for career counsellors to enable them to understand better the various career options open to students in the physical sciences" (IEI 2001).

There is a perception among third level SET educators and in industry that guidance counsellors are not proactive in the provision of information related to science and careers in industry; that the background training of the majority of guidance counsellors is in the Arts/Humanities area and, as such, their effectiveness in promoting science is limited. The NCGE, however, states that the academic background of guidance counsellors has been found to have no bearing on subject choice advice or take-up of science subjects in senior cycle. The role of guidance counselling has to be seen to provide balanced career advice: "For some, science holds the promise of an interesting career of intellectual challenge, but it is not alone in this regard" (TUI 2001). In the twelve Case Study schools, guidance counsellors indicated that they would not necessarily promote science, and indeed would not particularly promote any one subject over another.

*Many promoted the idea of students taking a science subject for balance in their portfolio of subjects, and thus giving students good options in choosing their career. Many Career Guidance Counsellors said that there was a particular effort made to promote science in their schools, particularly influenced by, for example, local industry (Finlayson & Killen 2002).*

The response of schools to the recent (2001) Guidance Enhancement Initiative indicates a high level of demand for, and interest in additional guidance provision for the general promotion of careers awareness. Under this enhancement scheme all second level schools were invited to apply for whole time posts; the posts were intended for the development of innovative ways of enhancing guidance for pupils and to promote links between schools, business, voluntary and state agencies. Particular priority was given to proposals from schools which contained strategies for developing the above links but which also proposed to promote take-up of science in senior cycle through the use of these links. 103 schools benefited from an extra 0.5 post guidance allocation, but almost 500 schools applied under the initiative. This demonstrates that many schools attach a high level of importance to providing students with a better understanding of careers and the workplace. Since the role of guidance is central to this activity, there should be adequate provision of guidance support to broaden out participation by schools in this type of activity.

#### 4.7.4 Effectiveness of Initiatives

The value of the broad range of promotional initiatives that operate across the country has been appreciated in the submissions to the Task Force. However, there is a need to examine the overall effectiveness of these activities. These individual programmes operate independently for the most part within a local region (larger programmes such as the STI and the Skills Awareness and STEPS coordinate their activities in areas where their mandates overlap). In general, the effectiveness of the many separate promotional efforts is compromised by a range of factors including geographical localisation, poor information flow, lack of partnership, isolation from mainstream events, limited funding and, not least, the disorienting effect of their diversity of messages. The common objective is diluted by limited collaboration; best practise is not shared. This is a strong recurring message coming from a wide range of sources.

*At present there are many programmes and promotional materials available. However, many are unaware of their existence or they have only local impact. IBEC recommend a central co-ordinating mechanism/ body/centre be provided (IBEC 2001).*



*A wide range of material and programmes are currently provided by industry to schools. These programmes are uncoordinated and often result in duplication and to confused messages being delivered to schools. These programmes, if co-ordinated, could significantly improve the return to the schools and to the donor companies (IDA 2002).*

*The main problem here is that only a proportion of companies see the need to be involved in promoting science education (as distinct from sport), and for most of them their main interest is the local community. This means that many schools who are not near a science-based industry miss out and existing industry-education activities are relatively small-scale, local and sporadic. There is no coherent industry-wide policy to support science education nationally and the funds that have been committed to this activity in the past are relatively small (University of Limerick Working Group on Science Education 2001).*

*The real issue is one of coordination at a national and regional level. If the identified aim of an awareness programme is to increase the pool of highly qualified graduates in science and technology, rather than simply address local skills shortages, then the coverage of awareness programmes has to be national, and not just in areas where science and technology firms happen to be located. At regional level there is also need for coordination. This would enable an audit of local needs and resources and enable better planning of new potential programmes (Gaffney 2001).*

As well as the beneficial effects of scale, cost-effectiveness and sharing of best practice that would be to the advantage of the promoters, a nationally and regionally coordinated effort would address the requirement for a more coherent message being sought by the school-based audience.

#### **4.7.5 Interactive Science Centre**

The Task Force is conscious of the importance of the promotion of Science in the wider arena, among parents and the general public, as well as bolstering the perception of science among the student body at large. It endorses the proposal by Forfás for an Interactive Science Centre; the advent of such a centre would provide a major boost to increasing public awareness and would lend significant support to a new promotional effort to schools.

#### **4.7.6 Government Chief Scientist**

The Task Force is also conscious of the fact that, unlike many developed countries, Ireland does not have a government appointed Chief Scientist who would provide broad-ranging advice on science, technology and innovation. At a time when the focus of investment in science and technology is to promote expertise in research and

development, as well as continuing to support hitech manufacturing, the advocacy provided by a high profile adviser becomes important. The leadership of a Chief Scientist would additionally give great impetus to the general awareness of science across government, industry, the media and the general public.

## 4.8 Higher Education

### 4.8.1 Transition to Higher Education

The evidence from retention data, pointing as it does to serious difficulties experienced by a significant proportion of students in the early stages of third level SET courses, calls for a re-appraisal of the transition from second to third level, in particular for science students.

It appears from the retention reports, that there are mismatches between students' expectations and their experiences on their courses, and mismatches also between students' abilities and the expectations of course deliverers. The issue of 'preparedness' of students for third level SET study requires the identification of these mismatches. The Task Force survey revealed that SET students find the transition to college more difficult than their Arts/Business counterparts, and that the Science group find the transition hardest, citing the difficulty and the demands of their courses.

#### PREPAREDNESS

There are two aspects to the issue of preparedness: these have been described by Barry McGaw of the OECD (McGaw 2001) as (i) the misspecification of pre-requisites and the (ii) the inappropriateness of prerequisites. The former refers to how well prepared or well advised prospective students are about the nature and demands of their chosen course. The latter refers to how prepared students are in their academic knowledge that would be considered as relevant background for embarking on undergraduate study. A poor preparation in the former is a contributory cause of non-completion through early withdrawal and a poor preparation in the latter is a contributory cause of non-completion through early withdrawal and also through failure in examinations.

#### 4.8.2 Awareness of the Nature and Demands of Courses

##### RANGE OF COURSES

Guidance counsellors and college brochures are the chief source of information upon which prospective students base their choice of science course and formulate their expectations of the course. The National Centre for Guidance in Education has expressed concern that the expanding range of denominated courses has presented guidance counsellors with an overload of complex and highly differentiated material that is not always amenable to interpretation. The findings of the Task Force survey suggest that, for the students interviewed, the highly denominated nature of courses is not problematic.<sup>82</sup>

##### NOMENCLATURE OF COURSES

As well as the emergence of several new science and technology courses whose distinctiveness may be unclear to many school-leavers, there is also the problem observed by guidance counsellors, of a wide variety of presentation styles and disparate levels of information in brochures from different colleges, so that a useful comparative study is not always possible to assist the student in making an informed decision. The Deans of Science of the universities have expressed concern about the nomenclature of some new specialist courses, suggesting that in some instances the titles may be misleading in so far as they imply a professional association that may not be the case. These factors may lead to a "misfit" of the student for the course i.e. the failure of students to choose a course suitable to their needs.

##### KNOWLEDGE OF COURSE

A qualitative study on retention in three Institutes of Technology (Healy et al. 1999) found that a significant percentage of students withdrawing from their course in the first year of study cite as reasons for withdrawal unsuitable choice of the field of study or lack of information about the course. This wrong choice would suggest that pre-conceived impressions of the course were not fulfilled, that the students, although able for the course, were not satisfied with its curriculum or that the students were not confident of their academic ability to handle the course. In both instances the action of withdrawing is forced upon the student because of the structure that prevails in third level institutions that is strict and inhibitive of student movement across courses in their first year of study. The Task Force survey illustrates that, even for students continuing on their courses (2nd and 3rd year science and engineering students) there is no strong agreement with the statement "the course is as I expected it to be". The results, from a needs analysis carried out at University College Dublin, concluded that more students are concerned with being on the wrong course than staff realise; second year students (across all disciplines) reported that restrictions to selection of second year subjects were not clear to them on starting out on their courses (Bates 2002).

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82 The survey does not, however, capture a representative sample of students at risk of withdrawing.

A growing percentage of students accepting places on SET courses, particularly in the Institutes of Technology, accept a course that is not one of their top choices on the CAO form (Flanagan et al. 2001). In a follow-on qualitative study on retention in progress by the Educational Research Centre (Morgan 2001), it is emerging that students know very little about their lower CAO choices. They do not realise the skills required for their courses. This gives rise to a mismatch between student academic abilities and the expectations of lecturers. The majority (80%) of first year SET students interviewed by MRBI had obtained their first or second choice of course; yet even these students found the transition difficult (more so than Arts/Business students). Second year science and engineering students found their courses difficult; 13% of 2nd/3rd year science (excluding Computing) students and 21% of 2nd/3rd year engineering students interviewed would not make the same choice of course again.

A UK report from the Learning and Skills Development Agency (Davies 1998), incorporating the findings from over 60 separate pieces of research, has found that non-completion in post-compulsory education is strongly related to lack of preparedness (as described in the introduction to this section). The lack of quality guidance leads to students failing to understand the demands of their courses. Also a range of factors concerned with teaching and learning ranks ahead of financial concerns in affecting retention.

New proposals from the Scottish Higher Education Funding Council (equivalent of HEA), Universities Scotland (equivalent of CHIU), the Quality Assurance Agency and student representatives have incorporated subject benchmarks and programme specifications into the Quality framework. There is also an undertaking to develop improved institutional information for students and applicants.

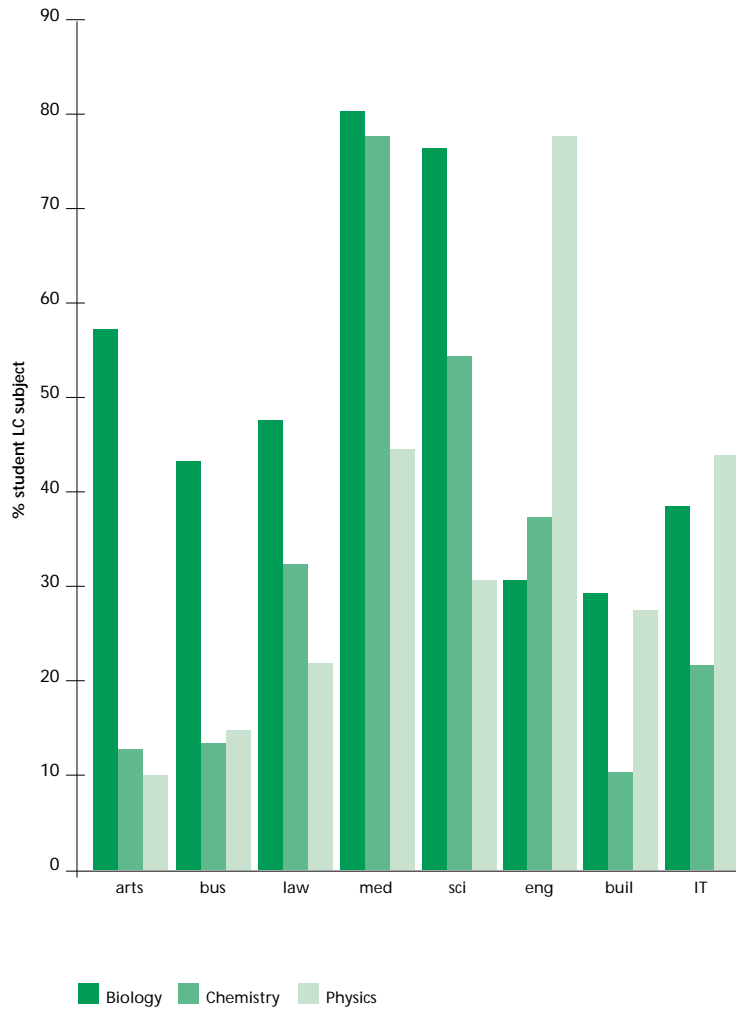
There is currently limited scope for lateral movement of students across SET courses in Ireland. More flexibility in this regard could address the level of dissatisfaction of students with their course and still retain them within the broader SET area of study. Another approach would be the provision of places for general entry; students could avail of denominated courses in the second year of study (delayed specialisation). University and Institute of Technology science departments have indicated their willingness to discuss cooperative action to facilitate transfer routes between their sectors in order to assist retention.

#### APPROPRIATENESS OF PRE-REQUISITES

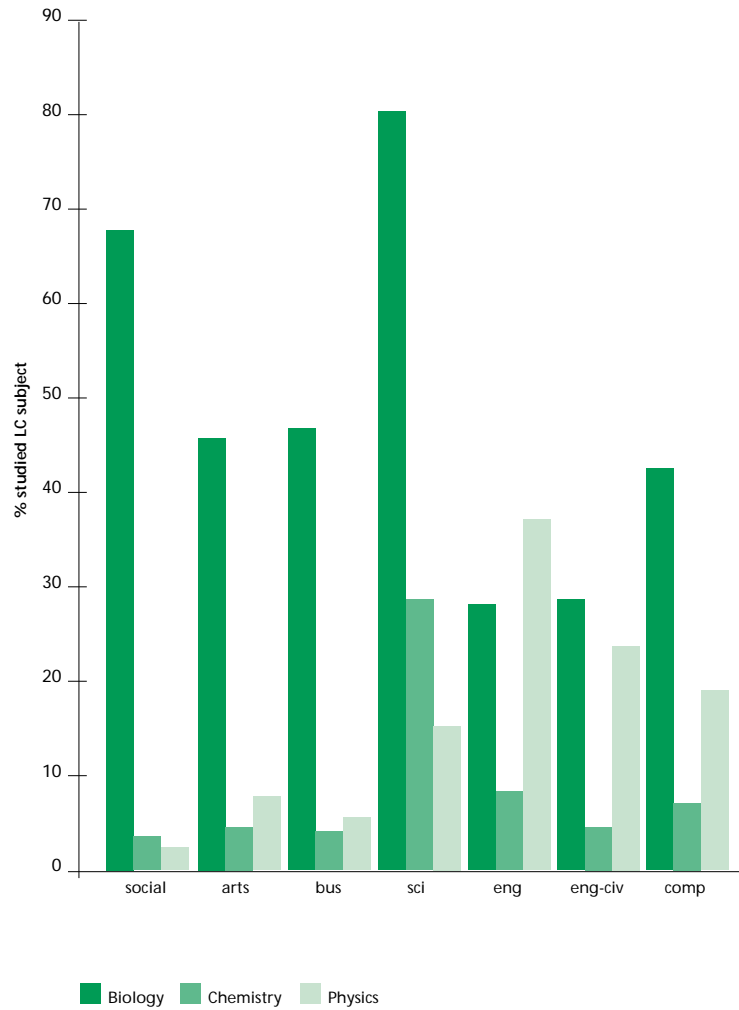
The requirements for entry to science and technology courses in universities and in institutes of technology do not demand prior exposure to the physical sciences. A science subject in the Leaving Certificate is a requirement for acceptance on to a science course in the universities, but not specifically a physical science. A recent study

undertaken on behalf of the National Council for Curriculum and Assessment (Flanagan 2001) examined the prior exposure to physics, chemistry and biology of students entering third level in the years 1996 and 1999. This study reveals that a significant percentage of students are entering science and technology courses in third level without having studied the physical sciences in the senior cycle of second level.

**Figure 34: Percentage of students in each major subject area on degree courses who had studied the three traditional sciences for Leaving Certificate in 1999 (Flanagan 2001)**



**Figure 35: Percentage of students in each major subject area on diploma courses who had studied the three traditional sciences for Leaving Certificate in 1999 (Flanagan 2001)**



**Table 39: The percentages of students on science degree and science diploma courses who had studied Physics and the percentages who had studied Chemistry for Leaving Certificate in 1996 and in 1999 (Flanagan 2001)**

YEAR	Physics Degree	Physics Diploma	Chemistry Degree	Chemistry Diploma
1996	41%	21%	59%	34%
1999	31%	15%	54%	29%

It can be observed that the prior exposure to the physical sciences of SET students is declining. A full analysis demonstrates that the vocational trend is increasing i.e. one or both of the Leaving Certificate physical sciences are chosen more as preparation for Medical and Engineering degrees. The Task Force survey of first year SET students on their retrospective view of their preparedness for college, revealed a weak response in favour of the statement "I chose the school subjects that were most useful for my course"; there was a markedly weaker agreement with this statement from institute of technology students. This is consistent with reports that an increasing proportion of students on science courses are not on courses of their first choice.

An attempt has been made by the Task Force to examine the correlation between prior exposure to the physical sciences and performance in the physical science elements in first year exams for science students at third level. Data was compiled on subject take-up for Leaving Certificate and student performance at the end of first year on a number of science courses across a range of third level institutions. Though not universally true, there was a greater correlation between non-exposure to the physical science subject at Leaving Certificate and failure in first year exams. Comparison of data-sets was not possible but for the majority of the sample examined the probability of failure was increased twofold for students who had not studied the physical sciences for Leaving Certificate

The reason behind such trends may be associated with the increasing numbers of students accepted on to science programmes, for whom science is not among their top CAO choices. Or there may be many students who are aspiring to courses in the Life Sciences and not aware of the demands of the course and particularly the disadvantage of not having previously studied a physical science. Whatever the reason, it might be argued that no prior knowledge of either of the physical sciences leaves the average student poorly prepared for entry to a third level science/technology course; this is probably particularly true if higher education teachers do not take account of the student's academic background in their approach to teaching them and many do not do so.

### BONUS POINTS AND COURSE CREDITS

There has been a strong recommendation from many different sectors, particularly third level, industry and professional institutes, for bonus points to be awarded for Leaving Certificate Physics and Chemistry for entry to third level SET courses. This is perceived to be a short-term measure to attract students into SET courses until such time as the physical sciences are made more attractive as Leaving Certificate subject choices. However practitioners at second level view this as a discriminatory tool. The general consensus of second level science educators is that making the physical sciences more attractive as

Leaving Certificate subjects requires dealing directly with the perception by students of the relative level of difficulty of the subjects, and providing due reward to students who take them. Thus a more equitable and speedier solution would be to redress the grading imbalance in the Leaving Certificate examination. This would be a more meaningful approach and should be achievable in a timeframe not longer than that required for the proposed bonus points scheme to become operative (i.e. 2004).

A further mechanism, which could have almost immediate effect, would be for third level SET departments to award course credits/exemptions to students who have achieved high grades in the physical sciences in the Leaving Certificate. Such action would have to take cognisance of the need to provide challenging and rewarding alternative options with associated credits.

### 4.8.3 Access for Other Learners

The Clancy studies (Clancy 1995, 1999) on access show that certain groups (such as mature students and groups from lower socio-economic backgrounds) are underrepresented in higher education. Even with the reversal of the downward trend in traditional applicants from second level, changing demographics will put pressure on numbers, while economic and technological advances will demand more skilled graduates. Some new programmes, such as the Accelerated Technician Programme and the Institute Trainee Programme concentrate primarily on increasing numbers of sub-degree graduates by providing opportunities for adults (unemployed adults and also under-skilled workers in employment) to enter directly on to third level courses.

