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## **SECURING THE FUTURE OF CHEMISTRY: A CASE STUDY OF DEVELOPMENTS IN CHEMICAL EDUCATION IN IRELAND**

*Received 1 July 2002; in final form/accepted 17 October 2002*

**ABSTRACT:** In the last three years (1999-2002) science education has moved to the top of the government's agenda in Ireland, from a position of benign neglect over many years. This paper reviews various initiatives that have taken place in Ireland since 1999, with particular reference to chemistry and science education. In particular, the new Leaving Certificate (LC) Chemistry syllabus, implemented in September 2000, will be described against the backdrop of falling numbers in Chemistry at second and third level. Other official reports, the Physical Sciences Initiative (March 1999) and the setting up of a Task Force on the Physical Sciences (November 2000) will also be reviewed. The potential effect of these welcome initiatives for securing the future of chemistry in Ireland will be assessed. . [Chem. Educ. Res. Pract. Eur.: 2002, 3, 361-369]

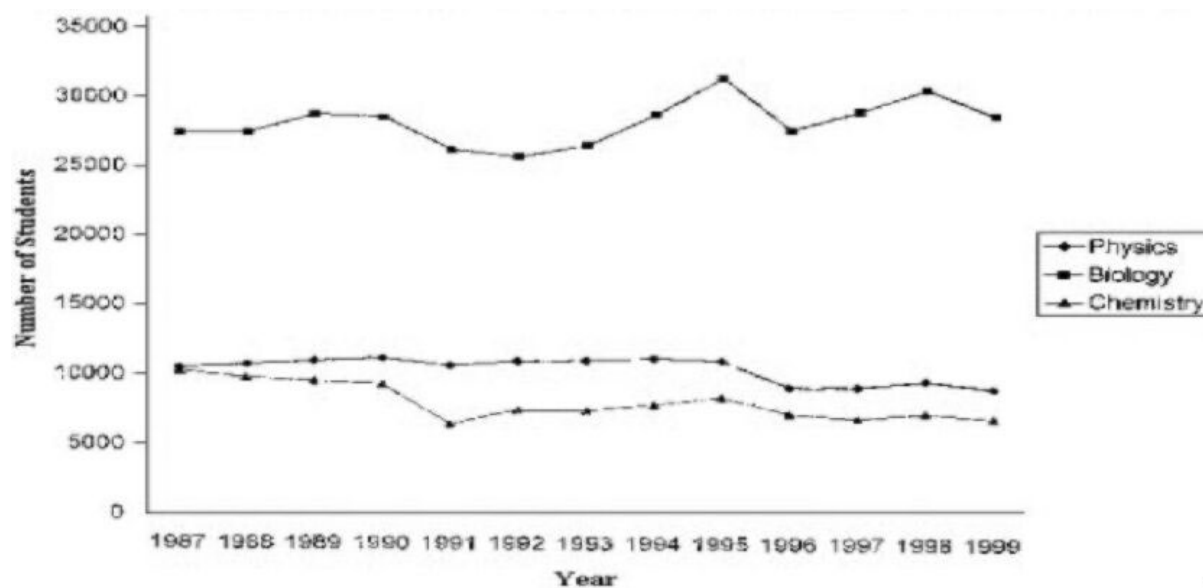
**KEYWORDS:** *chemical education in Ireland; curriculum; second level*

### **INTRODUCTION**

The decline in numbers doing chemistry at second level and at third level in Ireland has been well documented (Childs, 1995a, 2000a) and has become a topic of widespread discussion in the last two years. Since 1987 the uptake of Chemistry at the Leaving Certificate (LC) level has dropped in real terms (Figure 1) and in percentage terms of the total LC cohort from around 21% to less than 11%. LC Physics numbers have also declined from 21% to 14% over the same period. Biology is the most popular LC subject in Ireland.

At the same time Ireland's economy has grown to become one of the most dynamic in Europe (Childs, 2000b), largely driven by the growth of exports from high-tech companies in pharmaceuticals and information technology. In 1995 the Irish chemical industry was one-twentieth the size of the German industry in sales and in 1999 it was a quarter the size! This growth in the chemical industry continues in 2002 despite the high-tech slowdown.

