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Science Education in the Republic of Ireland and the 'Celtic Tiger'

La enseñanza de las ciencias en la República de Irlanda

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Abstract

In the last 20 years, particularly in the last 10 years, Ireland has been transformed from a country dependent on agriculture and tourism to a high-tech economy with one of the highest growth rates in Europe, with strong ICT and chemical industries. The birth and growth of the 'Celtic tiger' has depended on a highly-educated, young English-speaking workforce. Ireland has one of the youngest populations in Europe with a high proportion of the population in full-time education. The development of science-based industries depends on a good foundation of science education at second and primary levels. Despite the economic success the state of science education is quite worrying, with declining numbers taking the physical sciences which under-pin the growth industries of chemicals and ICT. This paper will survey the state of science education in Ireland from primary level to third level and will describe new initiatives in this area aimed at correcting the swing away from science, at a time when the economy is becoming more, not less, science-based. The crucial role of science teachers and their pre-service and in-service education in improving science education will be highlighted.

KEYWORDS: Science education, Ireland, teacher preparation

Resumen

Irlanda en los últimos 20 años se ha transformado de país agrario y de turismo a una economía con proporciones de alta tecnología. El nacimiento y crecimiento de ' el tiger' Céltico ha dependido de una joven mano de obra muy-educada. Irlanda tiene una de las poblaciones más jóvenes de Europa con una proporción alta en la educación de jornada completa. El desarrollo de industrias basadas en ciencias depende de una buena organización educativa. A pesar del éxito económico el estado de la educación en ciencias está preocupado realmente, con el bajo número de estudiantes en ciencias físicas lo que influye negativamente en la industria química y la alta tecnología. Este trabajo analiza el estado de la educación en ciencias en Irlanda del primero al tercer nivel y describe las nuevas iniciativas en esta área apuntada a corregir el balance a favor de la ciencia, en un momento en que la economía está basada en las ciencias.

También se analiza el papel primordial de maestros de las ciencias y el mejoramiento de su preparación en las licenciaturas y en el sistema de actualización de conocimientos.

Palabras clave: enseñanza de las ciencias, Irlanda, preparación de profesores

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The Celtic Tiger

In the last ten years Ireland has moved from being a back-water in the EU to being lauded as 'the Celtic Tiger', whose economic performance has outclassed the rest of the EU. In relation to its economic turnaround and dramatic growth in high-tech. Industries, notably computers, software and chemicals, Ireland has mimicked the earlier growth of the Asian economies - hence the term 'Celtic Tiger', although tigers are unknown in Ireland except in zoos! In September 2000 Ireland is ranked 5th. in Growth Competitiveness in the World Economic Forum ranking, up from 10th. in 1999. Some facts and figures highlight this growth since 1985:

_ total manufacturing output has increased 256%

_ output of chemicals has increased 555%

_ output of metals and engineering has increased by 403%

_ output of food has grown by 104%

’ GDP per capita is now 95% of the EU average, now exceeding the UK

If we look specifically at exports in the period 93-98, industrial exports have grown from £15,842* million to £41,040 million, 91.3% of the total. Agriculture, forestry and fishing over the same period grew from £2,741 to £2,966 million, but declined in importance from 13.9% to 6.6% of exports. Annual growth rates in industrial production are now around 17% on average.

If we focus specifically on the chemical and pharmaceutical industry, as one with which I am most familiar, it was identified 25-30 years ago by the Industrial Development Authority (IDA) as an important growth area. Around 220 companies in total are now included in this sector, including many subsidiaries of multi-nationals: 8 of the world's top 10 pharmaceutical companies have plants in Ireland. Since 1973 exports have grown from £73 million to £11,684 million in 25 years! Table 1 shows how the industry has grown in value since 1990 and it now ranks 8th. in Europe in output (CEFIC website). In Ireland it is second in exports only to machinery (including computers) and exports were £11,684 million in 1998, 25% of the total exports, and with a growing surplus of exports over imports. Employment in this relatively small but highly productive sector has been growing at 20% per annum in recent years (*IPCMF 5-Year Business Plan 1997*). In terms of productivity and annual growth it has out-performed the chemical industry in most of Europe (Table 2). Turnover of the Irish industry in 1999 is now 25% of the German chemical industry.