### FURTHER EDUCATION

Other programmes, such as courses accredited by the Further Education and Training Awards Council (FETAC) in engineering and laboratory science, have been successful in equipping students to apply to SET courses in higher education. An estimated 50% of graduates from these programmes, accounting for a total of 200 students in one college in the Dublin area, transferred directly on to degree/diploma courses in institutes of technology in the last five years. However, the representation of SET among the total range of courses on offer in further education is severely limited (in 2001 only about 1% of NCVA awards were in science, 4.8% in engineering/construction and 16.8% in computing). The review of the further education sector currently in progress should provide an identification of the needs to enable the sector to deliver appropriate courses to meet market demands. On the basis of participation figures above, there is a requirement for greater support for the development of courses in the SET area. This must be accompanied by the development of adequate structures for progression routes, to allow for transfer within or to higher education.



### INCREASING PARTICIPATION

In recent years there is a growing number of alternative means for third level providers to meet the educational needs of an increasingly diverse student population. But the routes available for these diverse groups of learners to participate in SET education and training need to be made more flexible and more accessible. The opportunity is available for SET course providers in third level to respond to the recommendations of the Action Group on Access to Third Level Education and orient their provision towards a wider range of learners including the three groups selected for attention by the Action Group, namely students with disabilities, mature students and the disadvantaged. The framework that will be available under the National Qualifications Authority of Ireland (NQAI) should facilitate the development of procedures for greater participation. One of the objectives of the NQAI is to promote and facilitate access, transfer and progression. Science and engineering educators in third level will need to be proactive in exploiting the opportunity it provides for reaching a new pool of potential students.

### RECOGNITION OF PRIOR LEARNING

In approaching the development of SET programmes tailored for this wide cohort of mature students and disadvantaged population, the existing impediments to access will first need to be examined. Many mechanisms operate in different institutions and entry requirements vary. Science and engineering subject groups across the university and the institute of technology sector should take proactive steps, in consultation with industry, to devise a common protocol for the recognition of prior learning and for the assessment of applicants in each sector. Schemes for partnerships between universities and institutes, with mutual recognition of entry assessments, would widen the appeal of these programmes.

The Australian Qualifications Framework ensures educational recognition across all education and training systems (schools, vocational education and higher education). Credit transfer arrangements and Recognition for Prior Learning operate across the second level-third level boundary to ensure that minimum inefficient repetition of learning takes place. This avoids the situation of undergraduate cohorts with greatly disparate prior experience being catered for simultaneously at the onset of third level education. Preparedness for entry to undergraduate courses is the responsibility of the applicant and entry tests are conducted to stream students according to performance. Options for bridging and preliminary courses allow for meeting requirements for entry on to the full undergraduate programme in some instances, twice yearly. The Victorian Department of Education Employment and Training recognises the importance of improved pathways to higher education for improved rates of transition. This would be of particular importance in an Irish context for increasing rates of transition on to SET courses.

#### 4.8.4 Retention

The retention data in Chapter 2 demonstrates the seriousness of this problem for the SET areas of study. Qualitative studies (Healy et al. 1999, Morgan 2001) are revealing that the problem is multi-faceted. There is an urgency to understand and address the underlying causes, particularly as the profile of students entering SET courses continues to change. The Higher Education Authority has dedicated funding to targeted initiatives on retention, encouraging the universities to develop projects aimed at combating non-completion. The Department of Education and Science has provided funding for the institutes of technology to support retention initiatives and the Dublin Institute of Technology has instigated special measures to boost retention. Third level SET departments have responded in various ways to the changing level of preparedness of their students and have instituted special initiatives to try to smooth the transition. These responses have been largely directed at first year students and the actions adopted include:

- Pre-science induction courses in chemistry and physics;
- Science mentoring schemes;
- Streaming of first year classes in chemistry, physics and mathematics to accommodate students who have not studied such subjects to a level appropriate for the course;
- Diagnosis and intervention in the area of mathematics;
- Targeted tutorial sessions;
- The development of tailored electronic multi-media tutorial programmes for self-learning and revision.

Extension of these schemes is severely hampered by the lack of resources allocated to/available in higher education institutions (Deans of Science 2001).

Non-completion issues have focussed attention on the need to address the integration of all first year students into their third level courses. Strategies for doing this need to combine actions with surveys and evaluation. The Task Force survey indicates that university SET students particularly appreciate the level of support provided by tutorials. However students are unhappy overall with the level of feedback on their progress during term. This is in keeping with results from a needs analysis (Bates 2002) carried out at UCD which found that students benefit from focussed feedback on their work, but are not comfortable with approaching lecturers to get this feedback.

The need to smooth the transition to third level SET courses is widely recognised in other countries as participation in higher education increases. The report from the International Union of Pure and Applied Physics Commission on Physics Education (Black 1999) points to the need to adjust curricula and pedagogy and to recognise the vital role of technology as new technological goals are increasingly considered in

tertiary science education. An e-learning project developed at Heriot-Watt University and involving a consortium of second level schools and further education colleges, facilitates flexible learning and a variety of accreditation schemes for third level that "eases the transition from school to college, university and the workplace, and is a vital approach to development in a rapidly changing economy"<sup>83</sup>. The rapid increase in admissions to higher education in Finland has led to an increasing variation in the mathematics and science knowledge of students. Many institutes of higher education have introduced tutorials and workshops to support poorly prepared students.

### TEACHING AND LEARNING TECHNIQUES

The successful integration of different student groups on to SET programmes will entail continued attention to results emerging from educational research. The Task Force is aware from submissions and from research nationally and internationally that there is a growing recognition of the potential of new methodologies in increasing the quality of teaching and learning in third level SET. Techniques such as laboratory-based learning, innovative assessment procedures and e-learning modules have the potential to significantly enhance the early learning experience on undergraduate SET courses. The mismatch between 2nd/3rd level methodology (from prescriptive and directed education to greater independence of learning) is a greater impediment for the poorly prepared students; for such cohorts, there are added benefits to be derived from flexible learning techniques.

A re-evaluation of teaching and learning techniques is required to provide quality teaching and meet the new demands of the changing undergraduate student cohort. All SET student groups in universities and institutes of technology interviewed in the Task Force survey identified the need for a more practical orientation to their courses. The adoption of these practices is limited, often because of the demands these make on academics (Deans of Science 2001).

Initiatives for the development of teaching and learning strategies at third level have been promoted in the U.K. since 1996. The Higher Education Funding Council for England (HEFCE) has set up a Teaching Quality Enhancement Fund (TQEF), which operates an institutional programme as well as an individual programme, to develop and disseminate good practice in the use of new technologies and new techniques in teaching and learning at third level.<sup>84</sup> Targeted funds for the development of teaching and learning techniques (Fund for Development of Teaching and Learning) are made available for different subject areas.

In Finland a special initiative by the Ministry of Education in 2002 has provided funding for the development of "virtual university education" as well as for the development of standard university education with the aim of increasing participation.

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83 <http://www.hw.ac.uk/press/pr118.htm>

84 <http://www.ncteam.ac.uk/tltp.html>

Quality in university teaching is one of the ten points on the Australian Vice Chancellors' Committee plan<sup>85</sup>. A Teaching Quality Fund of up to \$50 million each year is made available for improving teaching on university courses.

The Higher Education Authority has recently introduced a targeted initiative for the Support of Teaching, to encourage activities aimed at rewarding excellence in teaching and to encourage the development of inter-institutional strategies for the advancement of teaching at third level. Since 2000 almost €950,000 has been allocated towards supporting strategic activities underpinning the importance of teaching and learning as a core activity in HEA designated institutions.

### TEACHING QUALIFICATIONS

Research into learning is leading to new practices in pedagogy at second level. There is a need for the new insights into pedagogy to be carried through into third level if lecturing staff are to be adequately prepared for early-years undergraduate teaching. Most third level institutions in Ireland provide a course in teaching skills and teaching management through voluntary staff development programmes. There is as yet, relatively little consideration given to the acquisition of teaching qualifications by third level lecturers, although there is an emerging emphasis on teaching as a measure of quality. Following a 1998 colloquium on university teaching and learning, sponsored by the Irish Universities Training Network, an All Ireland Society for Higher Education (AISHE) was established to promote the professional recognition and the enhancement of teaching and learning in higher education.<sup>86</sup>

The Institute of Teaching and Learning (ILT) in the UK is the main source of professional recognition for staff engaged in teaching in higher education. This Institute, originally established with government support but now operating independently, has attracted a membership in excess of 6000. It has so far rejected the idea of mandatory teacher training for higher education lecturers. However, some individual institutions are introducing requirements for teaching qualifications. An example of one such programme is in the University of Glasgow<sup>87</sup> where new staff members are required to successfully complete a module as part of their probationary period. In the University of Ulster in Northern Ireland, a Postgraduate Certificate in University Teaching has been introduced and new staff are obliged to obtain this qualification within three years of assuming their post.

In Australia there are a number of programmes for staff development at graduate certificate level. An attempt to accredit these is being examined by HERDSA (Higher Education Research and Development Society of Australia). Some universities require successful completion of a programme before awarding tenure to new staff.

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85 <http://sunset.avcc.edu.au/tenpoint.doc>

86 <http://www.aishe.org/etc/about.html>

87 <http://www.hw.ac.uk/press/pr118.htm>

In Finland teaching staff in polytechnics are required to complete pedagogical studies similar to secondary school teachers. The requirement for training in pedagogy for university lecturers has recently become an issue; some special modules have been developed and some universities offer support to staff to participate. However, there is no state-wide policy on university teaching qualifications.

New accredited programmes for training of third level lecturers (Postgraduate Cert/Dip and also MA in Teaching and Learning at Third Level) have been set up in the Dublin Institute of Technology. No system wide position has been taken on teacher training requirements in either the university or the institute of technology sector in Ireland.

### QUALITY OF TEACHING ENVIRONMENT

Integrating an increasingly broad student body, with a wide diversity of background experience into a quality learning environment, makes new demands on SET departments. The quality of the environment is driven both by the quality of the teaching and the quality of the physical infrastructure and equipment. Inadequate infrastructure has the potential to seriously impair the effectiveness of other measures to enhance teaching and learning. State investment in building maintenance, equipment and recurrent expenditure providing for the core activities of undergraduate science departments has been relatively poor in comparison with investment in the new technology/computing areas. The Conference of Heads of Irish Universities, responding to the setting up of the Action Group on Access to Third Level Education, expressed concern at the worsening levels of funding for the universities, pointing to the mismatch between funding and costs over the period 1993 to 1998 as follows:

- Core funding increased only 25% in comparison with a related costs increase of 36%
- Core state funding increase per university student was 4.5%; this compared with a unit cost increase per student of 18%
- A decline of 5% in the staff: student ratio

Referring to what is perceived as necessary investment in facilities for undergraduate teaching the Deans of Science state:

*This will help to provide the necessary infrastructure and recurrent resources to allow provision of some of the developments outlined in the document to enhance the quality of teaching laboratories, allow replacement of old equipment, improve the staff: student ratios in science departments and overall improve the quality of the experience of the students in science programmes (Deans of Science 2001).*

In recent years large-scale investment has been made in the area of Information Technology, to increase the number of places available and to provide appropriate infrastructure and equipment for these courses. This has resulted in a massive increase in output. For example, since the publication of the First Report of the Expert Group on Future Skills Needs, this investment provided for 350 new intake places per annum in 1996/1997, rising to approximately 1500 in 2001. This case provides a vivid illustration of the impact of sustained investment in addressing particular sectoral needs. The most recent recommendation of the Expert Group on Future Skills Needs advised on the allocation of €165 million to meet the requirements of part-time and conversion courses, enhanced completion rates and equipment renewal.

Similar attention and resources will be required if the supply of appropriately qualified science graduates is to be addressed under conditions where the drift away from science is in part due to the increased attractiveness of the computing/IT areas of study. Efforts invested in recruitment cannot provide the guarantee of return unless students are being encouraged into what they perceive to be a quality teaching and learning environment, with modern infrastructure and the capacity to equip them with skills and experience for the modern technological workplace.

*What happens when a successful re-branding programme orients students in the desired direction, only for them to discover that the 'product' – that is, the actual experience of studying science...is dull, boring, difficult and distinctly non-rewarding? (Gaffney 2001).*

#### 4.8.5 Mathematics

The study of mathematics and science are inextricably linked. However, any question concerning the need to address the teaching of mathematics at second level has to take cognisance of the broad rationale underlying education in mathematics i.e. the provision of fundamental tools for basic mathematical literacy as distinct from the provision of a gate-keeping mechanism for entry to third level courses. Nonetheless, this gate-keeping function is implicit for many third level courses, as well as SET courses, in that Leaving Certificate Mathematics is mandatory. However, the problem with the growing decline in mathematics performance is that it has a greater impact on participation in SET courses than for other subject areas.

#### DECLINE IN PERFORMANCE AT SECOND LEVEL

The decline in performance in mathematics at second level has received much attention with the publication of the highest failure rate in Ordinary Level Leaving Certificate Mathematics in August 2001 - 16.7% compared with 12.7% and 12.2% in the previous two years. This was accompanied by a fall, though less dramatic, in the percentage of students obtaining A, B or C grades. The percentage of students taking

all ordinary level subjects in Leaving Certificate who failed mathematics rose from circa 50% to 60% between 2000 and 2001. This high failure rate blocks off one sixth of school leavers from participation in science courses at third level. Because the failure rate among the male cohort was the higher, at 18.7%, this has a particular impact on the pool of eligible candidates for a range of engineering technology courses in the Institutes of Technology that are sought after by a predominantly male group of applicants.

The Chief Examiner's report on the Ordinary Level Leaving Certificate Mathematics exam for 2001, found that there was no difference in the standard of the examination compared with the previous two years, but that there was a "noticeable increase in the incidence of difficulties experienced by candidates". The main causes for low grades suggested in the report were the knock-on effects of difficulties with the older Junior Certificate syllabus (which was revised in 1999), and a lack of continuity in learning due to increased part-time work by students. This latter cause must be given serious consideration as the same phenomenon - of increasing participation in part-time work with consequent growing absenteeism from class - is also observable among students in higher education. It particularly affects performance in hierarchical subjects like Mathematics that require sequential development and consolidation. There is urgent need for an examination of this growing practice of part-time work and any other factors that may be impacting negatively on mathematics performance at second level.

### IMPACT OF MATHEMATICS ON SCIENCE TAKE-UP AT SECOND LEVEL

The effects of decreasing competence in mathematics influences the participation in science at an even earlier stage than third level. Perceived inability in mathematics is a factor in deciding against a physical science subject in the senior cycle of second level. And confidence in mental and practical skills learned in mathematics influences the perception of the physical sciences by those who take these subjects. Low self-confidence, as a barrier to choosing science, affects mature students as well as traditional students (Association of Heads of Schools of Science 2002). This alternative interpretation i.e. that of confidence rather than competence, as the source of the declining mathematics standard, is also put forward by Sheila Tobias a consultant on college and university curricula in US and an adviser on Curricular Broadening to the University of Leiden (Netherlands). She expresses the view that the problem with students' performance in mathematics is not a "failure of intellect" but rather a "failure of nerve" which can be overcome (Tobias 1995).

Students' perception of mathematics difficulty and students' poor performance in mathematics both act as barriers to participation and success in the sciences at second and at third level. The risk in not addressing the problem with mathematics is that it will undermine reform in science education.

### IMPACT AT THIRD LEVEL

The qualitative studies on retention underway at the Educational Research Centre (Morgan 2001) reveal two aspects of the impact of mathematical competence on the success of the transition to third level. Many new third level students are surprised to discover a mathematical or scientific content to their studies. It is questionable whether students in the Life Sciences have an accurate assessment of the Maths/Stats demand of their courses as these become increasingly quantitative.

The other fact emerging from the above studies is that there is a mismatch between the Ordinary Level Mathematics syllabus and the mathematical knowledge actually acquired by students on completion of the Leaving Certificate. This is the view of the Association of Heads of Schools of Science of the institutes of technology. They observe that inordinately large numbers of students present at third level, with passes in Leaving Certificate Mathematics, but with severely limited ability to carry out algebraic, geometrical and arithmetic calculations assumed as outcomes of the Ordinary Level syllabus. Lack of adeptness in basic mathematical skills requires that even the lesser cognitive skills, that the Leaving Certificate certifies, have to be re-taught at the outset of first year undergraduate (Cawley 1997; Association of Heads of Schools of Science 2002). It is observed by the Association of Heads of Schools of Science that over 50% of students are at risk of failure by virtue of having less than a B grade in Ordinary Level Leaving Certificate Mathematics and it is typically mathematical subjects that attract the highest failure rates in first year courses in the institutes of technology.

### PURPOSE OF MATHEMATICS COURSES

Quite apart from the impact of mathematics on the uptake of, and success in, science at second and third level, there is a more fundamental question about the choice of mathematics syllabus by students. With the introduction of the Foundation Level Mathematics course in 1995, the National Council for Curriculum and Assessment Course Committee intended that the Leaving Certificate cohort would divide in the ratio 1:2:1 in uptake of the three mathematics syllabuses: Higher Level, Ordinary Level and Foundation Level respectively. None of these targets has been achieved, the ratios being significantly out of line with those envisaged. The Chief Examiner's report recommends that a comprehensive review be undertaken and that particular emphasis be given to determining the appropriate target groups for the different levels of syllabus. An investigation along these lines would inform the current debate on the role of mathematics in the teaching and learning of science at all levels.

### COMPARATIVE VIEW

There has been growing concern in education circles across the developed world about a declining competence in mathematics in schools. Reform in science in most countries is coupled with reform in



mathematics. The US National Commission on *Mathematics and Science Teaching for the 21st Century* has given this priority to mathematics (NCMST 2000).

A number of UK studies have also identified a general underperformance in mathematics as a threat to the success of students on SET courses at third level. The Undergraduate Physics Inquiry (Institute of Physics 2001) has found that changes in the mathematics curriculum at school level have resulted in students being less proficient and confident in their mathematical skills at college. A survey undertaken by the Royal Society of Chemistry in UK universities revealed serious problems with progression from second to third level. A seminar on Progression in Mathematics, organised by the Engineering Council also raised concerns. The Science, Technology and Mathematics Council conducted a 'Mathematics Hotspot Survey' in 2000, to identify the mathematical topics necessary for the biology, chemistry and physics areas of science learning, and the difficulties encountered in teaching these topics in senior cycle of second level. The purpose of the project is to disseminate best practice.

The LUMA project in Finland addresses mathematical as well as scientific knowledge. Targets have been set for increased participation of second level students in advanced level mathematics. The role of mathematics for the vocational institutions (secondary and post-secondary) is considered of such importance that a Mathematics Development Plan, derived from a national evaluation, is envisaged for vocational education. Weight is given to mathematics in admission to teacher education programmes. An element in the latest phase of LUMA concerns mathematics at third level; a tri-lateral initiative has been launched to involve Finland, Hungary and Sweden in a project to improve the quality and efficiency of university mathematics education.