In the last 2-3 years industry and government have become aware that the fall away from science will affect the long-term health and continued growth of a science-based economy and both the chemical industry and the IT industry are already experiencing skills shortages. This single uncomfortable fact has put science education firmly at the top of the agenda for government, for academia and for industry. Ireland is in the enviable position of being awash with money due to the success of the 'Celtic Tiger' economy and can now fund much-needed investment in education and in science research. Ireland's economy has been described as a Celtic Tiger because of its similarity in rapid growth to the economies of the



**FIGURE 1:** Numbers taking Chemistry, Biology and Physics (1987-1999) (Source: DoES Statistics).

Asian Tigers such as Singapore and Taiwan. In an earlier paper I looked at the importance of science education for the past and future health of the Celtic Tiger (Childs, 2001). However, the worldwide economic recession has hit the Irish economy and in 2002 public spending is in deficit. This throws into question the implementation of the recommendations of the Task Force on the Physical Sciences (TFPS) to improve the teaching of the physical sciences (see later).

The bottleneck in continued growth of a knowledge-based economy is the shortage of skilled personnel, and the decline in science at second and third level is a serious threat to science-based industry. In 10 years Ireland has gone from high unemployment of over 20% to essentially full employment and from net emigration to net immigration and population growth. Several reports have been produced in the last two years addressing the skills shortage and the decline in numbers studying science (ICSTI, 1999b, IPCMF, 2000, RDS, 2000). There are welcome signs that the nature and scale of the problem has been recognised and the remedial and restorative action is either being taken or is planned. In this paper I will review what has happened from 1999 onwards and assess the likelihood that the projected measures will be effective.

### NEW LC CHEMISTRY SYLLABUS

In September 2000 a new LC Chemistry syllabus was introduced into all second level schools, for examination in 2002. This syllabus revision was started in 1992 to update and modify the syllabus introduced in 1983. LC subjects are usually offered at two levels: Higher and Ordinary level. Students take a general science course in the Junior Certificate (JC) junior cycle from ages 12-15, as one of 8-10 subjects. From 16-17 students take the Leaving Certificate (LC) senior cycle, and take 6-7 subjects. Points accrued over six/five best subjects are used for third level entry. Mathematics, English and Irish are compulsory subjects. About half the students now do an additional non-examination year between the two cycles, known as the Transition Year. As well as the traditional academic Leaving Certificate, originally designed for the higher ability range, a Leaving Certificate Applied and Leaving Certificate Vocational Programme are also offered, which are more applied and vocational in emphasis

as the names suggest. The majority of students still do the higher-status academic course and Chemistry is one of the five science subjects offered.

The old Chemistry syllabus had not been successful in attracting students, particularly to the ordinary level course, and Chemistry has become an elite subject, taken only by the high-fliers. Since it was introduced in 1983 the numbers and percentage taking Chemistry have declined steadily. In addition failure rates were high, particularly at the lower level, and this discouraged students from taking it. The existing Chemistry course has also been perceived by students and teachers to be long, difficult and too mathematical (Childs & McDonnell, 1999). The slow decline in Chemistry from 1987 onwards, against a backdrop of increasing numbers staying on in school, is due to a loss of boys opting to take Physics and other subjects. The numbers of girls taking LC Chemistry have actually increased and they now constitute a majority, unlike Physics where girls only make up 25% of the numbers (Childs, 2000a). LC Chemistry and LC Physics are not offered by all schools, and Physics is favoured in one sector of second-level education (the vocational schools), which traditionally has a more technical bias. However, even when Chemistry is offered teachers report difficulty in getting students to take it. One major factor is the pressure for university entry, which in Ireland is based on the aggregate of points awarded on grades in six LC subjects. To enter a science course *any* LC science subject will do, and the greater the points score the greater the chance of success for a chosen course. Students (and to some extent schools and teachers) have played the system to optimise their points total and have turned away from Chemistry and other 'hard' subjects towards easier, less time-consuming courses. Biology is perceived as being easier by students and is the dominant LC science subject (see Figure 1). This game has been played most successfully by private, 'grinds' schools, which have sprung up in the last decade to capitalise on the 'points race', as it has been called. The government convened a commission to look at university entry and came up with the conclusion that, although flawed, the points system was still the fairest option (DoES, 1999a). However, the points race has worked to the detriment of the physical sciences.