Table 1 Production of the Irish chemical industry (1990-1998)

(Source: CEFIC, www.cefic.be)

Year 1998	1990	1991	1992	1993	1994	1995	1996	1997
Prod.								
/Meuro 14,835	3,712	4,154	4,680	5,206	6,551	6,744	9,012	11,973
/M£IR 11,684	2,923	3,272	3,686	4,100	5,159	5,311	7,098	9,430
% annual +24%		+12%	+13%	+11%	+26%	+3%	+34%	+33%
change								

- All figures in Irish£ where1IR£ = 0.787564 Euro = US$1.2

Although employment is relatively low (23,000 in 1999) this has been growing rapidly by 20% p.a. in recent years and the net growth includes losses in traditional chemical industries like fertilizers. Al;so each job in manufacturing is estimated to create at least two more jobs in service and supporting industries. Two-thirds of people employed have third level qualifications so it is also a highly-qualified workforce. The chemical industry has also proved to be very stable and is currently committing massive funds to new plants and expansions. The chemical industry illustrates the importance of high-tech. industries in Ireland's recent economic growth.

Table 2 EU Chemical Industries by Size (1998)

(Source: CEFIC, www.cefic.be)

Country	Turnover/MEuro	% change (1990-98)
Germany	95,186	+20%
France	69,679	+34%
UK	46,731	+33%
Italy	44,451	+9%
Belgium	32,316	+46%
Spain	27,151	+24%
Netherlands	26,084	+29%

Ireland	**14,835**	**+300%**
Sweden	8,419	+32%
Austria	4,462	0
Denmark	5,031	+44%
Finland	4,363	+24%
Portugal	3,509	+19%
Greece	2,519	+45%

All the statistics show rapid growth and OECD figures show Ireland outperforming all other countries in GDP forecasts, with growth of over7% in 2000. This growth has occurred so rapidly and consistently over the last 10 years that Ireland is now experiencing a severe skills shortage at all levels, whereas only ten years ago there was net emigration. Why has this happened?

Factors affecting Irish economic growth

Many factors have been cited for the sudden emergence of Ireland as an economic powerhouse, albeit a small powerhouse! Today's success has been built on policies started 20 or 30 years ago, designed to modernize Ireland and bring it into Europe as a member of the (then) Common Market (now the European Union). A recent commentary (Wong, Richard 1999) made the point that "Asia's success has been built, not on a the discovery of a new form of capitalism, but on a tried-and-true- formula, the initial ingredients of which include a hard-working, well-educated and trained labour force, and a vigorous entrepreneurial class that invests in plant and equipment." All apart from the last this could well describe Ireland and massive investment by foreign multinationals has supplied the last requirement. Ireland was 4th. in terms of foreign direct investment as a % of GDP in 1998 (at just under 8%) according to the OECD.

A number of important factors can be identified which have resulted in this dramatic growth:

- joining the European Community in 1972 with access to a larger market
- free second level education in 1967 (20 years later than most other European countries)
- building 10 Regional Technical Colleges and 2 National Institutes of Higher Education (NIHEs) in 1972 with a technological/industrial focus
- a traditional education system focusing on the basics where Maths and English are compulsory throughout all years of the school system
- a large number of young people in the population, with over 25% in full-time education

- innovative tax laws to encourage inward investment from high-tech. Multinationals, tax-free industry zone at Shannon - first in the world
- aggressive wooing of new companies from the Industrial Development Authority particularly in pharmaceuticals and computers
- availability of clean water and green field sites
- few smokestack industries to hinder growth of new industries
- young, well-educated, English-speaking adaptable workforce
- social partnership since 1987 restraining wage demands