Task Force *on the* Physical Sciences

## ***Chapter 5***

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## **Recommendations**



## Chapter 5 Recommendations

The Task Force believes that no single action will achieve the desired impact on take-up. The problem is multifaceted and consequently so must the solution be, also. The recommended strategy is based around six areas for action:

1. Planning and Resources for School Science
2. Equity of Access
3. Teaching and Learning of Science
4. School Curriculum and Assessment
5. Promotion of Science And Careers
6. Science Education At Third-Level

The actions form a single, holistic strategy. They are designed for impact simultaneously at first, second and third levels, reflecting the interrelated issues and the need for input at all levels of the education system. It is crucial that the timing of provision respects this design and that connected actions are implemented in tandem.

### 5.1 ACTION AREA #1: SCHOOL PLANNING AND RESOURCES

#### 5.1.1 Aim

Actions in this area will provide at the national, regional and local levels, the resources and support needed to enable all schools to target science education as a developmental priority. A collaborative approach to planning and action will systematically address barriers to take-up of the physical sciences and will particularly emphasise increased levels of practical work within schools.

#### 5.1.2 Issue to be Addressed

Research in both Ireland and elsewhere demonstrates that practical science work in schools is one of the key sources of motivation for students. However, there are significant variations in the extent to which students engage in practical work. While approximately 50% of students report practical work on a weekly basis, around 10% state that they never work with apparatus or materials.

Schools demonstrate large variations in enrolment rates in the physical sciences. It would appear that the way science is "handled" at the local level has a significant impact on subject take-up by students. Variations in local provision are seen in relation to, inter alia:

- practical resources (laboratories; equipment; technical assistance; resource management)
- staffing (background of teachers in the physical sciences; access to and participation in professional development; support for new teachers);

- school culture (support for science; management of resources; priority attached to science);
- curriculum (management; grouping of students; time-tabling; impact on subject choice; availability of teachers and teaching resources e.g. laboratories);
- teaching/learning methodologies (extent of practical work, access to new technologies)
- promotion and guidance for science courses and careers.

Deficiencies within these factors manifest themselves in different ways within different schools and thus priorities for development must be determined locally and supported nationally. The interconnected nature of the multiple factors impacting on the take-up of science in schools necessitates a strategic whole-school response requiring input from all stakeholders including school principals, guidance counsellors, teachers of sciences and others.

Case studies of high take-up in the physical sciences suggest a number of successful strategies namely:

- a high priority attached to school science at management level;
- good subject-level co-ordination and planning;
- an emphasis on building positive student experience at Junior Certificate;
- a strong emphasis on science within Transition Year;
- an emphasis on practical work;
- good access to laboratory resources.

### 5.1.3 Objectives

Actions in this area of School Planning and School Resources will ensure that all schools will:

- Have addressed science as a key component in school developmental planning, through the drafting of a separate science strategy or by including science as a major element in an overall school plan;
- Have a school plan or strategy for science education with established goals, defined targets, quantified resources and defined criteria for success;
- Develop a positive culture of science education that promotes pupil interest and engagement including, participation in activities such as science clubs, visits, science fairs, exhibitions etc.;
- Put in place a programme for subject promotion and career guidance in relation to the physical sciences specifically and science-related careers generally;
- Have teachers, with content expertise and pedagogic skills, available to teach the physical sciences curriculum;

- Put structures in place to ensure that local factors, such as time-tabling, are managed in a way that maximizes the availability of teachers for, and accessibility of pupils to, the teaching and learning of the physical sciences;
- Ensure that an appropriate priority is attached to the funding and resourcing of science at the school-level;
- Obtain the necessary physical resources to ensure "state of the art" laboratories and equipment;
- Generate appropriate access to technical assistance to support practical work in science.

#### 5.1.4 Description of Actions

The overriding goal of this area is to ensure that the level of practical activity, occurring within science classrooms, is in line with curriculum objectives (whether at primary or post-primary level). Implementation requires the coordinated implementation of two key actions, namely the linkage of a strategy on science, developed at school level, with the provision of resources by the Department of Education and Science (DES). These resources will be both physical (laboratories, equipment) and human (technical assistance) and will be provided as a means of driving practical activity within school science.

The responsibility for implementation of this action is shared jointly between schools and the DES. It is clear that the provision of resources alone will not promote better uptake of the sciences unless there is a matching commitment at school level from management and teachers alike.

#### **ACTION 1.1: ENSURE THAT SCIENCE EDUCATION IS ADDRESSED IN EVERY SCHOOL PLAN**

**This action will ensure that all primary and post-primary schools include science education as a priority in a school plan or strategy, to be evidenced by the development of goals, defined targets, quantified resources and defined criteria for success. For this process to be effective, planning must address, not just physical infrastructure requirements, but also needs around issues such as professional development, curriculum, and science promotion. The planning activity must also capitalize on external linkages, whether with other schools, local industry, parents etc. This is necessary to ensure the maximum return on the resources committed.<sup>88</sup>**

- **Planning & Support Team (primary)**

An additional 20 science trainers should be appointed to the existing DES in-service team to support implementation of the science component of the revised primary curriculum in 2002/03.<sup>89</sup> This enhanced provision will ensure more effective support for planning at the school level. **(€1m recurrent)**

88 It is also important that this action is in concert with the various DES initiatives relating to whole-school planning at both primary and post-primary levels. Implementation should examine the models and strategies underlying the DES School Development Planning Initiative (SDPI).

89 This would have the impact of doubling the training resource.

- **Planning & Support Team (post-primary)**

A national infrastructure should be in place for the promotion and support of science planning at schools' level. This team (principally seconded second-level teachers) will co-ordinate actions between school planning initiatives and the provision of national resources by the DES.<sup>90</sup> **(€1m recurrent)**

- **School Science Co-ordination (post-primary)**

Within each school a teacher should be appointed to take responsibility for local co-ordination of the planning process and associated resources. This appointment will take the form of an ex-quota post of responsibility. **(€5.2m recurrent)**

### **ACTION 1.2: PROVIDE RESOURCES FOR PRACTICAL SCIENCE**

This action will ensure adequate national provision of practical science resources, including:

**Capital Funding:** a national plan to provide an up-to-date physical infrastructure for science in all schools science will be established. This plan will set ambitious targets both in terms of standards and implementation. For post-primary schools it will ensure the provision of state-of-the-art school laboratories and equipment before the end of 2004. For primary schools it will ensure that the necessary resources are in place to facilitate the introduction of the new science curriculum in 2003.

**Current Funding:** realistic ring-fenced funding for science, to be provided on an annual basis to all (primary and post-primary) schools. All post-primary schools will have access to dedicated technical assistance to support practical work.

- **Start-up Equipment for Primary Science**

All primary schools should receive sufficient "start-up" funds to ensure appropriate levels of resource for the implementation of the new science component in the primary curriculum. **(€3.9m capital)**

- **Annual Science Resources (Primary)**

All primary schools should receive an annual grant to fund "hands-on" practical science. This grant will be provided on a "per class" basis and provide adequate funding for replacement of practical consumables. **(€5.8m recurrent)**

- **Laboratories & capital equipment (post-primary)**

A national programme, should commence in 2002/03, to provide all schools with first class laboratories and equipment for the teaching of science within 2 years. This programme will refurbish existing laboratories as well as building additional laboratories through a

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<sup>90</sup> This may best be achieved through an extension and a development of the role of the team established to implement the existing Physical Sciences Initiative (PSI). At schools-level, the appointment of an external facilitator to assist the planning process may be appropriate.

substantial increase in existing levels of capital expenditure.

**(€142.8m capital)**

- **Technical Assistants**

All post-primary schools developing a "science plan" should receive funding for the provision of technical assistance.<sup>91</sup> The primary purpose of this provision is to promote levels of practical science work within schools. This initiative should be in place before the 2003/04 academic year. **(€18.8m recurrent)**

- **Annual science resources (post-primary Junior Certificate and Transition Year):**

All post-primary schools should receive an enhanced grant to fund "hands-on" practice of science. This grant, based on pupil numbers enrolled in Junior Certificate or Transition Year programmes, must provide adequate funding for the replacement of laboratory consumables on an annual basis. **(€2m recurrent)**

- **Annual science resources (post-primary physical sciences):**

All post-primary schools should receive an enhanced grant to promote take-up within Leaving Certificate physical sciences.<sup>92</sup> This grant, based on the number of pupils enrolled in the 3 Leaving Certificate physical science subjects, will provide adequate funding for the replacement of practical consumables on an annual basis.<sup>93</sup> **(€2.8m recurrent)**

## 5.2 ACTION AREA #2: EQUITY

### 5.2.1 Aim

Actions in this area will seek to build capacity within the present school system so that every student has the opportunity to study the physical sciences from the beginning of primary to the end of post-primary education. Thus national planning will ensure that pupils are not disadvantaged in terms of access to the physical sciences because of gender, school size, geographical location etc. These actions will target schools requiring additional intervention over and above the provision of physical resources and ensure that such schools derive maximum benefit from the resources provided under *Action Area 1: School Planning and Resources*.

### 5.2.2 Issue to be Addressed

66 post-primary schools have pupils enrolled in the Leaving Certificate programme but no take-up of the Leaving Certificate physical science

91 In the opinion of the Task Force the employment arrangements for Special Needs Assistants in post-primary schools offers a model for the provision of Technical Assistants. The provision of Technical Assistants will need to be commensurate with the size of the school: in a smaller school the position may be shared with another school or alternatively may be on a full-time basis but providing support for other areas in addition to Science (e.g. IT).

92 Schools presently receive €12.7 per pupil per annum.

93 This action strand will partially recompense schools who successfully build pupil numbers within the LC physical science programmes and hence lose entitlement to the enhanced teacher provision recommended under action 2.1.

subjects. This impacted on 3,332 Leaving Certificate students (3% of the cohort) in the academic year 2000/2001. These students were consequently at an obvious disadvantage in terms of pursuing further study or careers relating to the physical sciences.

11% of Leaving Certificate students are in schools that do not offer Physics and 14% in schools that do not offer Chemistry as separate subjects to Leaving Certificate (in comparison with 1% in schools not offering Leaving Certificate Biology).

A large number of schools operate with relatively small numbers of pupils in Leaving Certificate physical science classes.<sup>94</sup> There is concern that these schools may stop providing these subjects because of the resourcing implications associated with maintaining small classes.

Where schools have non-existent or limited take-up of the physical sciences at Leaving Certificate, schools may not be able to justify the employment of a teacher with a background in the physical sciences. This can impact detrimentally on the treatment of the physical sciences within other programmes e.g. the Junior Certificate or Transition Year programmes.

A low demand for teachers may discourage graduates in the physical sciences from entering teaching, particularly when set against the opportunities for such graduates in other employment sectors. Many developed countries are experiencing a critical shortage of physical science teachers.

### 5.2.3 Objectives

This action will seek to realise the following objectives:

- That *all* schools are supported in providing pupils with increased exposure to the physical sciences in the curriculum;<sup>95</sup>
- That enhanced provision of resources to schools (under *Action Area 1*) is targeted in order to ensure that equity considerations are addressed (e.g. through consideration of factors such as school location, size, gender etc.);
- That teacher provision (with regard to background in the physical sciences) is enhanced in a manner which both supports equity considerations for pupils *and* promotes demand and opportunity for newly qualified teachers of the physical sciences.

### 5.2.4 Description of Actions

Delivery within this area will build on the positive experience of previous interventions<sup>96</sup> to improve the provision of science in schools and will involve two key actions.

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94 An estimated 500 classes in LC physical sciences have less than 10 students.

95 In addition to broadening access at LC, this action will help to ensure the realisation of the Task Force recommendation on the introduction of JC Science as a core subject.

96 Examples include the Intervention Projects in Physics and Chemistry, and the Developmental Project in Science (Primary).



**ACTION 2.1 ENHANCED TEACHER ALLOCATION**

**An enhanced teacher allocation will be provided to all post-primary schools with small numbers of pupils studying the physical sciences to Leaving Certificate by providing ex-quota support to any school with fewer than 16 pupils enrolled in any Leaving Certificate physical science subject.<sup>97</sup>**

Such provision will provide a number of benefits for pupils, teachers and schools:

- It will provide a strong incentive for schools to enhance curriculum provision;
- It will provide direct support for schools who operate with small numbers of Leaving Certificate pupils in the physical science subjects;
- It will provide some schools with improved access to expertise in relation to the teaching of the physical sciences which in turn will help to build capacity within other programmes e.g. Junior Certificate, Transition Year, Leaving Certificate Applied;
- It will stimulate additional demand for physical science teachers (and by extension for graduates of teacher training programmes).

- **Enhanced teacher provision (existing schools)**

A significant number of schools have low enrolments in the Leaving Certificate physical sciences. An enhanced teaching resource will help to ensure the viability and continuation of these classes. It recognises that in such circumstances there is a cost to the school in ensuring curriculum provision in the physical sciences.<sup>98</sup> **(€5.2m recurrent)**

- **Enhanced teacher provision (intervention schools)**

This strand is included to encourage schools to improve their curriculum provision with regard to the physical sciences e.g. (i) schools with no Leaving Certificate physical sciences choosing to offer one or more of the subjects to Leaving Certificate or, (ii) schools already offering one of the Leaving Certificate physical sciences providing an additional Leaving Certificate physical science subject. This strand will ensure that schools are encouraged to broaden their curriculum provision. **(€3.7m recurrent)**

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<sup>97</sup> An enhanced teacher allocation should apply where a school is operating with less than 16 pupils enrolled in Leaving Certificate Chemistry and/or Leaving Certificate Physics and/or Leaving Certificate Chemistry & Physics (combined) programmes. This is based on the rationale that a pupil:teacher ratio of 16:1 is typical of post-primary school sector (while acknowledging that there are variations within the different sectors).

<sup>98</sup> It is proposed that this enhancement should be on a sliding scale whereby schools with 1 pupil in any LC physical sciences programme would receive an enhanced teacher allocation of (15/16) while a school with 15 pupils would receive an enhancement of 1/16 of a teacher.

**ACTION 2.2 INTERVENTION TO BUILD SCHOOL CAPACITY**

**An intervention will be provided in primary or post-primary schools where a case for additional support can be made on the basis of equity considerations. This intervention will take the form of additional support to help schools develop their teaching capacity in relation to the physical sciences.**

Schools will be selected for participation on the basis of application and in this way the initiative can ensure that it is sensitive to local issues and not guilty of "imposing" a particular curriculum perspective. On the grounds of pupil equity, national implementation must ensure that a proactive and dynamic operation enables schools to tackle barriers to participation.

The period of intervention will be appropriate to the target programme. Participating schools will receive direct support and funding for at least four years (or until success has been achieved). This would allow, for example, for the completion of a two-year cycle within the Leaving Certificate programme.<sup>99</sup>

- **Equity Intervention: National Planning**

Management of this action will require national co-ordination and planning. A team (principally seconded teachers) will co-ordinate actions between school planning initiatives and the provision of resources by the DES.<sup>100</sup> **(€0.3m recurrent)**

- **Equity Intervention: Local Support**

The precise nature of the action at school-level will be appropriate to the curriculum programme. For example, based on the previous intervention to widen the provision of Leaving Certificate Physics and Chemistry within girls' schools, each participating school might receive direct on-site support for a minimum period of two years and ongoing support thereafter through the establishment of support networks. Thus intervention would work with participating schools to provide:

- a school science plan linked with the necessary physical resources (provided under *Action Area 1*);
- a strategy to build their own teaching capacity including an enhanced teaching provision (under *Action 2.1*);
- a visiting teacher to provide support and/or teaching input (under this strand).

**(€2.2m recurrent)**

<sup>99</sup> This action has been costed based on the LC physical sciences programme. However implementation may target all programmes where provision of the physical sciences is an appropriate and necessary curriculum component including:

Primary (Science); Junior Certificate (Science); Transition Year (Science related courses); Leaving Certificate (Physics, Chemistry, Physics & Chemistry); Leaving Certificate Applied (Science electives); Leaving Certificate Vocational (Physics, Chemistry, Physics & Chemistry).

<sup>100</sup> An examination of requirements suggests that management and planning should be absorbed with other initiatives (e.g. intervention around LC Physical Sciences should be absorbed with the planning role identified under Action Area 1: School Planning and Resources; any intervention around primary science should be absorbed within the Primary Curriculum Support Programme).

## 5.3 ACTION AREA #3: TEACHING AND LEARNING

### 5.3.1 Aim

The availability of high calibre teachers is a critical determinant of a quality education in science. These actions ensure that appropriate measures are taken to maintain and develop the professionalism of those presently teaching in Irish schools.

### 5.3.2 Issue to be Addressed

Providers of both pre-service and in-service teacher training must prioritise the physical sciences.

Only a minority of primary teachers have taken a physical science subject to Leaving Certificate level. Science education must be treated systematically in a fully integrated fashion across all the years of the BEd programme so that science becomes a core curriculum element within the pre-service training of primary teachers. Pre-service providers must ensure that there is sufficient time made available to fully address both pedagogy and science content.

The successful implementation of the science component of the revised primary curriculum is dependent on adequate in-service training and support for 22,000 serving primary teachers. A particular priority must be attached to the physical sciences content associated with this training.

The content of the Junior Certificate science curriculum is such that it requires teachers to address all three sciences: physics, chemistry and biology. While two thirds of the syllabus content is drawn from the physical sciences, the background of the cohort of approximately 3,000 Junior Certificate science teachers, is primarily in the biological sciences. There is also concern around Transition Year both in terms of the amount of time within it devoted to science and the quality of the treatment. The experience of some schools<sup>101</sup> suggests that a stronger emphasis on science in Transition Year would be a contributor to high science take-up at Leaving Certificate.

There is no evidence of an impending shortage of teachers of the physical sciences but this is not unlikely in the future if experience in other countries is replicated in Ireland. The Task Force survey of student attitudes raised some concerns in this regard, in that Leaving Certificate students of the physical sciences are less interested in teaching as a career than other students. Appropriate steps must be taken if science teaching is to remain an attractive and challenging career for graduates. The desire of teachers to voluntarily participate in professional development must also be recognised and promoted.

Curriculum reform is on-going throughout the education system. There is also a desire to see more flexible and creative approaches to teaching and learning. The Task Force survey has confirmed the positive impact

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101 Task Force Case Studies (Appendix IV)

of practical work on students. All of these initiatives are dependent on comprehensive, effective and on-going in-service programmes if they are to effect real change in Irish classrooms.

The application of new technologies to teaching and learning is providing a positive pressure for change within schools and there is evidence of significant teacher support for this innovation. Science is well positioned to capitalise on this but there are a number of pre-requisites including the need for appropriate electronic content for science to be provided within a flexible curriculum framework and supported by access to on-going professional development.

### 5.3.3 Objectives

The objectives identified under this action area are:

- to ensure recruitment and retention of teachers of science;
- to develop new approaches to teaching and learning science;
- to develop pre-service training;
- to support participation in professional development;
- to enhance the science education capacity of Colleges of Education, Teacher Groups, Higher Education Institutes;
- to support curriculum implementation e.g. Primary Science, Junior Certificate Science, Leaving Certificate sciences;
- to promote school-based curriculum development;
- to support science education research in Ireland;
- to promote education-industry collaboration.