An earlier article surveyed the challenges to chemical education and developments in science education in the early 90s (Childs, 1995a). This identified falling numbers, the need for in-service education, assessment of practical work and gender imbalance as the major challenges. The decline in Chemistry and Physics numbers, and dissatisfaction with the courses, has been apparent since the early 90s. Consequently the National Council for Curriculum and Assessment (NCCA), the body responsible for curriculum reform in Ireland, reconvened the chemistry syllabus committee to revise the Chemistry syllabus. This was essentially completed by 1994 and the draft syllabus was discussed in detail at ChemEd-Ireland 1994 (ChemEd, 1995). The syllabus was revised slightly and published (DoES, 1999b) but not implemented until September 2000, partly due to disagreements between the syllabus committee, the Irish Science Teacher's Association and the Department of Education and Science (DoES) on the place of practical assessment in the new course. It has been implemented without agreement on this matter and so the new course thus has no formal practical assessment, except in the terminal written examination, although it does have a set of mandatory experiments.

The new syllabus has a number of interesting features, but has received significant criticism (Matthews, 1995, Childs, 1995b). These new features are listed below and Table 1 lists the topics included in the course. These are common to both the Ordinary and Higher level courses.

**TABLE 1.** *Topics in the LC Chemistry syllabus (180 hours teaching time).\**

<b>Core syllabus</b>	
1. Periodic table and atomic structure (14.2%) 2. Chemical bonding (11.2%) 3. Stoichiometry, formulae and equations (15.9%) 4. Volumetric analysis (14.6%) 5. Fuels and heats of reaction (9.9%) 6. Rates of reaction (1.3%) 7. Organic chemistry (11.2%)	8. Chemical equilibrium (5.6%) 9. Environmental chemistry: water (6.0%)  <p style="text-align: center;"><b>Options</b></p> 1. Industrial chemistry and atmospheric chemistry (9.9%) <i>or</i> 2. Materials and additional electrochemistry and extraction of metals (9.9%)

\* % of time recommended in brackets.

New features of the course include:

- a list of mandatory experiments;
- an increased emphasis on social and applied aspects (30% of course content);
- an optional section, where students choose one of two options;
- a new 4-column presentation indicating content, depth of treatment, activities and social aspects;
- a detailed Teacher's Guidelines.

One criticism of previous curriculum developments in Ireland has been poor implementation, with inadequate in-service training to prepare teachers for new material, new approaches etc. A much greater effort has been made to equip teachers of Chemistry and Physics (introduced at the same time) to teach the new syllabuses effectively. A Physical Sciences Support team for Chemistry (and another for Physics) was set up in 1999, composed of seconded teachers together with DoES inspectors, to deliver a structured programme of in-service training before and during the implementation of the new syllabus. All teachers teaching Chemistry (or Physics) have been offered time off school for these in-service days, offered in different regions of the country by the trainers, and covering both the theory, methodology and practical aspects of the new course. Attendance, however, is voluntary and the result is that not all teachers have taken advantage of the provision. The courses have been well received by teachers. Emphasis has been placed on explaining the new content in the syllabus and in giving teachers opportunity to try out new experiments and equipment. The programme was originally for three years (1999-2002) but this has been extended for a further period.

In addition the Department of Education and Science has published a set of background booklets for both Chemistry and Physics, in a loose-leaf file and on CD-ROM (DoES, 2000), covering the main topics in the course and giving teachers additional information, particularly in the social and applied areas.

### **Other syllabus revision**

In addition to the revision of the main LC science syllabuses, Biology, Chemistry and Physics, the NCCA is also revising the combined Physics with Chemistry course. This was last revised in 1972 and is taken by very few students, but has the potential to offer an alternative physical sciences syllabus to schools, which are not able to offer the full LC

Chemistry or Physics courses, or who don't want to choose between them. The draft of this syllabus was published in August 2000 (NCCA, 2000) and a consultation document on the provision of Science and Technology at Senior Cycle was published in September 2000. This includes a suggestion for a LC Science course incorporating aspects of all three sciences. The need to revise science syllabuses on a regular basis (rather than every 15-30 years) has now been accepted and this should allow the examination system to be more responsive to changes in the subjects.

The precursor to the senior cycle courses is the Junior Certificate (age 15, 9<sup>th</sup> Grade), where around 90% of students take Junior Science at Higher or Ordinary levels. This course was introduced in 1993, replacing three different science courses, and there has been pressure almost since its inception for revision. The Chemistry component has been strongly criticised as an inadequate and unattractive foundation for further study in Chemistry. This revision of JC Science is also underway. Primary science is also about to be introduced formally into Irish primary schools, after a major revision of the primary curriculum, and is due to be phased in over several years from September 2000. Primary teachers do not have a strong background in science and science has not been a significant part of their training. The introduction of primary science has major implications for pre-service and, more importantly, in-service education of primary teachers.