Ireland has grown from a small industrial base, where agriculture/food and tourism were the most important sectors to one where high-tech. industries such electronics, software and pharmaceuticals dominate the economy, particularly exports. Many of the world's top pharmaceutical companies have production plants in Ireland e.g. Pfizer making the world's supply of Viagra, Eli Lilly making Prozac, Schering Plough making Interferon, Bristol Myers Squibb making Taxol. In addition the giants of the computer industry - Intel, Hewlett Packard, Xerox, IBM, Dell, Gateway, Microsoft ... have manufacturing plants or software/teleservices centres in Ireland. This expansion has been so rapid that despite special government initiatives in the last 2-3 years to increase the number of third level places in Information and Computer Technology (ICT), there is a large and growing skills shortage in this industry, as well as in other manufacturing industries, particularly at technician level. Net emigration has been replaced by net immigration, population growth instead of decline, almost full employment instead of high unemployment and recruitment drives in Europe to meet skills shortages. This amazing turnaround is due in no small part to the Irish education system, a factor highlighted in a recent book by Paul Sweeney on *The Celtic Tiger* (Sweeney 1998). An OECD report in 1997 ranked Ireland top in Europe for its educated workforce and second (after Germany) for the skills of its workforce.

(OECD 1997)

The Irish Education System

The Irish education system and science education in Ireland were reviewed in an earlier paper up to 1995 (Childs 1995). One feature of Ireland is the high proportion of the population in full-time education. In 1996-97 out of a total population of 3,621,035 no fewer than 26.5% were in full-time education as the figures in Table 3 show and the total labour force in 1996 was 1,533,964.

Table 3 Irish Education Statistics 1996-97

(Source: DOES Statistics)

	Number	%female
First level	476,632	48.5
Second level	375,518	51.1
Third level	107,501	51.3
Total	959,651	49.8

In 50 years the number of people in higher education has grown from 8,000 to nearly 110,000. More girls stay on into second level and third level than boys.

Ireland thus has the advantage of having a high percentage of young people in full-time education. However, this means that although the education budget is around the EU average as a % of GDP, spending per student is one of the lowest in the EU! Lack of resources and poorly-equipped laboratories is a perennial complaint of Irish science teachers. Birth rates have dropped in Ireland in line with the rest of Europe, but they have started to increase slightly in recent years to around 54,000 per year and are still above the EU average.

a) First and second level:

Most children start school at age 4 with two years of preschool education in the national (primary) schools. Compulsory education starts at 6 and the students spend 6 years in primary school. There is no primary school leaving examination or, as yet, any national testing of children at first level. At age 12 they transfer to the junior cycle of the second level sector. This takes 3 years to the first national examination, the Junior Certificate, taken by most at age 15. All schools offer this and most students take it. 24 subjects are offered at Higher and Ordinary levels (plus foundation levels in Mathematics, English and Irish) and Science is a single subject, combining Biology, Chemistry, Physics and Applied Science. Mathematics, English and Irish are compulsory subjects in both the Junior and Senior cycles. Most students take 8-10 subjects at this level. Although Science is not compulsory around 90% take the subject at junior level.

Almost all schools now offer a Transition Year Option (TYO) which is a year between the Junior and Senior Cycles without any fixed curriculum and around 50% of students now take up this option. The Senior Cycle lasts 2 years, from age 15/16 to age 17/18. There are three national examinations/curricula on offer: the traditional, academic Leaving Certificate (34 subjects) offered at Higher and Ordinary levels, with Foundation levels in Mathematics and Irish; the Leaving Certificate Applied Programme and the Leaving Certificate Vocational Programme. These last two have a more applied and vocational emphasis and are intended for the less academic students. However, the majority of students who stay on at school after age 15/16 (92% at age 16, 81% at age 17) take the traditional Leaving Certificate course which is the main means of selection for third level courses using the ‘Points System’ (see below).

Students usually take 7 subjects at Leaving Certificate level, three of which are compulsory (Maths, English, Irish) and the aggregate of grades on 6 (or 5) subjects are used to determine entry into third level. Science is represented by the following subjects: Agricultural Science, Biology, Chemistry, Physics, and Physics with Chemistry (a combined course). Most third level courses in science or technology require just one science and any science is accepted (except for medicine and pharmacy where Chemistry is now essential). The majority of students take Biology and Table 4 shows the numbers doing the various science subjects in 1999 (Childs 1999).