### 5.3.4 Description of Actions

Actions under this area will benefit all those involved in the teaching of science at primary and post-primary schools. Implementation will be designed to:

- purposefully manage and maximise the impact on students and classrooms while at the same time supporting, promoting and enhancing the profile of teachers of science;
- seek to strategically build and enhance the capacity of those who have an existing or a potential responsibility in relation to teacher training (Teacher Organisations, Colleges of Education, Third Level Institutes and others);
- utilise the potential of technology to mediate and maximise the impact of a dynamic series of initiatives which will provide teachers of science with access to innovative programmes for professional development, professional support and curriculum delivery;
- build partnership and collaboration across all levels and sectors, (public, private and voluntary).

The first three actions under this heading are deliberately flexible and non-prescriptive in nature to maximise innovation and partnership within implementation proposals. For this reason the financial allocation is conservative and is best regarded as "seed funding". This will need to be reviewed and augmented in the light of implementation experience. Direct investment to support teaching and learning innovation is a critical element within the overall Task Force strategy.

Consortia submitting proposals for implementation under this heading may include representatives from some or all of the following:

- schools (primary/post-primary/both);
- teachers and teacher organizations;
- higher education institutions;
- industry;
- community and voluntary organizations
- other public and private sector bodies.

### **ACTION 3.1: VIRTUAL LEARNING ENVIRONMENT FOR SCIENCE**

**This action will ensure that the maximum return is obtained on any public investment in new technologies in school laboratories. Implementation should be to be through a public procurement (tender) process overseen by the DES. A key criterion will be the delivery of maximum and immediate usability in the teaching and learning of science, within schools, teacher training and adult education. A public-private collaboration may provide the most effective model for implementation, both from cost and quality perspectives.**

#### **• Software infrastructure to support teaching and learning**

Those bidding to develop this virtual learning environment for science will be asked to provide the following:<sup>102</sup>

- a software environment for science education which can be exploited by all schools, students, teachers and teacher trainers;
- a system accessible via the Internet to learners outside the conventional school system, including adult learners;
- a system containing e-learning content for science, particularly the physical sciences;
- open-ended system protocols so that teachers and others can add their own content;
- a framework allowing teachers and others to structure and manage learning resources, curriculum content, student access, collaboration and assessment.

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<sup>102</sup> It is likely that the most cost-effective solution may be to utilise and customise an existing Virtual Learning Environment (VLE). Many different models for implementation are available. For example, the Virtual High School (VHS) initiative is used by US teachers to provide on-line courses to hundreds of schools and thousands of students. Riverdeep, has developed an Internet solution for US teachers to use in the teaching of science and mathematics.

This environment will be particularly important in schools where staffing and other constraints limit curriculum provision. As such it will extend access to the physical sciences and in particular support the implementation of *Action Area 2: Equity*.

This strand will also seek to broaden curriculum access, by providing appropriate resources and materials for the e-learning of science. These materials may take a variety of forms e.g. interactive content and plug-ins for web-pages, stand-alone programs for download to desktop computers etc. The universality of science content may offer an opportunity to collaborate with others who may have similar objectives in relation to education systems outside Ireland. **(€1m recurrent)**

### **ACTION 3.2: RESEARCH AND INNOVATION IN TEACHING & LEARNING OF SCIENCE**

**This action will seek to add value to existing activities and structures. Funding will be provided to catalyse activity within particular areas seen as priorities for development from a science education perspective.**

- **Research and innovation in teaching and learning**

This action will seek the involvement of all relevant partners (teachers organizations, teacher trainers, higher education institutions) to ensure good practice in relation to design, evaluation and dissemination. This action will encourage bidding for funding by partnerships representing schools, industry, government agencies, and third-level institutions. However it will also be open to creative initiatives proposed by individual teachers where it can be shown that the appropriate evaluation and dissemination issues have been addressed.

This strand will provide a mechanism for funding:

- the design, piloting and evaluation of innovative curricula, particularly at Transition Year;<sup>103</sup>
- the piloting of innovative approaches to teaching and learning;
- the development of innovative programmes for teacher training;<sup>104</sup>
- the development of science teaching resources;<sup>105</sup>
- the development of e-learning resources for science;
- research on effective pedagogy for the teaching of science;
- research on science education e.g. student attitudes to science.

**(€1m recurrent)**

103 A significant number of proposals to the Task Force have suggested innovations aimed at Transition Year.

104 The availability of modular and flexible programmes in science education, leading to the award of post-graduates diplomas, and potentially masters programmes have been identified.

105 Including resources to support the teaching and learning of science through Irish.

### **ACTION 3.3: INCENTIVES FOR RECRUITMENT & RETENTION OF TEACHERS**

**This action will provide funding for the provision of incentives targeted at teachers of science.<sup>106</sup>**

- **Innovative ideas to support teachers of science**

The key criteria for initiatives supported under this action will be that they should lead to better recruitment and retention of teachers. Implementation will attempt to dovetail with the actions in other action areas that seek to promote employment opportunities for newly qualified graduates. This will be achieved through the identification and support of innovative ideas that are seen to support the profession of teaching. These ideas may include the following, though many other initiatives would be given consideration:

- teacher sabbaticals in industry and research institutions;
- work in schools by science graduates from industry and research;
- involvement by teachers in scientific research;
- support for the participation by individual teachers in further education.

**(€1m recurrent)**

### **ACTION 3.4: REVIEW PRE-SERVICE TRAINING FOR PRIMARY & POST-PRIMARY TEACHERS OF SCIENCE**

**This action will ensure that appropriate steps are taken to address needs identified in relation to the pre-service preparation of teachers. It will ensure that providers of training are able to derive maximum benefit from actions 3.1, 3.2, 3.3 and 6.4.**

- **Review Pre-service Training for Teachers**

The Department of Education should oversee a review by the appropriate stakeholders of pre-service training in relation to science. This review should address the concerns raised in this Report, namely:

- the provisions necessary to address the variability in the science background of entrants;
- how graduating teachers can be best prepared to teach "all" of the sciences;
- the treatment of science as a core subject in primary BEd programmes;
- protecting the future intake of graduates of the physical sciences into the HDE;
- the extent to which pre-service provides linkage with professional development of teachers;
- the potential of new technologies to facilitate the needs identified;

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<sup>106</sup> The employment and retention of newly qualified teachers will be supported by the expansion in demand that will arise as a consequence of implementation of other actions (e.g. Actions 2.1, 2.2).

This review should take the form of a "Needs Analysis" which is speedily undertaken and which also serves the purpose of helping providers of pre-service training to derive maximum benefit from resources that will be provided as a consequence of the implementation of other recommendations. It should also help to identify opportunities for collaboration in relation to implementation.

## 5.4 ACTION AREA #4: CURRICULUM & ASSESSMENT

### 5.4.1 Aim

Nationally provided educational services (e.g. approved curricula, assessment and examination systems) are important determinants of the quality of any education system. Successful implementation of local initiatives in order to transform science education is dependent upon appropriate and responsive national systems. This action will seek to identify and remove blockages to change that exist at the level of national education provision.

### 5.4.2 Issue to be Addressed

In an era of rapid technological change science is an essential component of a broad education for citizenship. The goal of "scientific literacy for all" has become one of the primary objectives of a general education. The introduction of a revised junior cycle science curriculum in 2003 is an opportunity to broaden access to an education in science for all Junior Certificate students.

Equity considerations from social, vocational and educational perspectives, demand that all students should attain a level of competence in science equivalent to the completion of the Junior Certificate programme. Ireland is unusual amongst developing nations in not requiring that all students continue to study science until the conclusion of the lower secondary phase of education. There is an additional gender-related issue in that an examination of the take-up data demonstrates that girls are more likely to be disadvantaged in terms of participation in, and completion of, Junior Certificate Science.

The planned introduction of science into primary schools will demand careful co-ordination between schools at first and second level. There is an opportunity to build partnerships between schools and all other public and private sector bodies who are "stakeholders" in Irish science. There is also a need to review and evaluate Irish science education in the context of external factors. A forum in which all of these ideas – and others - can be explored with representatives of all sectors and phases of education is needed.

The Task Force survey indicates that the experience of science at Junior Certificate has a strong influence on student choice to study science subsequently. There is an anxiety that the revised Junior Certificate curriculum, which will embody a new approach to the learning of science, should be introduced as quickly as possible.



There is a frustration with the slow pace of curriculum change. Efforts to speed up curriculum reform must be supported by appropriate changes in assessment techniques. Clarity is needed around the outcomes anticipated from an education in science. Practical work is considered to be an integral element of a science education and there is almost universal support for its inclusion as a component within the assessment of school science.

There is a widely held perception that it is more difficult to get higher grades in the physical sciences than in other Leaving Certificate subjects. Preliminary research findings confirm that this perception is based on fact.<sup>107</sup> The Task Force survey on student attitudes indicates that the perceived difficulty of science subjects is one of the factors inhibiting student choice of the physical sciences.

### 5.4.3 Objectives

Actions in this area will ensure that the necessary changes are facilitated within national systems for curriculum and assessment leading to the achievement of the following:

- ensuring that all students have an appropriate education in science;
- providing the optimum preparation for students entering further scientific study;
- ensuring a seamless curriculum and transition from first level to second level;
- providing a clear definition of outcomes for a science education including an understanding of how these contribute to a "general" education;
- ensuring that assessment methods are appropriate to the desired learning outcomes;
- ensuring that the outcomes for engagement in practical work are defined and supported by appropriate assessment methods;
- addressing concerns about variation in standards across Leaving Certificate subjects;
- enhancing the curriculum development process through a reduction in time and an increase in flexibility.

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<sup>107</sup> The Task Force commissioned the Educational Research Centre, Drumcondra, Dublin to undertake research into this issue. The full report is due in March 2002.

#### 5.4.4 Description of Actions

##### ACTION 4.1: PRIORITISE POST-PRIMARY CURRICULUM REFORM

- **Fast-track curriculum changes already identified<sup>108</sup>**

The National Council for Curriculum and Assessment must prioritise actions relating to science education, including:

*at Junior Certificate:* the revised syllabus for Junior Certificate Science to be ready for implementation in schools commencing 2003;

*at Transition Year:* science curriculum and experience within Transition Year (TY) must be reviewed and developed commencing 2002;

*at Leaving Certificate:*

- immediate action to be taken to provide for the assessment of practical work within the sciences;
- an impact study to determine the feasibility of introducing a new, general science subject at Leaving Certificate level to be completed (2002);
- the revision of the Physics/Chemistry (combined) syllabus (to be titled Physical Science) to be completed for implementation in schools with a particular focus on broadening up-take (2003);
- the physical science content of subjects within the technology and applied science grouping, should be highlighted and enhanced;
- an evaluation of the Leaving Certificate Applied programme should be completed to examine the science exposure of LCA students in general, and ensure that content relating to the physical sciences is appropriately represented within electives (2002);
- Science must be a priority for the introduction of on-going rolling review of subject syllabuses and programmes (2002);
- Planning for the co-ordination of curriculum provision for science across all phases of the education system should commence immediately, particularly in relation to the primary to second-level transition (2002).

- **Shorten the period for curriculum design**

The National Council for Curriculum and Assessment should set a two-year target for the curriculum design process.

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<sup>108</sup> The list of objectives identified under Action 4.1 are based on the list of priorities identified by the NCCA (2000:36).

- **Stream-line procedures for curriculum implementation**

The Department of Education and Science should examine its procedures for curriculum implementation to facilitate the achievement of these time-scales

#### **ACTION 4.2: ESTABLISH SCIENCE AS A CORE SUBJECT IN THE POST-PRIMARY CURRICULUM**

- **Science to become a core subject within post-primary junior cycle**

The Department of Education and Science should ensure that all students study science by establishing it as a core requirement in the post-primary curriculum. This should be done to coincide with the proposed introduction of a new Junior Certificate Science curriculum in 2003/04.<sup>109</sup> **(€1.6m recurrent)**

#### **ACTION 4.3 UNDERTAKE A REVIEW OF MATHEMATICS**

**Four strands of action are required:**

- **Investigation into the decline in mathematics performance**

The Department of Education and Science should institute an urgent inquiry into the decline in mathematics performance by students. This should include a consideration of the social and behavioural factors identified in the Chief Examiner's report on ordinary level Mathematics in the Leaving Certificate Examination in 2001.

- **Increased input into mathematics curriculum by higher education**

A higher education SET group, nominated by the universities and institutes of technology, should be appointed to consult with the National Council for Curriculum and Assessment course committee on Leaving Certificate Mathematics.

- **Review Leaving Certificate Mathematics**

The National Council for Curriculum and Assessment should undertake a review of Leaving Certificate Mathematics.

- **Credit for Foundation Level Mathematics**

Higher education institutions should consider taking into account higher grades in foundation level Leaving Certificate Mathematics in assessing entry requirements for certain courses.

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<sup>109</sup> It is recognised that the JC Science curriculum may need to be adjusted to take account of a broader range of student ability. The implementation of this action should take place in tandem with the introduction of a revised JC Science syllabus which is presently nearing completion by the NCCA. The training costs will thus be met by the in-service programme associated with the new curriculum. Additional resource requirements will be met under Action Area 1.

#### **ACTION 4.4: ENSURE EQUITY OF GRADING AT LEAVING CERTIFICATE**

The Department of Education and Science, as the body responsible for assessment, must act immediately to ensure comparability of grading at Leaving Certificate. Three strands of action are needed:

- **Annual review of examination papers for Leaving Certificate Physical Sciences**

The Department of Education and Science must re-establish the practice of convening a standardising committee to critically review the Leaving Certificate examination papers in the physical sciences (2002);

- **Establish comparability of grading between Leaving Certificate subjects**

The Department of Education and Science must prepare a plan of action based on the report from the Educational Research Centre when it is published in March 2002; this plan must clearly state what action will be taken to ensure that the variation in severity of grading between Leaving Certificate subjects is minimised.<sup>110</sup> This plan should be in place for the 2002 examination results.

- **Introduce practical assessment for Leaving Certificate physical sciences**

This should be proceeded with as quickly as possible (for students commencing the Leaving Certificate programme in 2002).

**(€0.6m recurrent)**

#### **ACTION 4.5: NATIONAL FORUM ON SCIENCE EDUCATION**

- **A National Forum on Science Education to be held annually (commencing 2002),**

This forum, jointly organised by ICTSI and the NCCA, should bring together all of the stakeholders from public and private sectors, and:

- engage those charged with policy development and implementation at local, regional and national levels;
- provide opportunities to learn from best practice and innovation both within Ireland and abroad;<sup>111</sup>
- establish collaborative relationships across all educational sectors and levels (primary, post-primary, tertiary)
- identify opportunities to explore and establish education-industry partnerships;
- establish how providers of both formal and in-formal education in science can work together to maximise impact and outreach;
- seek to establish change and innovation as a norm within Irish science education and provide the basis for future development.

<sup>110</sup> The Task Force suggests that the Subject Pairs Analysis methodology could form the basis for establishing the comparability of grading between subjects.

<sup>111</sup> The Task Force has, during the course of its work, identified a number of systems in this regard: Scotland, Finland, Victoria (Australia).

An expert panel will draw up a report and identify how to build upon the forum outcomes. **(€0.1m recurrent)**

## 5.5 ACTION AREA #5: PROMOTION OF SCIENCE

### 5.5.1 Aim

The aim here is to raise the level of awareness of the physical sciences among school students and parents both for their intrinsic value and for their potential to open up career opportunities.

This action will involve schools, industry, third level institutions and professional bodies in a coordinated effort to increase interest in the study of science and to promote a positive attitude towards careers in science, engineering and technology.

### 5.5.2 Issue to be Addressed

There is need for collaborative action by third level educators and industry to highlight the importance of the physical sciences at second level for opening up routes to a wide vista of courses and careers.

There are many individual promotional initiatives for science and technology but no one initiative that integrates these to allow second level students and their teachers and advisers to make fully-informed decisions around choosing/not choosing the physical sciences.

The effectiveness of the many separate promotional efforts are compromised by a range of factors including geographical localisation, poor information flow, lack of partnership, isolation from mainstream events, limited funding and, not least, the disorienting effect of their diversity of messages.

### 5.5.3 Objectives

Action in this area is designed to enhance the image of science through a high profile programme that reaches all schools in the country. This action will achieve the following objectives:

- Students (across primary and second level) will be made aware of the range of careers in science, engineering and technology; will be given informed, balanced information on role, status and job profile of scientists and engineers (in order to counteract the stereotype of scientists).
- Science teachers, guidance counsellors and students will be made aware of careers in industry and will be exposed to the working environment of scientists and engineers.
- All student groups -Junior Cycle, Transition Year and Leaving Certificate - will receive suitably targeted information from industry and from higher education institutions for making subject, course and career choices. Targeted information will also address gender differences in subject take-up and career interests.
- Second level students will be given exposure to the third level science, engineering and technology environment.

#### 5.5.4 Description of Actions

Delivery will involve the central coordination of existing awareness activities and the design of a school-based package/s.

Coordination will involve the amalgamation of existing efforts for the beneficial effects of scale, cost effectiveness, controlled funding, evaluation, dissemination of best practice and the centralisation of all information on the totality of activities for the benefit of all stakeholders.

The schools-based promotional initiative will provide the opportunity for schools at local or regional level to benefit from a comprehensive package of awareness resources provided by third level, industry and professional bodies.

The Task Force fully endorses the proposal by Forfás for an *Interactive Science Centre*. There is a full realisation that the promotion of science must extend beyond the focus on schools and must encompass the general public in a wide appreciation and awareness of science as part of culture and national progress.

#### ACTION 5.1: COORDINATION OF PROMOTION

- **Establish an integrated National Science Awareness programme**

A new body should take charge of the diverse promotional activities that exist and set new goals for maximising their effectiveness. The existing activities under Forfás, involving the Department of Education and the Department of Enterprise, Trade and Employment, should be drawn into this effort. Successful implementation will also require the participation of the professional institutes (e.g. Institute of Physics, Institute of Chemistry, Irish Pharmaceutical & Chemical Manufacturers Federation) and professional networks capable of identifying and incentivising sponsorship from a broad range of industry. This body will require additional funding to that already provided to support awareness programmes under Forfás/ICSTI.

This body will take draw together the various science promotional activities. It will involve the integration of separate initiatives and the centralisation of information (one-stop-shop) for promoters and consumers. The coordinating team will:

- Audit promotional activity vis-à-vis geographical reach and regional equality;
- Provide advice to all participants on how to benefit from activities and provide advice on best practice;
- Dispense funding for the maintenance of worthy initiatives and the establishment of new initiatives;
- Undertake the evaluation of activities.

It will ensure that all schools benefit from a specially designed promotional package containing resources for students (at all levels), teachers and guidance counsellors. This will require the joint participation of academic institutions, industrial partners and professional bodies. The involvement of academic interests can be achieved through building on the schools liaison programmes already in existence in Science/Physics and Chemistry departments in higher education institutions. The administration of the programme should be representative of the broad range of interest groups.<sup>112</sup>

This school-focussed programme will include the following elements:

- roadshow (college and career stands ‘manned’ by academics, scientists and engineers);
- awareness programmes/ career seminars for science teachers and guidance counsellors;
- partnership scheme to link schools and local industry;
- schools-college links for science promotion by SET lecturers;
- volunteer programme for teacher-scientist network;
- resource material (customised for different student groups: Junior Certificate, Transition Year, Leaving Certificate, and including information to address gender balance);
- associated interactive website.