One major criticism of curriculum development in the past has been the lack of integration between courses at the different levels. Revision has tended to take place from the top down, starting with LC courses (1980s), then the JC courses (1990s) and finally the primary curriculum (2000s), rather than the other way round. The smooth development of subjects from one level to the other has thus been hindered, as students transfer between schools and move up through the educational system. Teachers at all levels need to see where their contribution fits into the overall system their students will experience. At present there is no coordination between science provision at different levels. Needless to say third level science courses in the main take no account of changes in the school curriculum!

Another important aspect of the Irish educational scene is that there is almost no educational innovation in the mainstream. Education is centrally controlled and the Department of Education and Science is responsible for finance, curriculum, examinations and inspection. Although there has been wide consultation by syllabus committees, their membership is still decided by political and other considerations (rather than by expertise). Once the syllabus is agreed by the Minister of Education and Science, after recommendation by the NCCA, that is it – 'one size fits all'. In the 1980s there were three alternative science courses in the junior cycle, including the innovative ISCIIP course. Now there is one JC Science course, offered at two levels. There is one LC Chemistry course (at two levels), and so on. There is no room for alternative courses like the Salter's courses, which have been so influential and effective in the UK. If a new course turns out to be ineffective or flawed, like the 1983 Chemistry course seems to have been, there is no other choice. There is no competition in education between alternative approaches to teaching Chemistry, although other ideas were suggested to the syllabus committee, and a topic-based LC Chemistry course has recently been suggested (Cashell, 2000). If this new syllabus turns out to be flawed it will be years before it can be changed again.

### **Physical sciences initiative 1999-2001**

In March 1999 the Minister of Education and Science (then Mr. Michael Martin) announced a three-year plan involving a £15 million (€18.75 million) investment in

promoting physics and chemistry in Irish schools over three years (Martin, 1999). This initiative involved the following:

- Modernisation of school laboratories
- Introduction of the new syllabuses in LC Chemistry and Physics
- New syllabuses in LC Biology and LC Physics with Chemistry
- Review of the JC Science syllabus
- Revision of ordinary level exam papers to make them more accessible
- A major skills-upgrading of science teachers using a panel of trainers
- Investment in IT for school laboratories
- A Physical Sciences Support Team to provide in-service courses and help to teachers in implementing the new courses

This programme is well underway and all teachers have been offered opportunities to retrain to teach the new courses in Chemistry and Physics. Each school was given a £6,500 (€8125) grant at the end of 2000 to spend on IT equipment and software to introduce IT, including datalogging, into the classroom. A two year evaluation project by the Irish Science Teachers Association (ISTA) on 'Datalogging' reported in August 2000 and the ISTA has just produced two manuals to support the use of datalogging in schools (ISTA, 2001).

## OTHER INITIATIVES

### **Irish Council For Science Technology And Innovation (ICSTI)**

ICSTI was set up in 1997, chaired by Dr. Edward Walsh (former President of the University of Limerick) to look at ways of encouraging innovation in science and technology and to recommend policy to the Irish government. In its short life it has been very active and has had a significant impact. It produced a series of Foresight Reports in 18 months, (ICSTI, 1999c), which led to the decision to invest over £500 million (€625 million) by the Irish government in science research and development initiatives. Although not specified in its brief, ICSTI also set up a working group to look at science education (chaired by Professor Donald Fitzmaurice) and this has produced three important reports – one on Primary Science and two looking at Second-level Science: (ICSTI, 1998, 1999a and 1999b). One of the second-level reports was a general review of Science Education and the other was a benchmarking study, which compared Ireland with Finland, Malaysia, New Zealand and Scotland. These are a significant contribution to the science education debate.

### **IPCMF Skills Working Group**

The Irish Pharmaceutical and Chemical Manufacturers Federation (IPCMF) set up a new Skills Review Group in 2000 to look at the implications of the declining numbers doing chemistry for the chemical industry in Ireland. This contained a mix of industrial and academic members. IPCMF sent an Irish delegation to the York conference on Industry-Education Liaison. The National Forum, chaired by Dr. Peter Childs, submitted its recommendations to IPCMF after this meeting. One of these was to set up an Education trust Fund, funded by levies on science-based industry, which would disburse funds for educational projects. The IPCMF group has made its own proposal to the IPCMF council for an Education Officer to liaise between education and industry and to promote chemistry in the schools. This is a development of the Promotion of Chemistry in Schools Project (PCSP), funded by IPCMF from 1998-2001, directed by Dr. Peter Childs at the University of

Limerick and involving the evaluation by Ms. Elaine Regan of an intervention strategy in schools (reported elsewhere in this meeting).

IPCMF had earlier published reports on skills shortages in the chemical industry (IPCMF, 2000), which identified a significant shortfall in the period 1998-2001. This led to the setting up of the Skills Review Group and a greater direct involvement of IPCMF in promoting chemistry and encouraging member companies to become more proactive. In April 2002 appointed Dr. Mark Glynn as its first Education Officer to promote chemistry in schools and liaison between schools and the chemical industry.

### **Task Force on the Physical Sciences**

The Minister of Education and Science, Dr. Michael Woods, set up a new Task Force on the Physical Sciences (TFPS) in November 2000, and invited submissions by December 29<sup>th</sup>. A university chemist, Dr. Danny O'Hare, former President of Dublin City University, was appointed chairman and people representing a wide range of interests – educational, governmental, industrial – were invited to join it. The ambitious start continued with a series of monthly meetings, the setting up of two working groups (WG2 for primary/secondary and WG3 for tertiary/industry) and a target of December 2001 for the final report and recommendations. Two coordinators were appointed for the duration of the Task force – Cyril Drury for primary/secondary and Dr. Aine Allen for tertiary/industry. All their deliberations are now posted on a new website (TFPS, 2002), including copies of all the submissions from individuals and institutions that have been submitted, and links to other relevant reports.

The aims of the Task Force are:

- To devise and recommend additional measures to address the issue of low take-up rates;
- To consider how physics and chemistry can be most effectively promoted among students particularly those at Junior Certificate and Transition Year;
- To 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 is also addressing 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 up-grading and in-service training of teachers;
- The support and promotion of a strengthening in the contacts between Physics and Chemistry Departments and Education Department 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.

The work of the Task Force was finished almost on schedule and the final report was published in April 2002 and sent to the Minister of Education and Science. Comments on it were invited to the end of September 2002. The full report is available on the TFPS website (TFPS, 2002). This report is one of the most significant publications on Irish science education in the last twenty years. The report makes wide-ranging recommendations involving substantial investment in refurbishing and equipping laboratories, and providing technical assistance to science teachers. The government intends to consider the implementation of some or all of these recommendations at the end of 2002.

In addition to all these government initiatives, the Oireachtas Joint Committee on Science and Technology (the Oireachtas is the Irish Houses of Parliament) has also conducted its own investigation of the declining science enrolments and published a wide-ranging report (Oireachtas, 2000).

## CONCLUSIONS

The last four years, 1999-2002, has seen unprecedented activity in the area of science education in Ireland, particularly in reference to the physical sciences at second level. After over a decade of slow decline in numbers at second level doing chemistry and physics, the reality and seriousness of the situation and the consequences for the economy suddenly became public knowledge and a matter of concern. This decline had been signalled for years in some quarters but now government and industry have woken up to the implications. A number of conferences, official reports and finally government and industry initiatives have resulted from this new awareness.

The question is whether the measures already taken or planned will be enough to slow and reverse the decline in numbers doing the physical sciences at second and third level. Change in education has a long time-scale. Children who started primary science in grade 6 (age 11/12) in 2000-01 would not leave school until 2007 and would not graduate from university until 2011, a span of at least ten years. Changes in the LC Chemistry course in September 2000 will not result in new Chemistry graduates until 2006. As the skills shortage is already apparent in all science-based industries, changing the curriculum is not a short-term solution to the problem. There is also no evidence that changing the curriculum at primary or second level will actually improve the situation anyway, as many other factors are involved. These factors include student perceptions of subject difficulty, inconsistency in grading between different subjects, lack of appropriate careers information, the pressure to maximise points for university entry, amongst others. The new LC chemistry syllabus introduced with great fanfare in 1983 was followed within a few years by the steady decline in the percentage doing chemistry from around 20% to 10% in the next 15 years.

The nature of education with its long time scale and the urgency of the problem means that a variety of initiatives must be taken with different time scales, different geographical targets, and different audiences – there is no single ‘magic’ solution. The time scales involved are short-term, medium-term and long-term. Geographically there is a need for local initiatives e.g. between industries and their local schools, as well as for regional and national initiatives. Different audiences must be targeted in different ways – primary school children, junior and senior cycle second level students, primary and second level teachers, career guidance counsellors, parents, the general public etc.