The role of the Irish Science Teachers’ Association in science promotion should be supported and reinforced through the secondment of a member to a full-time position, with responsibility to work with this coordinating team.

**(€3M Recurrent)<sup>113</sup>**

- **Industry must co-ordinate its effort**

Industry must become more proactive in raising awareness of the science sector amongst the Irish population in general and use every opportunity to develop the profile of science careers as both interesting and rewarding.

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<sup>112</sup> A project management team will need to be identified. This team should consist of an executive manager together with administrative support, working full-time on the project. A steering group representative of all partners listed above will design, oversee and evaluate the programme. This action must be accompanied by the action (6.1) at third level to provide science staff for schools liaison work to contribute to the development and to participate in operation.

<sup>113</sup> Funding for this action is estimated as additional to the current annual budget for the awareness programmes under Forfás.

- **Evaluate the School Guidance Enhancement Initiative**

It is noted by the Task Force that priority was given to proposals centred around school links with business and community and around promotion of science in senior cycle. These activities are central elements in the national promotional programme being recommended. The Department of Education and Science should therefore review the experience of schools that were successful in gaining support for additional ex-quota guidance under this initiative in 2001. The objective of this review should be two-fold:

- To disseminate best practice in relation to promoting take-up of science;
- To extend the scheme to schools who were not included in the first round of the initiative.

- **Implement the proposal to establish a National Interactive Science Centre**

The Task Force is conscious of the need to promote science in the wider arena, among parents and the general public, as well as among the student body. It welcomes the fillip that the advent of a National Interactive Science Centre would give to increasing the public awareness of science and the interest it would generate in young people at a time when Government seeks to promote science uptake in schools and at third level.

## **5.6 ACTION AREA #6: SCIENCE EDUCATION IN HIGHER EDUCATION**

### **5.6.1 Aim**

To increase recruitment to science, engineering and technology courses in third level institutions and to provide an environment that encourages integration and retention.

To develop a strategic vision for third level undergraduate science, engineering and technology education that is focussed on flexibility and quality.

### **5.6.2 Issue to be Addressed**

There is a decline in the number of students enrolling on SET courses at third level at a time when national technological progress demands a continued supply of appropriately qualified scientists, engineers and technologists.

High rates of non-completion are further depleting the quota of SET graduates and this is feeding back a negative message to schools about third level science.

Poor completion rates indicate that there are growing mismatches between students' expectations and their experiences on SET courses, and also mismatches between students' abilities and the expectations of course deliverers.



The changing profile of entrants to SET courses requires a new approach to the management of teaching and learning and to the use of new methodologies in teaching and learning, in order to provide a positive experience to undergraduate students with widely disparate prior experience of science. These new approaches include the development of modularisation, recognition for prior learning, facilitation of transfer, adoption of e-learning and other new learning techniques.

Access routes into higher education SET courses for a wide range of prospective students, from mature, disadvantaged, apprenticeship and further education backgrounds are poorly developed and, as such, are discouraging participation by these types of students.

The quality of the education provided by higher education SET departments is driven by both the quality of teaching and learning and the quality of the physical infrastructure and equipment which is provided to support teaching and learning.

General underperformance in mathematics is posing a threat both to the supply of students to third level SET courses and to their success on these courses.

### 5.6.3 Objectives

This action will provide the structures and resources to encourage participation in and successful completion of higher education SET programmes by a broad spectrum of students. The objectives identified are:

- To communicate accurate and complete information on SET courses to prospective students.
- To ensure wider access for non-standard applicants by the development of new introductory and foundation courses and by drawing up an agreed system-wide selection and assessment procedure for such applicants, including mature students, apprentices etc.
- To smooth the transition from school to third level by the provision of bridging and preliminary courses by higher education institutions for poorly prepared students and for non-traditional entrants.
- To cater appropriately for a wide spectrum of learners by provision of flexible assessment, credit for prior learning and associated transfer routes.
- To enhance the undergraduate experience by the adoption of new teaching and learning techniques.
- To increase the capacity of educators to provide quality teaching by providing the opportunity and incentives for training in pedagogy at third level.
- To provide a quality environment for teaching by ensuring students have access to modern state-of the art facilities and equipment.

#### 5.6.4 Description of Actions

Delivery within this area will involve four key areas addressing promotion and recruitment, access, transition and transfer, innovation in teaching and learning and enhancement of teaching environment.

The Task Force proposes the establishment of a designated capital fund of circa €30 million to be allocated for urgent needs in the area of physical infrastructure and circa €10 million to be available annually to support initiatives for increased participation by targeted groups, for retention, for development of strategies for teaching and learning and for training in pedagogy.

Funding for development of projects to increase participation and retention will be based on applications from collaborative groups within or across institutions. This funding will be provided to catalyse activity within the particular areas seen as priorities for widening access to third level SET and establishing conditions for successful transition and integration.

Implementation will seek to encourage collaboration across the SET disciplines and across institutions.

The purpose of the total fund will be to support all institutions in their strategies to address each of the areas under this action.

The Task Force considers that it is important that the fund should be capable of supporting projects with a multi-annual focus, rather than being confined to annual allocations of funding. The management of the fund should be devolved to the HEA.

#### **ACTION 6.1 RECRUITMENT TO THIRD LEVEL SET**

**This action will break down barriers to recruitment by ensuring that all prospective students have access to comprehensive information about SET courses and are given the opportunity of exposure to the third level SET environment. This will include:**

- **Supporting school-higher education links**

Provide funding and invite bidding by SET departments to collaborate with the national promotional effort to foster schools links. Incentivise school-college links for promoting Transition Year science and for maximising the preparedness of disadvantaged students.

**(€0.5M Recurrent)**

- **Advertise courses effectively**

Ensure that college brochures/prospectuses are re-designed in consultation with all stakeholders to ensure that effective advertising reaches all potential student target groups.

**ACTION 6.2 ACCESS, TRANSITION AND TRANSFER**

**This action will provide routes into higher education SET for students from a diversity of backgrounds and will enable all students to experience a smooth transition into, and flexible progression through, higher education. Particular actions to ensure this include:**

- **Course development for wider access and successful transition**

- new foundation courses for mature students;
- introductory courses for disadvantaged groups and other learners;
- part-time courses in SET for different student groups;
- enabling courses in introductory mathematics and engineering science for apprentices to prepare them for further appropriate SET courses;
- additional preliminary and bridging courses in science and mathematics for poorly prepared students, to help them integrate successfully into first year courses.

**(€8M Recurrent)**

- **Improvement of access routes for all applicants**

This strand will build cooperation:

- between SET departments within each sector in the drawing up of a common system of selection and assessment procedures for mature students and other learners (guided by principles laid out by the Action Group on Access to Third Level Education)
- to ensure that pathways for progression, for full-time and part-time courses, are facilitated within the new National Qualifications Authority of Ireland framework.

- **Greater Recognition for Prior Learning (RPL)**

This strand will ensure provision of course credits to first year students with high grades in the physical sciences.

- **Accommodation of student transfer**

This strand will ensure the review of mechanisms for transfer between different higher education institutions and the drawing up of procedures to facilitate movement of students across institutions.

**ACTION 6.3 RETENTION / QUALITY TEACHING AND LEARNING**

This action will ensure that maximum attention is given to optimising retention by providing quality teaching and learning in SET departments. This requires support for lecturers to employ new teaching and learning techniques and to develop their own capacity to deliver quality teaching. This action will provide a mechanism for:

- **Setting up of a Collaborative Teaching and Learning Centre:**

It will enable lecturers to collaborate in the development of new teaching and learning techniques. It will provide a platform for cooperation across the two third level sectors. It will also provide a hub for the development of resources for the support of science promotion. This strand will encourage partnerships between science and engineering and partnerships between universities and institutes of technology. **(€1M Capital, €0.5M Recurrent)**

- **Training in Pedagogy:**

It is strongly recommended that SET departments set goals for the acquisition of a teacher training qualification by new members of staff and put in place mandatory modules in pedagogic training for postgraduate students.

This action will provide a mechanism for SET departments to cooperate with other departments and with education departments to develop teacher training courses for lecturers. It will provide support for participation in teacher training and in staff development related to SET teaching. **(€1M Recurrent)**

**ACTION 6.4 PHYSICAL INFRASTRUCTURE FOR QUALITY TEACHING AND LEARNING**

Inadequate infrastructure will seriously impair the effectiveness of other measures for encouraging participation. This action is designed to restore basic infrastructure to departments that have had an investment deficit and to provide for the building up of a modern teaching environment with state-of-the-art equipment. The review of barriers to participation and completion represents a valuable opportunity to ensure that not only are current and past difficulties in the learning of science identified and remedied, but also that a stable and appropriate infrastructure is put in place for the learning of science into the future.

- **A fund will be designated for the refurbishment of undergraduate science laboratories for the use of undergraduate SET students and for students on teacher training programmes.**

Such investment will have regard to the different sectors in higher education involved in science education: the university sector, the institute of technology sector and the teacher training sector. This capital investment will extend to equipment up-grading. This will allow the provision of up-to-date laboratory training for undergraduates and science teachers in training, as well as providing a positive environment for exposure to prospective students.

**(€30M Capital)**



Task Force *on the* Physical Sciences

## ***Chapter 6***

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## **Implementation**



# Implementation

## 6.1 MANAGEMENT

From its analysis the Task Force has concluded that no single action can reverse the decline in take-up of the physical sciences. The problem is multifaceted and consequently so too must be the solution. Hence, the actions proposed in this document are designed for delivery as part of a single, holistic strategy.

Actions are designed for simultaneous impact at both first, second and third levels reflecting the interrelated nature of issues and the need to provide input at all levels of the education system. It is crucial that the timing of provision respects this design and that the implementation of connected actions moves in tandem.

### 6.1.1 Implementation Group

The importance of these proposals has already been stressed and cannot be exaggerated. It is important, therefore, that they are put carefully and effectively in place over a short period of time. Reflecting the high priority and urgency for action, we recommend the establishment by Government of a high level Science and Technology Implementation Group whose function will be to source the finances and to otherwise ensure the implementation of these proposals. Its membership should be small, circa seven persons, and should reflect the high priority attached to these actions. It should include:

- Secretary General of the Department of Education and Science;
- Secretary General of the Department of Enterprise, Trade & Employment;
- Chief Executive of Forfás;
- Chairman of the Irish Council for Science, Technology and Innovation
- Chairman of the Higher Education Authority;
- Chairman of the Expert Group on Future Skills Needs;
- A senior official from the Department of Finance.

In addition, it is recommended that a nominee of the Task Force on the Physical Sciences should be appointed to this group to ensure continuity.

This, we acknowledge, is an unusual proposal, but is a vital element, which must be implemented if we value the central role of science and technology in sustaining national development.

### 6.1.2 Continuing Review and Annual Report

Continuing review and the creation of new initiatives and the elimination of unsuccessful elements is crucial in ensuring that the major national issue, which is the subject of this report, is addressed and reviewed regularly. It should not be a matter which is addressed occasionally or as and when a crisis occurs. If a strategic review is carried out on an ongoing basis, it may point to the need for new elements to be grafted on to the strategy; changing demographics and evolving conditions in higher education and in the workplace may require that new initiatives are introduced or that the original ones are adjusted.

The Task Force recommends that the *Irish Council for Science, Technology and Innovation (ICSTI)* is the appropriate body to be responsible for this role and that it should establish a Standing Committee of the ICSTI Board for this purpose; it should report to Government annually on the state of science educational provision and the relevant Oireachtas Committee should receive that annual report and be expected to comment on it.

During the course of its work the Task Force has identified a significant number of instances in which the national data is weak; for example, the extent of practical work in schools; the quantity, quality and level of usage of school laboratories; the background and qualifications of teachers; the level of expenditure on science at the school level. The efficacy and success of any future review is dependent upon good quality information on these and other issues. The Task Force recommends that the Department of Education and Science should take immediate steps to review its procedures in this regard. It also needs to be stated that building an accurate picture of school science is not solely the responsibility of the Department but also requires the co-operation of other stake-holders. For example, school managers must provide information on expenditure; teachers must facilitate the building of a picture of student experience and classroom practice.

### 6.1.3 Government Chief Scientist

The Task Force also recommends to Government the creation of a position as *Government Chief Scientist* who would have responsibility for overseeing this and other science-focussed initiatives and for providing government with an authoritative source of professional advice regarding national science and technology. We have reflected on the fact that Ireland is unusual in the developed world in not having such an advisor to Government.

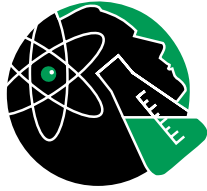


## 6.2 FINANCIAL SUMMARY

Actions have been fully costed on the basis of information provided to the Task Force by the Department of Education and Science and others. The figures provide an estimate of the level of investment needed and are additional to present expenditure. They are based on costs at the time of writing (February 2002) and will need to be adjusted upwards to take account of inflation.

**Table 41: Summary of Capital and Annual Recurrent Costs (All Actions)**

	<b>Action</b>	<b>Capital (€m)</b>	<b>Annual Recurrent (€m)</b>
1.1	Helping Schools to Plan for Science		7.2
1.2	Provision of Resources for Practical Science	146.7	29.4
2.1	Enhanced Teacher Allocation		8.9
2.2	Intervention to Build School Capacity		2.5
3.1	Virtual Learning Environment for Science		1.0
3.2	Research and Innovation in Teaching & Learning of Science		1.0
3.3	Promote Recruitment & Retention in Teaching		1.0
4.2	Science as core Junior Cycle subject		1.6
4.4	Equality of grading at Leaving Certificate		0.6
4.5	National Forum on Science Education		0.1
5.1	Co-ordination of promotion		3.0
6.1	Recruitment to Third Level SET		0.5
6.2	Access, Transition & Transfer		8.0
6.3	Retention/Quality Teaching and Learning	1.0	1.5
6.4	Physical Infrastructure for Quality Teaching and Learning	30.0	
	<b>Totals (€m)</b>	<b>177.7</b>	<b>66.3</b>



Task Force *on the* Physical Sciences

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# Task Force *on the* Physical Sciences

## ***Appendices***

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## Appendix I: Membership of The Task Force on the Physical Sciences

<b>Nominating Organisation</b>	<b>Task Force Member</b>
Task Force on the Physical Sciences	Dr. Daniel O' Hare, Task Force Chairman
Task Force on the Physical Sciences	Dr. Aine Allen, National Strategy Co-ordinator (Third Level)
Task Force on the Physical Sciences	Mr. Cyril Drury, National Strategy Co-ordinator (Second Level),
Association of Community and Comprehensive Schools	Mr. Pat Canty, St. John the Baptist Community School, Co. Limerick
Association of Secondary Teachers of Ireland	Ms. Catherine Fitzpatrick, President, Association of Secondary Teachers of Ireland
Church of Ireland Board of Education	Mr. Brian Cairns, Principal, Midleton College, Co. Cork
Conference of Heads of Irish Universities	Prof. Iggy McGovern, Department of Physics, TCD
Conference of Heads of Irish Universities	Prof. Julian Ross, Dean of Science, University of Limerick
Council of Directors of Institutes of Technology	Dr. Ruaidhri Neavyn, Limerick Institute of Technology
Department of Education & Science	Dr. Tim Desmond, Department of Education & Science
Department of Education & Science	Mr. John Mc Cullagh, Department of Education & Science,
Department of Education & Science	Mr. Fintan O'Brien, Department of Education & Science
Department of Education & Science	Mr. Christopher McCamley, Department of Education & Science,
Department of Education & Science	Mr. George Porter, Department of Education & Science
Department of Enterprise, Trade & Employment	Mr. Ronald Long, Assistant Secretary, Department of Enterprise, Trade & Employment
Dublin Institute of Technology	Dr. Vincent Toal, Head of School of Physics, DIT Kevin Street

Economic & Social Research Institute	Dr. Emer Smyth, Economic & Social Research Institute
FÁS	Mr. Eamon Carey, Loughlinstown Training Centre, Co. Dublin
Forfás	Dr. Jacqueline Allan, Science Technology and Innovation Division
Gaelscoileanna	Ms. Maire Ní Shlatara, Gaelscoileanna
Gaelscoileanna	Fionnula Ni Chasil, Gaelscoileanna
Higher Education Authority	Ms. Orla Christle, Higher Education Authority
Higher Education Authority	Mr. Sean Foghlu, Higher Education Authority
Higher Education Authority	Mr. Fergus Costello, Higher Education Authority
Higher Education and Training Awards Council	Mr. Joe Cox, Registrar, Higher Education and Training Awards Council
Irish Association of Science Education Lecturers	Dr. Peter Childs, University of Limerick
Irish Business and Employers Confederation	Dr. Marian Byron, Irish Pharmaceutical and Chemical Manufacturers Federation
Irish Business and Employers Confederation	Mr. Sean Ward, Shering Plough (retired)
Irish Business and Employers Confederation	Mr. Frank Turpin, Intel Ireland Limited
Institute of Chemistry of Ireland	Dr. Imelda Averill, Central Laboratory, Dublin Corporation
Institute of Engineers of Ireland	Dr. Donal Finn, Department of Mechanical Engineering, UCD
Institute of Engineers of Ireland	Dr. Lisa Looney, School of Mechanical and Manufacturing Engineering, DCU
Institute of Physics in Ireland	Prof. Robert McCullough, Queen's University, Belfast
Institute of Physics in Ireland	Dr. John Costello, School of Physical Sciences, DCU
Irish Council for Science, Technology & Innovation	Prof. Jane Grimson, Department of Computer Science, TCD
Irish Council for Science, Technology & Innovation	Mr. Brian Trench, School of Communications, DCU
Irish Federation of University Teachers	Dr. Donal Leech, Department of Chemistry, NUI Galway

Irish Federation of University Teachers	Mr. Paddy O'Flynn Department of Chemical Engineering, UCD
Irish National Teachers' Organisation	Ms. Jennifer O'Connell, North Dublin National School Project
Irish Science Teachers' Association	Mr. Seamus McManus, Post-Primary School, Maynooth, Co. Kildare
Irish Vocational Education Association	Mr Tony Breen, City of Dublin Vocational Educational Committee
Irish Vocational Education Association	Mr. John Mc Kay, Chief Exective Officer, Co. Cavan VEC
Joint Managerial Body	Mr. Tom Loughnane, Principal, St. Joseph's Secondary, School, Rush, Co. Dublin.
Marino Institute of Education	Ms. Miriam Carolan, Marino Institute of Education
National Association of Principals and Deputy Principals	Mr. Sean Ashe, Principal, Maynooth Post Primary School, Co. Kildare
National Council for Curriculum and Assessment	Mr. Bill Lynch, Education Officer for Science & Technology, NCCA
National Council for Education Awards	Dr. Marian O'Sullivan, Registrar for Science and Computing, NCEA
National Centre for Guidance in Education	Mr. Vivian Cassells, National Centre for Guidance in Education
National Parents Council,	Mr. Tom Lillis, National Parents Council, (Post Primary)
National Parents Council,	Ms. Rose Tully, National Parents Council, (Post Primary)
Royal Dublin Society	Dr. Tony Scott, Office of Public Affairs, UCD
Royal Irish Academy	Mr. Pauric Dempsey, Royal Irish Academy
Royal Irish Academy	Prof. Johannes Vos, School of Chemical Science, DCU
Royal Irish Academy	Prof. Martin Henry, School of Physical Sciences, DCU
Skills Initiative Unit	Dr. Seán McDonagh, Skills Initiative Unit
Teachers' Union of Ireland	Dr. Maureen O'Rafferty, Teachers' Union of Ireland