Many types of initiative are needed to reach the different targets – competitions and projects, industry-school links, promotional activities in schools such as Chemistry Magic Shows and Science Clubs, relevant and attractive careers information, open days and visits to industry, production of teaching resources, posters and publications, investment in pre-service and in-service training of teachers, refurbishment and re-equipment of laboratories, technical assistance in schools etc. This is a long shopping list and some activities are already ongoing, but there is a need to prioritise initiatives, to fund them adequately and to maintain this funding for an adequate time. It will require cooperation and partnership between government, schools, third level institutions, industry and professional bodies. A massive investment of money will be needed to do anything significant and the investment must be made regularly over many years to ensure long-term change.



Reversing the decline in science education in Ireland will not be an easy task but it is now possible given that the problem has at last been recognised by all interested parties and that the public finances and the state of economy is such that money is available. The massive investment in science research and development in Ireland announced in 1999 shows that decisive action is possible. It needs the same spirit of decisive and targeted action, with proper funding, to be applied to science education. Please wait for the update on the situation!

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## REFERENCES

- Cashell, A.M. (2000). *Second-level Chemistry Provision for Schools in the republic of Ireland*. Ph.D.Thesis, University of Limerick.
- ChemEd-Ireland, (1995). Proceedings ChemEd-Ireland 1994, 'The new LC Chemistry Syllabus', *Chemistry in Action!*, 46, 20-44.
- Childs, P.E. (1995a). The challenge of chemical education. *Irish Chemical News*, X(II), 23-30
- Childs, P.E. (1995b). Comments and outline of the new LC Chemistry Syllabus', *Chemistry in Action!*, 46, 42-44.
- Childs, P.E. & McDonnell, P. (1999). The popularity of Chemistry in Irish schools', 5<sup>th</sup>. ECRICE, Ioannina, September 1999.
- Childs, P.E. (2000a). 2000 LC results and CAO offers. *Chemistry in Action!*, 61, 29-32.
- Childs, P.E. (2000b). Ireland's booming chemical industry', *Chemistry in Action!*, 61, 15-16.
- Childs P.E. (2000c). Science education in the Republic of Ireland. *Science and Technology Education in the new Millennium*, 3<sup>rd</sup>. IOSTE Symposium, 61-66, Peres Publishers, Prague
- Childs, P.E. (2001). Science education in the Republic of Ireland and the 'Celtic Tiger', *Revista de Educacion en Ciencias*, 2(1), 6-12.
- ICSTI (1998,). *Science in primary schools*. ICSTI Statement, May 1998..  
[<http://www.forfas.ie/icsti/statements/primary.htm>]
- DoES (1999a). Commission on the Points System. [<http://www.irlgov.ie/educ/comm.htm>]
- DoES (1999b). Leaving Certificate Chemistry Syllabus Dublin: Government Printing Office.  
[<http://www.irlgov.ie/educ/areasofinterest/LC%20Chemistry%20Syllabus.pdf>]
- DoES (2000). *Teacher's reference handbook: Chemistry*. Dublin: Government Printing Office.
- ICSTI (1999a). *Benchmarking school science, technology and mathematics education in Ireland against international good practice*. ICSTI, September 1999.  
<http://www.forfas.ie/icsti/statements/benchmark/index.html>
- ICSTI (1999b). *Science in second level schools*. ICSTI Statement, November 1999.  
[http://www.forfas.ie/icsti/statements/secondlevel\\_99.htm](http://www.forfas.ie/icsti/statements/secondlevel_99.htm)
- ICSTI (1999c). *Technology foresight report*. Dublin: Forfas. [<http://www.forfas.ie/icsti/index.htm>]
- IPCMF (2000). *Educating a skilled workforce*. Dublin.
- ISTA (2001). *Datalogging with PASCO: Chemistry experiments manual*, Vol. 1. (R. Henly, ed.).
- Martin, M. (1999). New science education initiative. *Chemistry in Action!*, 58, 2.
- Matthews, P. (1995). A critique of the revised LC Chemistry syllabus. *Chemistry in Action!*, 46, 24-35.
- NCCA (2000). *Draft Syllabus in Physics and Chemistry*. Dublin.
- Oireachtas (2000). Report of the Oireachtas Committee on Science and Technology.  
[<http://www.irlgov.ie/committees-00/c-education/rep-scitech/default.htm>]
- RDS (2000). *Science education in erisis*. (C. Power, ed.). Dublin.
- TFPS (2002). [[www.sciencetaskforce.ie](http://www.sciencetaskforce.ie)]

**NOTE:** Back issues of *Chemistry in Action!* From issues 38-63 can be accessed free-of-charge at [www.ul.ie/~childsp](http://www.ul.ie/~childsp)