## Appendix II: Submissions made to The Task Force on the Physical Sciences

### Submissions from Organisations

1. Association of the Heads of School of Science of the Institutes of Technology
2. Association of the Heads of School of Science of the Institutes of Technology (Mathematics)
3. Association of Secondary Teachers, Ireland (ASTI)
4. Chemistry Society, University College Cork
5. Committee of Heads of Irish University Chemistry Departments
6. Deans of Science of the Irish Universities
7. Department of Chemistry, NUI Maynooth
8. Department of Chemistry, University College Dublin
9. Department of Chemical and Life Sciences, Institute of Technology Tralee
10. Faculty of Science and Health, Dublin City University
11. Heads of Physics Departments (Universities & DIT)
12. Industrial Development Authority
13. Institute of Chemistry of Ireland (ICI)
14. Institute of Engineers of Ireland
15. Institute of Physics in Ireland (IOP)
16. Intel Ireland
17. Irish Business and Employers Confederation
18. Irish Council for Science, Technology & Innovation
19. Irish National Teachers' Organisation (INTO)
20. Irish Science Teachers' Association
21. Lucent Science Teacher Initiative, University of Limerick
22. Microelectronic Industry Design Association (MIDAS)
23. National Association of Principals and Deputy Principals (NAPDP)
24. National Centre for Guidance in Education
25. National Commission for the Teaching of Physics, Royal Irish Academy
26. National Committee for Physics, Royal Irish Academy
27. National Council for Curriculum and Assessment
28. Royal Irish Academy Working Group on Practical Work in Secondary Science
29. School of Science & Technology, Dun Laoghaire Institute of Art, Design and Technology
30. Teachers' Union of Ireland (TUI)
31. Working Group on Science Education, University of Limerick



### Submissions from Individuals

1. Professor Paul Brint, University College Cork
2. Professor L.D. Burke, University College Cork
3. Dr. Seán Cawley, Institute of Technology, Carlow
4. Dr. Peter E. Childs, University of Limerick
5. Dr. Ian Elliott, Dublin Institute for Advanced Studies
6. Dr. Cathal Flynn, Dublin Institute of Technology
7. Stephen Kearney, Student
8. Raymond Keary, Marine Geology Consultant
9. Eddie Laverty, Distance Learning Unit, Dublin Institute of Technology
10. Sean Lydon, Post-Primary Teacher (Retired)
11. Shelia Mc Carthy, Post-Primary Teacher
12. Dr. Paul McElwee, University College Dublin
13. Brian Mc Enerney, Ionad na hEaladhan Duchais
14. Dr. Philip Matthews, Trinity College, Dublin
15. Eamonn Grennan
16. John Moore
17. Dr. C.F. Murray, Dundalk Institute of Technology
18. Joseph O'Donnell, Former Teacher
19. Professor Mike Redfern (NUI Galway), Geraldine Simmie (TYCSS, DES),  
Dr. Andrew Shearer (NUI Galway), Dr. Phil Samways (UL).
20. Geraldine Simmie, Teacher, Teacher-Trainer and Author
21. Tom Tierney, Second-Level Teacher of Science and Mathematics
22. Harry Toher
23. Dr. Paul Tomkins, Athlone Institute of Technology
24. Brian Woods, School of Biological Sciences, DIT (Kevin Street)

## Appendix III

### **A preliminary report to the Task Force on the Physical Sciences on the issue of the comparability of grades awarded in different subjects in the Leaving Certificate Examination**

David Millar and Ruth Murphy

Educational Research Centre

## Background

In December 2001, the Task Force on the Physical Sciences commissioned the Educational Research Centre (ERC) to ascertain whether physical science (Chemistry and Physics) candidates are treated 'unfairly' by the examination system, that is, whether it was more difficult for physical science candidates to achieve high grades in the physical sciences than in other subjects. It was agreed that this preliminary report would be made available to the Task Force for inclusion in the Task Force report due to be released in February 2002. The preliminary report comprises:

1. A brief discussion of some issues surrounding grade comparability.
2. A summary of the findings from the National Council for Curriculum and Assessment (NCCA) *Longitudinal Study* (Millar, Farrell & Kellaghan, 1998; Millar and Kelly, 1999) .
3. Some initial findings from the current analysis.

The full report will be completed by the end of March 2002 and will:

1. Replicate the analysis conducted in the *Longitudinal Study* which used an overall performance scale (OPS) based on students' Junior Certificate performance as a proxy for academic ability.
2. Use the findings of the analysis to suggest further and more in-depth work that the Task Force may wish to undertake at a later date.

To facilitate the work of the Task Force, the Department for Education and Science made available Leaving Certificate (LC) results by subject for students who took the examination in 2000 and 2001 together with their Junior Certificate (JC) results from 1997, 1998 and 1999.

### 1. Issues Surrounding Grade Comparability

The belief that a given grade in the certificate examinations should represent the same standard of achievement, regardless of the subject in which it is awarded, 'is a very strong one which lies at the heart of the use of public examinations as providers of information for selection purposes. Indeed, to argue the need for comparable standards is simply to restate the need for selections made on the basis of them to be fair in terms of the meritocratic philosophy which underpins their use' (Cresswell, 1996, p. 68). Indeed in Ireland the Points System as operated the Central Applications Office (CAO), a limited company set up by the third-level institutions, as an administrative mechanism for dealing with applications and admissions, operates on the de facto assumption of comparability. An A1 in Higher level Art is worth just as much to a student in terms of selection for third-level as an A1 in Chemistry.

It is interesting to note that in this regard the Leaving Certificate results are being put to a use for which they were not, at least originally, intended. The Department of Education and Science's *Rules and Programmes for Secondary Schools* prefixes the section describing the Leaving Certificate examination with the following note. 'The aim and purpose of the established Leaving Certificate course is to prepare pupils for immediate entry into open society or for proceeding to further education. The examination is mainly a test of achievement. Employers and others wishing to use it for selection purposes are advised to institute their own supplementary tests, which should assess aptitude rather than achievement' (Department of Education and Science, 2001, p. 17).

In spite of its intuitive appeal, grade comparability is a difficult concept to define precisely. Nuttall, Backhouse and Willmott (1974), in one of the early UK attempts to address the issue, took the following approach. 'We argue as follows: we do not expect an individual candidate to achieve the same grade in every subject that he takes. However, we can see no logical reason why, if a large *group* of candidates representative of the population took, for example, both English and mathematics, their average grades should not be the same' (p. 12).

Fitz-Gibbon and Vincent (1995) who reported to the then School Curriculum and Assessment Authority (SCAA), since superseded by the Qualifications and Curriculum Authority (QCA), on the relative difficulty of Mathematics and the science subjects in the UK A level examinations defined comparability in terms of the 'value-added' definition. This suggests that examinations are of comparable standards if pupils of the same prior academic achievement receive grades which are similarly distributed. Fitz-Gibbon and Vincent used average GCSE<sup>1</sup> score as their measure of prior academic achievement.

Cresswell adopts a different view. He argues that 'there is no external and objective reality underpinning the comparability of results from different examinations' (1996, p. 79). This is suggesting, essentially, that there is no statistically valid or meaningful way to measure comparability. He argues that comparability can only be thought of in relativistic terms. 'Given their selective purpose, examination grades can be likened to a currency with which candidates buy entry into higher education or employment. Developing this analogy a little further, the intrinsic value of banknotes does not match their face value but commerce functions because it is commonly agreed to accept them at face value. Similarly, educational and vocational selection exists provided that there is common consent that comparability exists between different examinations. The maintenance of public confidence is thus critical to the operation of a public examination system for selection purposes' (1995, p. 42).

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<sup>1</sup> General Certificate of Secondary Education, also known as O Levels – broadly equivalent to our Junior Certificate examinations.

The problem is, however, that there is evidence that such public confidence in the comparability of different examinations has been undermined. There is a common belief that certain LC subjects are more easy or difficult than others and that students are being influenced in their choice of subjects by such perceptions. The Commission on the Points System (1999), *Final Report and Recommendations* notes that 'The issue of the variation in marking between Leaving Certificate subjects and the effects that this has on subject choice was raised during the consultative process. Concern was expressed about the extent to which students' subject choices were being influenced by the perception that some subjects are likely to be marked "more easily" than others. The point was brought home forcibly to the Commission at the public seminars when some second-level students pointed out that the proportion of high grades awarded for different subjects was a major factor for them in deciding what subjects to take for the Leaving Certificate' (p. 69).

Findings from the recent NCCA *Longitudinal Study* which, amongst other things, looked at candidates' examination results in the LCs of 1996 and 1997, suggested that there may be some validity in such beliefs.

## 2. Findings from the NCCA Longitudinal Study

The NCCA *Longitudinal Study* (Millar, Farrell & Kellaghan, 1998; Millar & Kelly, 1999) followed the cohort of students who sat the JC in 1994 through to the LCs of 1996 and 1997. It examined students' subject choice and performance in both examinations, relating these to such factors as student gender, (and in the case of the LC) prior examination performance, school type, etc..

Concerns had recently been raised about differences in standards between subjects and how these might be influencing candidates' choice of subject. For example, the Association for Secondary Teachers, Ireland stated in their submission to the Points Commission: 'Students entering the senior Cycle make important decisions regarding subject choice. Decisions tend to be significantly influenced by the points system. Students are extremely conscious of the need to maximize their opportunities to gain high points, consequently, they frequently choose subjects which are perceived to offer the best chance of gaining high points. This perception is fostered because of the difference in grades between subjects. The reasons for this difference needs careful analysis which might involve consideration of the ability levels of pupils taking different subjects and a critical analysis of syllabus content. It is important that this perceived inequity in grades between subjects be addressed' (1997, p. 10).

The fact that the NCCA study was longitudinal made it possible to measure progress as well as outcomes. Students with similar JC results could be tracked through to the LC. Comparisons of student

performance in the various LC subjects revealed marked differences in the results of students who, according to their JC results, were of similar ability<sup>2</sup>. In the *Longitudinal Study Final Report* the comparatively low proportion of low grades (grades E, F and NG) in Higher level Art (3.3%) was contrasted with the much higher proportions in Chemistry (8.2%) and Physics (10.2%). 'It could be argued that the relatively low rate of low grades in Art is due to the fact that the candidates who chose to sit the subject were ones who had a natural aptitude for the subject. On the other hand candidates who chose Chemistry and Physics had substantially higher JCE OPS scores; yet this does not seem to be reflected in the results' (Millar & Kelly, 1999, p. 179). The NCCA commentary to the report noted that the science subjects exhibited high 'difficulty factors'. It picked out for comment the fact that the mean JC performance of Higher level Physics students who were awarded D grades in the LC was higher than the mean JC performance of students who were awarded a B grade in Home Economics, Art and Geography.

The *Longitudinal Study* found that failure rates for the physical sciences were comparatively high in spite of the fact the Chemistry and Physics ranked well in terms of the JC performance of the body of students who chose to sit them. Figures for those candidates who sat the LC in 1996 showed that the failure rates in Higher level Geography and Art were between one-half and one-third of those in Chemistry or Physics, despite the fact that the body of students taking Geography and Art had performed much less well in the JC than those who went on to sit the sciences. More than 20 percent of students sitting the physical science subjects at Ordinary level were awarded low grades. This pattern of findings was repeated for those students who sat the LC in 1997. A principal reason for the Task Force to commission an update of the *Longitudinal Study* analyses is to see whether such findings still hold true.

### 3. Some Initial Findings from the Current Analysis

It was agreed that in addition to providing the Task Force with a replication of the analysis contained in the NCCA *Longitudinal Study* that the ERC would provide an alternative analysis of subject difficulty, one which did not rely on knowledge of candidates' JC performance.

The method used was Subject Pairs analysis (SPA) of the relative difficulty of subjects which involves comparing the mean grades of students sitting a target subject with their performance on a comparison subject (or group of comparison subjects) (c.f. Nuttall, et al., 1974). This methodology has been widely used in the study of grade comparability in the UK (Nuttall et al., 1974; Fitz-Gibbon & Vincent, 1995). Lloyd (1999, p.64) notes that 'All [UK exam]<sup>3</sup> boards use subject-pairs analysis.'

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2 This approach assumes a similar definition of comparability to the one taken by Fitz-Gibbon and Vincent (1995).

3 Our addition.

The procedure is illustrated in Table 1 (below) which shows a subject pairs analysis for Higher level Chemistry from LC 2000 (For the present analysis the 16 most popular Higher level subjects were selected for comparison). A total of 4820 school regular candidates sat Higher level Chemistry in 2000, achieving a mean grade of 6.1 (around a C1, see below)<sup>4</sup>. A sub-group of 2540 of the students who sat Higher level Chemistry also sat Higher level Biology. These candidates were awarded a mean grade of 6.0 in Chemistry (C1) and 4.3 in Biology (between a B2 and a B3). On average then these students did 1.7 grades better in Biology than in Chemistry. Indeed it can be seen that students performed less well in Chemistry than in any of the comparison subjects, although for some subjects, such as Mathematics, this difference was very slight.

A general measure of the leniency or severity of a subject can be derived by calculating the difference between the means of the two sets of means. In the case of Chemistry the mean grade in Chemistry was 6.1 while the mean of the mean grade in the comparison subjects was 4.6. Therefore, according to the SPA, Chemistry was marked 1.5 grades more severely than the consensus grade<sup>5</sup> for the other 15 most popular Higher level subjects.

Table 2 shows the SPA for Higher level Physics in LC 2000. The procedure followed is the same as was outlined for Chemistry above. The table allows for a comparison of the grades achieved by candidates taking any particular subject pairing as well as giving an overall estimate of severity for Physics. The final row of Table 2 shows that Physics was marked 1.0 grades more severely than the consensus grade for the other 15 most popular Higher level subjects.

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4 The value assigned to the various grades were A1 – 1, A2 – 2, B1 – 3, B2 – 4, B3 – 5, C1 – 6, C2 – 7, C3 – 8, D1 – 9, D2 – 10, D3 – 11, E – 12, F – 13, NG – 14. A higher figure therefore indicates a lower grade.

5 i.e. The mean of the mean grades in the comparison subjects.

**Table 1: Subject pairs analysis for Higher level Chemistry LCE 2000**

	SUBJECT	NUMBER OF CANDIDATES	MEAN GRADE IN CHEMISTRY	MEAN GRADE IN THE SUBJECT
1	Accounting	861	5.2	4.3
2	Art	275	6.7	4.8
3	Biology	2540	6.0	4.3
4	Business Organisation	684	6.9	4.9
<b>5</b>	<b>Chemistry</b>	<b>4820</b>	<b>6.1</b>	-
6	Construction Studies	89	7.9	4.1
7	English	4342	6.0	5.7
8	French	2993	5.7	5.2
9	Geography	1255	6.6	4.6
10	German	1188	5.7	4.3
11	Home Economics (S&S)	691	6.4	4.2
12	History	577	6.6	4.9
13	Irish	3072	5.5	4.8
14	Mathematics	3354	5.2	5.1
15	Physics	1634	5.3	4.4
16	Technical Drawing	283	6.2	4.1
	Mean (all subjects)		6.1	4.6



**Table 2: Subject pairs analysis for Higher level Physics LCE 2000**

	SUBJECT	NUMBER OF CANDIDATES	MEAN GRADE IN PHYSICS	MEAN GRADE IN THE SUBJECT
1	Accounting	1071	5.7	4.8
2	Art	398	7.2	5.6
3	Biology	1144	5.9	4.7
4	Business Organisation	980	7.1	5.4
5	Chemistry	1634	4.4	5.3
6	Construction Studies	467	7.5	3.8
7	English	4539	6.1	6.3
8	French	2746	5.6	5.9
9	Geography	1557	6.9	5.3
10	German	1076	5.6	5.0
11	Home Economics (S&S)	333	7.0	5.4
12	History	586	6.9	5.7
13	Irish	2680	5.5	5.4
14	Mathematics	3949	5.4	5.5
<b>15</b>	<b>Physics</b>	<b>5284</b>	<b>6.3</b>	<b>-</b>
16	Technical Drawing	1060	6.5	4.5
	Mean (all subjects)		6.2	5.2

Tables 3 and 4 show the SPAs for Higher level Chemistry and Physics for LC 2001. It can be seen that, as in LC 2000, candidates did less well on average in Higher level Chemistry than in any of the comparison subjects (Table 3). However, the mean grade in Chemistry improved marginally (to 5.9 from 6.1) and the estimate of severity reduced from 1.5 to 1.3 grades below the consensus grade for the other subjects. The reverse was true for 2001 Higher level Physics candidates (Table 4). The average performance of candidates was almost half a grade lower than for those sitting the subject the previous year (from 6.3 to 6.7). This drop in mean grade is associated with an increase in the estimate of severity for the subject (from 1.0 in 2000 to 1.7 in 2001).

**Table 3: Subject pairs analysis for Higher level Chemistry LCE 2001**

	SUBJECT	NUMBER OF CANDIDATES	MEAN GRADE IN CHEMISTRY	MEAN GRADE IN THE SUBJECT
1	Accounting	760	5.1	4.0
2	Art	288	7.1	4.9
3	Biology	2233	5.7	4.1
4	Business Organisation	691	6.5	4.6
<b>5</b>	<b>Chemistry</b>	<b>4599</b>	<b>5.9</b>	<b>-</b>
6	Construction Studies	97	7.2	3.9
7	English	4134	5.8	5.1
8	French	2804	5.4	5.1
9	Geography	1289	6.6	5.0
10	German	1054	5.6	4.5
11	Home Economics (S&S)	604	6.1	4.4
12	History	590	6.3	4.7
13	Irish	2800	5.3	4.9
14	Mathematics	3059	4.9	4.4
15	Physics	1593	5.0	5.1
16	Technical Drawing	272	6.3	4.1
	Mean (all subjects)		5.9	4.6

**Table 4: Subject pairs analysis for Higher level Physics LCE 2001**

	SUBJECT	NUMBER OF CANDIDATES	MEAN GRADE IN PHYSICS	MEAN GRADE IN THE SUBJECT
1	Accounting	947	6.0	4.4
2	Art	414	7.5	5.2
3	Biology	1030	6.0	4.2
4	Business Organisation	1017	7.4	5.2
5	Chemistry	1593	5.1	5.0
6	Construction Studies	467	8.4	3.7
7	English	4426	6.6	5.6
8	French	2668	6.0	5.8
9	Geography	1648	7.4	5.6
10	German	1020	6.3	5.2
11	Home Economics (S&S)	294	7.2	5.2
12	History	568	7.3	5.1
13	Irish	2554	6.0	5.3
14	Mathematics	3844	5.8	4.7
<b>15</b>	<b>Physics</b>	<b>5144</b>	<b>6.7</b>	<b>-</b>
16	Technical Drawing	1057	7.2	4.2
	Mean (all subjects)		6.7	5.0

Table 5 shows SPA estimates of severity for 16 Higher LC subjects for 1996, 2000 and 2001. It can be seen that, in spite of some fluctuations, the individual figures and the rank order of subjects has remained remarkably similar between 1996 and 2001. Grades in Physics, Chemistry, French and Mathematics have consistently been lower on average than those achieved in other subjects.

**Table 5: Subject pairs analysis estimates of severity for 16 Higher level Leaving Certificate subjects (1996, 2000 and 2001)**

SUBJECT	ESTIMATE OF SEVERITY		
	LC 1996	LC 2000	LC 2001
Physics	1.7	1.0	1.7
Chemistry	1.7	1.5	1.3
French	1.0	1.1	1.1
Mathematics	0.4	1.4	0.7
Irish	0.3	0.4	0.6
German	0.7	0.0	0.4
Biology	0.1	0.4	0.3
Accounting	0.3	0.2	0.2
English	0.6	0.7	0.1
History	0.1	0.0	0.0
Home Economics (S&S)	-0.5	-0.5	-0.3
Geography	-0.7	-0.8	-0.4
Business Organisation	-0.4	-0.5	-0.5
Art	-0.8	-0.8	-1.0
Technical Drawing	-1.2	-1.0	-1.2
Construction Studies	-3.3	-3.0	-3.0

Table 6 shows the mean grade for 16 Higher level LC subjects in 1996, 2000 and 2001. A comparison of 1996 and 2001 figures shows that for all but one of the 16 subjects the mean grade was higher in 2001. This improvement ranges from 1.1 grades in Chemistry to no change in Irish, where the mean grade has stayed constant over the period. It is worth noting that in spite of the fact that the mean grade in Chemistry has increased by just over a grade between 1996 and 2001 its estimate of severity has remained high in relation to other subjects (Table 5).

**Table 6: Mean grade for 16 Higher level Leaving Certificate subjects (1996, 2000 and 2001)**

SUBJECT	MEAN GRADE IN SUBJECT		
	LC 1996	LC 2000	LC 2001
Home Economics (S&S)	7.4	7.2	7.3
Geography	7.2	6.8	7.0
Business Organisation	7.4	7.2	6.9
Art	7.3	7.1	6.7
Biology	7.1	6.9	6.7
French	7.3	6.9	6.7
Physics	7.3	6.3	6.7
History	7.3	6.9	6.6
English	7.3	7.2	6.5
German	6.7	6.0	6.2
Irish	6.2	6.2	6.2
Technical Drawing	6.4	6.3	6.0
Chemistry	7.0	6.1	5.9
Accounting	6.6	6.1	5.8
Construction Studies	6.0	6.0	5.8
Mathematics	5.7	6.3	5.5

It is important to note that the use of subject pairs analysis (indeed any analysis of the relative difficulty of subjects) is problematic. Some authors question the validity of the procedure and indeed whether it is possible to measure the concept at all (Goldstein, 1986; Cresswell, 1996; Goldstein & Cresswell, 1996; Newton, 1997). Two, amongst several, difficulties can be identified. First, suppose, as we have done in Table 3, that we look at the relative performance of students who have taken both Chemistry and Biology. We know that these students are matched in terms of factors that are likely to be important in terms of performance (e.g. gender, school type, general academic ability) since it is the same set of students sitting both subjects. However, it is not clear that the group of students who sit a particular pair of subjects are representative of those students sitting either. This problem may be compounded where mean grades are aggregated across subjects to provide an overall estimate of severity. Second, although we might find that mean grades in Physics might be lower on average than mean grades in English or Geography it is possible that stronger candidates may be more likely to do better in Physics than they would in English or

Geography and weaker candidates more likely to do less well. Thus, it is important to exercise caution in interpreting the results of the SPA presented here. Where statistical analyses of comparative standards are conducted, it is 'necessary to exercise a measure of professional judgement to determine the true nature of the statistics' (Lloyd, 1999, p. 67).

### Conclusions

Subject pairs analysis would appear to support the view that candidates sitting the physical sciences are generally less likely to perform as well as those sitting other subjects. Students sitting Higher level Chemistry and Physics in LCs 2000 and 2001 did consistently less well than they did in other Higher level subjects that they sat. Indeed, SPA for LC 1996 shows that there has been little improvement in performance in the physical sciences relative to other subjects in the last six years in spite of improved mean grades in absolute terms.

It is worth noting in the context of any discussion of addressing this problem, that the estimate of severity of Chemistry has remained high in spite of an improvement of the average performance in the LC by just over one grade since 1996 (the greatest improvement for any of the 16 Higher level subjects looked at). This may in part be due to a general trend towards higher mean performance across the comparison subjects. Only Irish (which has maintained a constant figure) failed to show a higher mean grade in 2001 when compared with 1996.

Despite some fluctuations in mean grade and estimates of severity, which demonstrate the need to analyse the results from a number of years, a clear pattern is apparent. Students sitting the physical sciences, along with Mathematics and French, do less well on average than students sitting other subjects. These findings replicate those of Fitz-Gibbon and Vincent (1995) and those of Nuttall et al. (1974) earlier (who also used SPA) and are in line with the findings of the NCCA *Longitudinal Study* as outlined above.

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## Appendix IV

# Case Studies of Schools Successful in Science

A Report commissioned by the Task Force on the  
Physical Sciences

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February 2002



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## Summary

This study was commissioned by the Task Force on the Physical Sciences to explore a number of issues, which the Task Force identified as being important in the provision of science at second level. Within the timeframe of the study, twelve schools were visited. Interviews were conducted with the school Principal (or Vice-Principal), the main teacher of Junior Cycle science and the Career Guidance Counsellor, either face-to-face or by telephone, using prepared questionnaires.

### Main findings of the study:

1. Ten of the schools in this study offered Physics, Chemistry and Biology at Senior Cycle (one of which also offered Agricultural Science). One school offered Chemistry, Biology and Physics/Chemistry and the remaining school offered Biology and Physics/Chemistry. The schools reported that the proportion of their students taking science subjects at Senior Cycle over the last few years was remaining relatively constant but one school reported that numbers taking Physics and Chemistry were increasing.

2. In all but two of the schools, science was compulsory for all Junior Cycle students.

In the schools where science was not compulsory, there was a take up by 88% of the first year students in one and 86% in the other school where science was not offered to a group of students with special needs. In this study, the overall percentage of the Junior Cycle cohort taking science was 97%. The emphasis placed in the first year science course in these schools was on practical work and generating interest in science.

3. Transition year was compulsory in nine of the schools and was not offered in one school. Science modules were compulsory for all students in transition year, and schools varied as to whether two or three science modules were taken by the students.

The science courses in transition year were given by the Senior Cycle science teachers. The choice of subjects for Leaving Certificate was decided during or at the end of transition year in most schools.

4. Science teachers played an important role in guidance and promotion of science in the schools. Career Guidance Counsellors stated that they would not promote one subject over another but some indicated that taking one science subject at Leaving Certificate was useful, to give balance to a portfolio of subjects.
5. In choosing a particular science subject for Leaving Certificate, the science teachers stated that the most important reason was interest in the subject rather than ability. A number of teachers suggested that a mathematical ability was useful for Physics; however, the required ability in mathematics was suggested as an honour in Junior Certificate

mathematics in one school and a pass in Junior Certificate mathematics in another. In one school, emphasis was placed on physics as a useful and practical subject for students not considering third level education.

6. The number of science laboratories in the schools varied from two to six, with the student/laboratory ratio varying from 107:1 to 226:1 over the sample (with a sample average of 156:1). Generally, the laboratories were designated as particular subject laboratories; however, in two schools, the laboratories were allocated to particular teachers.

It should be noted that the schools, that had student/laboratory ratios in excess of 200:1, stated that they had difficulty in timetabling all students in the laboratories. The science teachers in eight of the twelve schools rated their resources as high or reasonable. Only three schools had laboratory technicians, who were privately funded, but the other schools indicated a strong need for technicians/assistants.

7. In eight of the twelve schools, one science teacher had the role of 'head of science' or 'science co-ordinator'; in two of these schools, it was a special duties post. While most schools indicated that there was a budget for science, in only one school had the science teachers responsibility for the budget. However, in all of the schools, teachers indicated that they had no difficulty in obtaining money for any small items of equipment or resources that they needed.
8. The student to full-time science teacher ratio in the schools varied from 65:1 to 186:1, with an average of 106:1 over all schools. The majority of the schools had teachers qualified in each of the science subjects, Physics, Chemistry and Biology. From the data collected, 90% of the teachers in the schools were teaching the subjects in which they had qualified at degree level.
9. The 'success' of science in these schools was attributed by the Principals to excellent, innovative teachers in whom the students had confidence. The influence of the science teachers (in both Junior Cycle and Senior Cycle) was cited by the Principals as a key factor. The other reasons given were that science was a core subject in Junior Cycle, that there was parental influence and that the school had good resources and facilities. Science teachers suggested that the good experience of science by the students, the science in transition year and the good resources were key factors in maintaining the uptake of science in the schools.
10. In all of the schools, the Principals stated that there was a tradition of science in their schools, as evidenced by their commitment to science in Junior Cycle, the level of resources and the quality of the science teachers. To improve teaching of science subjects at second level nationally, the Principals suggested improved resources and facilities, including laboratory assistants, good training of teachers and more practical work, especially in the Junior Certificate.

## Introduction

The Task Force on the Physical Sciences commissioned a study of selected second level schools in December 2001 to explore issues that had been identified to the Task Force as important at school level. A number of second level schools were selected (13 in total) by the Task Force Co-ordinators, where there seemed to be significant numbers of students taking science subjects at Leaving Certificate. The schools were all in the Dublin area; they ranged in size from 200 to 900 students, consisted of Secondary, Vocational and Community schools, and the sample included three fee paying schools.

In this study, the main issues that were explored were as follows:

- Science ethos and tradition in the school;
- Resources for science within the school;
- Science management and budget;
- Issues concerning Junior Cycle science;
- Issues concerning Senior Cycle science;
- Science teachers i.e. expertise and professional development.

To explore these issues, the key individuals in the schools were identified as the Principal, the teacher of Junior Cycle science and the Career Guidance Counsellor. Three individual questionnaires were prepared, targeted at these three key people. A team of five interviewers then conducted face-to-face interviews with these individuals in the second and third weeks of January 2002. The interview with the science teachers typically lasted approximately 1.5 hours and that with the Principal (or Vice-Principal) typically took less than 30 minutes. In the case of the Guidance Counsellor interviews were conducted either face-to-face or by telephone and lasted approximately 15 minutes.

Of the 13 schools initially identified, one school could not be visited within the timeframe of this study. The remaining twelve schools were extremely co-operative, facilitated our interviewers by freeing up the science teachers and in general were anxious to provide any information that we asked for. Also, while some expressed surprise that their school had been selected for this study, they nevertheless were pleased with their science teaching. Table 1 summarises the twelve second level schools visited, listed as schools A to L.

This report presents the findings of the study and draws together the main similarities and differences with respect to science in the schools visited. No attempt is made to draw conclusions, to comment on the findings or to compare them to national norms.

**Table 1: Schools Selected for Case Studies**

<b>School</b>	<b>Type</b>	<b>Gender</b>	<b>Total Enrolment</b>	<b>Fee Paying</b>
A	Secondary	Girls only	300-400	No
B	Secondary	Mixed	600-700	Yes
C	Secondary	Boys only	300-400	No
D	Secondary	Boys only	400-500	Yes
E	Secondary	Boys only	200-300	No
F	Secondary	Girls only	600-700	Yes
G	Vocational	Mixed	800-900	No
H	Vocational	Mixed	500-600	No
I	Vocational	Mixed	200-300	No
J	Community	Mixed	200-300	No
K	Community	Mixed	800-900	No
L	Community	Mixed	600-700	No

## Section 1: Overview of Science in the Schools

Numerical data on the percentage of students taking science in Junior Cycle and particular science subjects at Senior Cycle is given in Table 2. The nature of transition year in these schools is also noted in Table 2. School J had no Junior Cycle.

In all but two schools, science was compulsory for all students to Junior Certificate. In school G, the incoming students made subject choices at the beginning of 1st year and science was an option in each subject choice band, thus ensuring that the majority of the students took it (88% of the total). In the other school, school L, where Junior Certificate science was not compulsory, all of the students with the exception of the special needs group took science, resulting in an 86% take up. In this school there was some class rearrangement at the end of 1st year and a small percentage would move away from science. Transition year was compulsory in nine of the schools; in two schools (schools I and K), transition year was optional. Only one school did not currently offer a transition year (school H).

Table 2 clearly shows a significant proportion of students in the Leaving Certificate cycle taking Physics, Chemistry, Biology or Physics/Chemistry. One school also offered Agricultural Science. In terms of the numbers of students taking science subjects in the Leaving Certificate over the last few years, the schools reported that numbers were generally remaining constant, but in school G, numbers taking Physics and Chemistry were actually increasing. In two schools the numbers were falling, because the total enrolment in the school was falling; however, the proportion of students taking science subjects was being maintained.

**Table 2: Junior Cycle (JC), Transition Year and Senior Cycle (LC) Data**

School	JC Science <sup>1,2</sup>	Transition Year <sup>1</sup>	% LC Physics <sup>3</sup>	%LC Chemistry <sup>3</sup>	% LC Biology <sup>3</sup>	% LC Phys/Chem <sup>3</sup>
A	C	C	19.0	29.5	50.5	-
B	C	C	26.0	35.9	36.4	*
C	C	C	37.1	28.6	13.3	-
D	C	C	34.0	58.4	27.0	-
E	C	C	37.7	15.5	35.6	-
F	C	C	30.9	36.8	79.5	-
G	N (88% take up)	C	25.7	14.2	42.2	-
H	C	N	18.8	22.7	47.5	-
I	C	Yes (not C)	-	3.6	52.8	26.4
J	-	C	-	0	55.6	17.3
K	C	Yes (not C)	24.5	10.7	45.8	-
L	N (86% take up)	C	32.5	12.8	49.6	-

1 C = Compulsory, N = Not compulsory.

2 Average take up of Junior Cycle science over the whole sample is 97%.

3 Percentage of Senior Cycle students taking Leaving Certificate science subject.

\* 23.4% of Senior Cycle students taking Leaving Certificate Agricultural Science

[The Leaving Certificate data was obtained through the Task Force from the Department of Education and Science and related to the 2000-2001 returns. Students taking Leaving Certificate Applied are not included].

The ratios of the enrolment for science subjects and technical subjects in relation to the total Leaving Certificate enrolment are given for the schools in this study in Table 3. On average the ratio of the enrolment for Leaving Certificate science subjects (i.e. Physics, Chemistry, Biology, Physics/Chemistry and Agricultural Science) to total Leaving Certificate enrolment is 0.98 over all the schools. Note, this does not mean that 98% of the students enrolled for Leaving Certificate are taking science subjects as some students will take more than one science subject and hence will appear more than once in the total science enrolment, but only once in the total enrolment figure. The average ratio of 0.98 is exceeded in just three schools (schools B, D and F), all of which are private schools, and it varies from 0.73 in school J to 1.47 in school F.

As regards the technical and applied science subjects (Engineering, Technical Drawing, Construction Studies, Home Economics (Social and Scientific) and Home Economics (General), the overall ratio of student numbers enrolled in these subjects to total Leaving Certificate enrolment is 0.56 over all the schools. In two schools (schools C and D) there are no students enrolled in these subjects, and among the remaining nine schools, the ratio varies from a low of 0.34 in school A to 1.43 in school J.

**Table 3: Leaving Certificate Enrolment in Science Subjects and in Technical and Applied Science Subjects**

School	LC science enrolment/ total LC enrolment <sup>1</sup>	LC technical enrolment/ total LC enrolment <sup>2</sup>
A	0.99	0.34
B	1.22	0.37
C	0.79	0
D	1.19	0
E	0.89	0.60
F	1.47	0.65
G	0.82	0.51
H	0.89	0.58
I	0.83	0.52
J	0.73	1.43
K	0.81	0.75
L	0.95	0.43
<b>Mean</b>	<b>0.98</b>	<b>0.56</b>

1 Science enrolment = total numbers enrolled in Leaving Certificate Physics, Chemistry, Biology, Physics/Chemistry combined and Agricultural Science.

2 Technical enrolment = total numbers enrolled in Leaving Certificate Engineering, Technical Drawing, Construction Studies, Home Economics (Social and Scientific) and Home Economics (General). Agricultural Economics has not been included in these figures.

[The Leaving Certificate data was obtained through The Task Force from the Department of Education and Science and related to the 2000-2001 returns. Students taking Leaving Certificate Applied are not included]



## Section 2: Science Ethos and Tradition in the Schools

Each school Principal was asked if there was a tradition of science in their schools – to which they universally replied in the affirmative. The evidence they used to support this statement included past pupils taking science in third level, the fact that science was a compulsory core subject in Junior Cycle in their schools, and the investment in good facilities and equipment. When asked why they thought that science had proved to be popular and successful in their schools, the Principals responded with a number of reasons, but overwhelmingly the influence of the science teachers (both in Junior Cycle and in transition year) was cited as a key factor. The teachers were described as innovative, flexible, committed individuals. Also mentioned was the fact that science was a core subject in Junior Cycle, and in addition in some schools, the influence of parents who were both supportive and ambitious for their children was noted. Two of the Principals suggested that the fact that their schools were single-sex schools was an advantage (one was all-girls and one all-boys). The presence of good resources and facilities was also highlighted.

The Junior Certificate science teachers were also asked to suggest the main reason for the good uptake of science in their schools. Responses fell into three categories: (a) committed, innovative teaching, providing the students with a good experience of science, (b) key role of transition year science and (c) very good resources.

## Section 3: Resources for Science within the Schools

The science teachers were asked about the number of science laboratories in their schools and their designation. Table 4a summarises the resources in each school in terms of science teachers and laboratories, and Table 4b gives some key ratios (based on total enrolment figures), – the ratio of students to laboratories, the ratio of students to science teachers and the ratio of science teachers to laboratories. The number of science teachers used in the calculation of the ratio is the number of full-time science teachers.

**Table 4a: Numbers of Science Teachers and Science Laboratories**

School	Number of science teachers full-time	Number of science teachers part-time	Number of science labs	Lab. designation <sup>1</sup>
A	4	1	3	3G
B	6	2	6	1P,1C,1B,1E,1AG,1G
C	2	2	2	1P, 1C
D	7	0	3	1C, 2G
E	4	0	2	1B, 1P&C
F	6	0	4	1P, 1C, 1B, 1G
G	8	1	4	1P, 1C, 1B, 1G
H	7	0	4	1P, 1C, 1B, 1G
I	2	0	3	1P, 1C, 1B
J	2	0	2	1B, 1P&C
K	8	0	4	Teachers
L	4	0	4	Teachers

<sup>1</sup> G = General use within Science, P = Physics, C = Chemistry, B = Biology, E = Electronics, AG = Agricultural Science

**Table 4b: Key Ratios in Resources for Science**

School	Students/lab <sup>1</sup>	Science teachers/lab <sup>2</sup>	Students/ Science teacher <sup>1,2</sup>
A	131	1.3	98
B	114	1.0	114
C	186	1.0	186
D	163	2.3	70
E	129	2.0	65
F	155	1.5	103
G	209	2.0	105
H	141	1.3	81
I	107	0.7	161
J	129	1.0	129
K	226	2.0	113
L	160	1.0	160
<b>Weighted average:</b>	<b>156</b>	<b>1.5</b>	<b>106</b>

1 Student numbers based on total enrolment in 2001.

2 Full time science teachers only

All of the schools had at least two science laboratories, and the number ranged from two to six over all of the schools. The overall ratio of total enrolment in the school to the number of laboratories averaged at 156:1. However, these ratios ranged from 107:1 to 226:1. In schools G and K, the ratio of total enrolment to number of laboratories was greater than 200:1 and in both of these schools the lack of laboratory space was a major issue for them (as explained to the interviewer by both the science teacher and the Principal). While they were managing to organise the timetable in such a way that all students were spending some time in the laboratories, they indicated that the students were not doing as much practical work as the teachers wished.

In each school, the laboratories were either designated as particular science subject laboratories or were allocated to a particular teacher or group of teachers. However, when a laboratory was allocated on a teacher basis, it seemed to be that particular teachers were specialising in teaching one particular science subject and therefore, in effect, the laboratories were being allocated to particular subjects.

From Table 4a, it is evident that some specialisation of laboratories occurs in most schools with a laboratory for each of Physics, Chemistry and Biology. However, in three schools there were just two laboratories; in one of these there was a laboratory each for Physics and Chemistry, with Biology laboratory work being done in either of these two laboratories, while in the other two schools, one laboratory was allocated to Biology and the other to Physics and Chemistry; one of these schools offered the Physics/Chemistry combined subject. Interestingly in school K, one laboratory had been assigned to Physics for this year, but this had caused immense difficulty in scheduling. This school also had a ratio greater than 200:1 in terms of enrolment to number of laboratories.

In five of the schools, the area designated as the preparation room for the laboratories also acted as the store room. In only four schools was there a dedicated space as the preparation room. However, interestingly this was generally not a key issue when talking to the Junior Cycle teacher.

Only three of the schools had a laboratory technician when we visited them. Two of these were private fee-paying schools and in each case the laboratory technician was funded out of school funds. The third school (Community) had employed a technician under a Community Employment Scheme. Some of the other schools indicated that they had had laboratory assistants in the past (funded under the above-mentioned scheme). In all of the schools the teachers (and Principals also, in some schools) stated their desire for laboratory assistants. Generally, they felt that even having a laboratory assistant for part of the week, perhaps shared over a number of schools in a locality, would have a very positive effect in their schools. This desire was particularly strongly expressed in the larger schools.

It was apparent in all of the schools in this study that there was a lot of emphasis on practical work and these schools were requesting the help of an assistant in the laboratory. It should be noted that two of the private schools had actually employed a qualified technician. The laboratory technician in both of these schools had a major role in stock control and maintenance of equipment as well as in setting up laboratories for practical work.

When the teachers were asked to rate the standard of the services/facilities in the schools as high, reasonable, fair or poor, eight out of twelve rated them as 'high or reasonable'. Three indicated that they were 'poor' but there is a major refurbishment programme planned for one of these schools in the coming months. Finally one school indicated 'fair'. We did not elicit any further comments on general services and facilities within the school as that was outside the scope of this study.

## Section 4: Science Management and Budget

In the majority of the schools, (ten out of twelve) a science teacher had the role of 'Head of Science' or 'Science co-ordinator'. In schools B and I it was a Special Duties post. School G had an interesting structure whereby the 'Head of Science' rotated between the science teachers every two years. This seemed to give rise to very good team work, which was also reflected in their approach to science teaching in this school. This spirit of teamwork was also evident in school A, with the team being responsible for managing resources.

In three of the schools (A, C and K), the science teachers planned resources as part of an informal team. In only two schools (D and I), did the individual teachers make decisions on resources. All of the remainder had some element of formal team structure ranging from weekly planning meetings to one meeting per year.

The science teachers and the Principals were questioned about budgets for science in their schools. When asked if there was a budget for science in the school, seven out of the twelve teachers interviewed said that there was, but that they did not know what the figure was, and that it was controlled by the Principal or the Bursar. Some of the Principals said that there was a budget, but did not put a figure on it.

The mechanism for obtaining equipment was, generally, that a science teacher would discuss their requirements with the science co-ordinator/head of science, who would in turn make a case for this with the Principal. It seemed to be the case that one teacher acted as a co-ordinator for the science teachers as regards the management of resources and materials, though in many instances that person was in this position on an informal basis. All of the teachers reported that they had no difficulty in obtaining equipment, within reason, once they made a case for it, and that there was absolutely no problem in obtaining small items.

In only one school was there a definite budget for science, which was controlled by the science teachers. This budget amounted to £6,000, £1,500 being allocated to each of Physics, Chemistry and Biology and £1,500 for Junior Certificate science. In one other school, the science teachers had had a budget in the past, but this had changed with a change of Principal two years ago. Generally the feedback on the question of resources was positive in that the teachers felt they were given what they required and received good support from their Principals. Similarly the Principals indicated that they tended to accommodate the requests from the science teachers.

## Section 5: Junior Cycle Science

### 5.1 Organisation of Junior Cycle Science

Science was taken by the bulk of the students in the schools in this study (97%), with the exception of the special needs students and some element of choice in school G. Several class groups of first years were formed in each school (except for school I). The number of teachers involved in teaching first year science is given in Table 5, together with the number of science class groups in first year and the average number of students per class.

**Table 5: Science Teaching in First Year**

School	No. Groups in First Year	Streamed/Mixed Ability <sup>1</sup>	Avg. no. of Students/class	No. Teachers in First Year
A	3	MA	28	3
B	5	MA	26	4
C	2	MA	27	2
D	3	MA	27	2
E	2	S	18	2
F	5	MA	20	3
G	6	MA	24	6
H	6	S	18	6
I	1	MA	22	1
J	-	-	-	-
K	9	S	24	8
L	5	S	20	3

<sup>1</sup> S = streamed, MA = mixed ability

In only four schools were students streamed to some extent for Junior Certificate science; this was in schools E (which is a small school), and in schools H, K and L (which are larger community/vocational schools). In the remainder of the schools, mixed ability classes were the norm. Students generally had the same science teacher for all three years (except when a teacher left the school). This was considered by the teachers as being important. However, in school L, due to a re-arrangement of the groups after first year, there could be a change of teacher for some students, but this teacher would continue from second year to third year. Class sizes varied from 17 to 30 and averaged approximately 23.

Schools varied in terms of the level of co-operation and teamwork among the science teachers. In Schools B, F, G, H, K and L, the teachers decide as a team the material to be covered at least in first year. In one of the schools (school H) Junior Cycle students have three teachers, one each for Physics, Chemistry and Biology. The science teachers themselves had implemented this system some years ago in an effort to give the students the best teaching possible, by having the specialist in a subject teaching that part of the course. In the remaining schools, the individual science teachers acted independently, and any co-operation was by chance.

When asked if they noticed any correlation between individual teachers at Junior Certificate and the take up of particular subjects at Leaving Certificate, they reported none. It was also stated by some of the teachers that they actively encouraged students to take Leaving Certificate science subjects that did not reflect their own discipline. In the majority of the schools, the degree specialisms of the teachers involved in Junior Cycle science in each school spanned Physics, Chemistry and Biology.

When the teachers were asked to rate the level of equipment/resources available in their school for Junior Certificate science, as 'excellent', 'reasonable', 'barely sufficient' or 'inadequate', one teacher indicated they were 'inadequate', one 'barely sufficient' and the remainder said they were 'reasonable' to 'excellent'. It is interesting to note that this was the opinion expressed by the teacher. It was apparent to the interviewers that there was certainly variation between the resources in the different schools but the variation as seen by the interviewers was not reflected in the teachers opinions expressed.

## 5.2 Provision of Science to Junior Cycle

In most schools, Junior Cycle science had 2.67 hours of science classes assigned per week (four 40-minute classes), but in one school it was 2 hours and in another it was 3.33 hours. In all of the schools, the teachers considered practical work as being very important at Junior Certificate level. The teachers stated that they spent approximately half of their time doing practical work, though sometimes more in first year and less in third year. When asked how the time spent on practical work was divided between biological/life sciences and physical sciences, the majority indicated a one third to two-thirds split in favour of physical sciences, though in one school (school F), the time split was equally divided between these two areas, and in another school (school A), it was 80% in favour of physical sciences. However, many of the teachers found this question difficult to answer accurately. All of the teachers indicated that the laboratory work was of prime importance but that it would be much more satisfactory if they had a laboratory assistant available.

In allocating teachers to the various classes in first year, none of the Principals said that there was any scheme for allocating particular teachers to particular classes or streams. Some reported that there was a policy in the school of rotating the teachers among the streamed groups.

The choice of science options taken in Junior Certificate science varied from teacher to teacher. Earth sciences and energy conversion were chosen in a number of schools, but electronics was also chosen. Food and materials also appeared, though less so than these other three. Horticulture was not chosen at all.

When asked what was the key objective of the teachers in teaching science in first year, the predominant answer was that they aimed to generate interest in and enthusiasm for the subject. In one school (Irish speaking) the objective was developing the necessary vocabulary, but generally the main aim was to get the students interested and excited about science.

On the subject of use of textbooks in Junior Cycle, we asked the science teachers whether they followed the books rigidly or just referred to them occasionally or got the students to use them for revision or homework. Most of the teachers indicated that they did not use the books rigidly, though most used them to source experiments. However, more than half of the teachers also used experiments which they had developed themselves, or which had been developed by the science teachers in the school.

When asked about participation of Junior Cycle students in science-based activities and events, such as school trips, quizzes, visits to the Young Scientist Exhibition, all except three indicated that there were some events organised for the science students. However, it would appear that most of these types of activities were for transition year and Senior Cycle students in most of the schools.

On the question of what changes, if any, they would like to see in the current Junior Certificate syllabus in science, the inclusion of more practical work was mentioned by half of the science teachers. Other topics suggested were electronics, biotechnology, astronomy and the inclusion of open-ended discovery.



## Section 6: Senior Cycle Science

### 6.1 Provision of Science at Senior Cycle

Only one of the schools did not have a transition year (school H), and in two further schools, transition year was not compulsory. All of the schools with transition year offered science as a component of the transition year programme. Generally, the science teaching in transition year was given by the Leaving Certificate science teachers. In most schools, science modules were offered in each of Physics, Chemistry and Biology, and in these schools, all students either took all three modules or had to take two of the three. In other schools, "interesting" science courses were given in transition year, again by the Leaving Certificate science teachers. Some of the teachers were quite innovative in what they taught in transition year. Teachers considered the exposure of the students to science topics in transition year was extremely beneficial and gave the students a real appreciation of the subjects.

In all but one of the schools (school L), the students chose their Leaving Certificate subjects during or at the end of transition year. For the most part, in choosing their subjects for Leaving Certificate, the students were asked to state their preferences from the total list of subjects available in the school and on the basis of what they requested the subject choices were drawn up. The schools considered that they were very successful in being able to give students the choices they had requested.

All of the schools offered Biology as a Leaving Certificate subject, just two offered Physics/Chemistry combined and the remainder offered Physics and Chemistry. In terms of numbers of students taking the science subjects in Leaving Certificate, the greatest numbers took Biology in all except three schools, which were the three all-boys schools in our study.

We asked the Principals how transition year was organised, and who decided what should be done in transition year. The situation in many schools was that it was up to the transition year co-ordinator, but that when transition year was being instigated, either the whole staff or a group of teachers decided between them on the overall programme for transition year. In one instance it was stated that the Principal decided on the content of transition year, and in another that what was studied in transition year depended on the students' choice of subjects for Leaving Certificate (that choice having already been made before the start of transition year). In most schools a science teacher was involved in the transition year co-ordination team, and in all except two schools there was a school policy for including science in transition year. In one of these two, transition year was not compulsory and the other was the school where the subjects taken in transition year depended on choices made for Leaving Certificate.

## 6.2 Guidance and Promotion of Science at Senior Cycle

Most of the promotion of science subjects in these schools appeared to come from the science teachers and especially through their input into transition year. Their role in the promotion of their subjects was in some cases quite informal and in other cases took the form of formal talks to the students when they were making their choices. It was also pointed out that students were often influenced by subject choices and chosen careers of older family members, and this would in itself help to perpetuate a situation of strength in science in a school. In one school the science teacher arranged for current Leaving Certificate students to talk to the students who were making their choices. Also one school reported that they invited past pupils to talk to the students when they were making their choices.

In choosing subjects for Leaving Certificate, the overwhelming view was that students should choose subjects which they liked and in which they had an interest, and that the choice was left to the students themselves. Guidance counsellors indicated that they would not necessarily promote science, and indeed would not particularly promote any one subject over another. Many promoted the idea of students taking a science subject for balance in their portfolio of subjects, and thus giving students good options in choosing their career. Many Guidance Counsellors said, however, that there was a particular effort made to promote science generally in their schools, influenced by, for example, local industry.

When the science teachers were asked if they would promote any particular science subject depending on the ability of the student, the response generally was that choice was mainly based on interest in the subject. A number of teachers mentioned that a competence in mathematics would be considered a pre-requisite for Physics at Leaving Certificate. However, the level of competency in mathematics suggested was an honour in Junior Certificate mathematics in one school and a grade C in ordinary level mathematics in another school. In two schools, ordinary level Physics was promoted for quite weak students, as a 'practical' subject which could be useful for students not considering third level education (especially for boys).

When asked if it was important for all students to take a science subject at Leaving Certificate level (as opposed to it being only important to those who needed it for their careers), two-thirds of the science teachers felt that it was important for all students,

## Section 7: Science Teachers

### 7.1 Teaching Expertise in the Schools

The number of science teachers in each school obviously varied according to the size of the total enrolment (see Table 4b). On average in these schools there was one full-time science teacher for every 106 students, but this ratio varied between 1:65 in school E and 1:186 in school C. Looking at the number of science teachers in relation to the number of laboratories in the school, there is an average of 1.5 full-time science teachers per laboratory. Again there is variation in this figure, ranging from 0.7 to 2.3.

The majority of schools had teachers qualified in each of the science areas (Physics, Chemistry and Biology). When asked to what they would attribute the success of science in their schools, the Principals mentioned that they had excellent and innovative teachers in whom the students had confidence. The teachers we spoke to were all very confident individuals and highly committed to teaching. Some were very experienced and had been teaching for more than twenty years. They indicated that the students 'knew that they would deliver', in terms of Leaving Certificate grades. While in terms of length of service in the school there was a spread, with some teachers having more than 20 years of service and some only in the school for a short time, in general there was a large proportion of very experienced science teachers in these schools.

We sought information concerning the qualifications of all of the science teachers in the schools and how the subjects they had studied at degree level matched with the subjects they were now teaching at Leaving Certificate. We received data for 49 teachers in these schools, and 90% of these were indeed teaching the subjects that they had qualified in at degree level, and in only 10% of cases was there a miss-match between qualification and their current teaching. One school made the comment that they had difficulty in recruiting a physics teacher, and another an agricultural science teacher.

## 7.2 Teacher Professional Development

The teachers all expressed satisfaction and enthusiasm for the recent in-service training courses, and a number of them had also participated in other courses and training programmes. However, all indicated that they would receive encouragement from the Principal for such activities (though some, particularly those in the community schools in this sample, cited a difficulty in substitution arrangements). Some of the teachers indicated that they were members of the ISTA, but most of those who said that they were not members indicated that there was a teacher in the school who was a member, and this allowed them to keep in touch with that organisation.

When the science teachers were asked about linkages and liaison with others such as Guidance Counsellors, science teachers in other schools, local industry and third level institutions, we were told in most cases that there was some liaison with the Guidance Counsellors, but this was mostly of an informal nature. Only two of the sciences teachers that we interviewed had interaction with science teachers in other schools and only three had linkages with local industry. As regards interacting with third level institutions, more than half of the schools had some interaction, usually by attending open days or demonstrations. In two cases the teachers reported that linkages with third level institutions, and in particular a local IT, had proved very useful.

All of the teachers were asked about the recent financial allocation to schools for data logging equipment. They indicated that the equipment had been purchased and they expressed enthusiasm for this innovation. However, when asked if this equipment had made an appreciable difference to their teaching in Junior Cycle, many indicated that they had not yet had the opportunity to implement it with their classes, as they were still familiarising themselves. They did, though, suggest that the equipment would have a very positive influence on their teaching. Those who were already using the equipment gave a very positive feedback on its use in Junior Cycle.

Courses/training that the teachers required to develop professionally varied widely. Other than comments on the success of the recent in-service courses, and the desire for further in-service training, and meetings between science teachers at local level, the main courses required involved computers (ICT), laboratory management, management training, and one teacher suggested skills management for students with learning disabilities. Another teacher stated that teachers were "coursed out".

## Section 8: General Issues

The fact that science is compulsory (or almost) in all of these schools was cited by Principals, teachers and Guidance Counsellors as being the single most important factor in the success of science in their schools. It was felt that the students were well informed about the science subjects as a result of studying them for three years. Compulsory science in Junior Certificate was a definite policy in these schools, and they intended continuing with this. When the Principals were asked why science was compulsory in Junior Cycle, they responded by saying that it was considered essential, as otherwise the students may never get exposure to science again, and that it was seen as a mechanism for maintaining numbers taking science subjects in Leaving Certificate.

The second factor, which was cited by many Principals, was the commitment and the quality of the teachers, and this was indeed evident in talking to the teachers themselves. Interestingly, the science teachers put a lot of emphasis on their science modules in transition year in generating interest in science for Leaving Certificate.

The Principals were asked to give their opinion on a hypothetical situation where there would be a requirement, nationally, for all Leaving Certificate students to take a science subject. Most of the Principals said that they would have reservations about such a requirement, on the basis that they felt that science is simply not for everyone. Only three Principals said they would be in favour of it, and interestingly, only one of these Principals had a science background.

The teachers were asked what they considered to be the single most important way in which the teaching of science at second level could be improved nationally. The responses were varied, but more practical work, the provision of laboratory assistants, and practical assessments, were the main themes touched on by the teachers.

Finally the Principals were asked what they considered would improve the teaching of science subjects at second level generally. Improved resources and facilities were mentioned by more than half of the Principals, and some of these also mentioned in that context the provision of laboratory assistants. Good training of teachers and on-going in-service to keep them up to date with new developments was cited also. The inclusion of more practical work, particularly in Junior Cycle, was also thought to be important, and it was suggested that the practical work should be assessed as part of the examination process. There was a suggestion that science in Junior Cycle was perceived as boring; one Principal suggested that starting students on science in first year was in fact too late. Reduction in class sizes was another factor, mentioned by one Principal.

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