Table 4 LC Science Subjects (1999)

(Source: DOES Statistics)

	Total	**%HL**	**%Cohort**
Chemistry	6953	83.5%	10.75%
Biology	28750	60.3%	44.4%
Physics	9112	68.7%	14.1%
Physics +Chemistry	1370	69.9%	2.1%
Agricultural Science	2999	71.4%	4.6%

(Total LC Cohort: 64,761)

If we look at the gender balance in science subjects then girls make up 46.8% at Junior Science, as not all girls are offered science. At Leaving Certificate level girls dominate in Biology (65.6%), are a small majority in Chemistry (50.4%) and minority in Physics (25.5%). Not all schools offer all science subjects and this is a major area of inequity of provision. Table 5 shows how many schools offer the main LC science subjects. There are three main sectors in the second level system: secondary schools ; vocational schools/community colleges; comprehensive and community schools . Secondary schools in Irish parlance means semi-private, voluntary, religious schools often single sex and with an academic bias. Schools in the other two sectors are state run, are mixed and offer a range of academic and vocational subjects. Two teacher's unions represent teachers in these two main groups of schools. Many Irish schools are small by European standards and a small town might have three small second-level schools: girls-only and boys-only secondary schools and a mixed vocational schools. There is a rapid move towards lay control of schools in the secondary sector and merger/amalgamation of small schools in country towns to form one large, mixed school offering all subjects, replacing of three small schools.

Table 5 Schools Offering Science Subjects (1997-98)

(Source: DOES Statistics)

Type of school	**Number**	**Biology**	**Chemistry**	**Physics**	**Phys+Chem**
Secondary	435	422	379	379	49
Vocational/ Comm. Coll.	245	206	75	134	53
Comp./Comm. Schools	81	79	63	74	12
Totals	**761**	**707**	**517**	**587**	**114**
%	**100**	**92.9**	**67.9**	**77.1**	**15.0**

b) Third level:

Entry into third level is on the basis of marks obtained in the Leaving Certificate examination, usually in 6 subjects of which Mathematics and English (and sometimes a language) are compulsory. Grades in the examination are converted into points (Table 6) and the aggregate is used to select students for courses. Higher points are given for equivalent grades in the Higher Level (HL) compared to Ordinary Level (OL) papers. Note that to get an A requires students to gain over 90% of the marks. Third level entry is done through a centralized Central Applications Office (CAO), where students can list up to 10 courses in the degree and sub-degree lists. Places are awarded on the basis of demand and the student's highest preference, and each course has a points cut-off reflecting the demand versus student quality each year. Courses in high demand like medicine with limited places have high points (typically 550 out of a maximum of 600); science courses with more places and lower demand range from 330-450 (5). This is an objective and fair system though its application can be rather ruthless. Demand for science and engineering courses and thus the points required has declined over the past few years.

Table 6 Grades and Points for 3rd. level entry

% marks in LC exam	LC Grade	Points HL paper	Points OL paper
90-100	A1	100	60
85-89	A2	90	50
80-84	B1	85	45
75-79	B2	80	40
70-74	B3	75	35
65-69	C1	70	30
60-64	C2	65	25
55-59	C3	60	20
50-54	D1	55	15
45-49	D2	50	10
40-44	D3	45	5
25-39	E	-	-
10-24	F	-	-
0-9	NG		

The higher education sector comprises 7 universities, 14 Institutes of Technology, 5 teacher training colleges and a number of private colleges. All now offer degree courses although the majority of courses in the Institutes of Technology are sub-degree level (certificates and diplomas). However, students can now convert Diplomas into degrees in many subjects and at many institutions by doing one or two year add-on courses. Third level education has expanded dramatically in the last 10 years and nearly 50% of school-leavers now enter third level courses of one sort or another. In the last 2-3 years there has been a major expansion of degree and sub-degree courses in Information and Computer Technology (ICT) to meet the massive demand from this industry.

The State of Science Education

Given the strong demand for people with a science & technology background in a high-tech. economy one might expect science education in schools and third level to be very strong in

Ireland. A previous report looked at the state of science education in Ireland up to 1995 (Childs 1995). However, this is not the case and the decline in numbers doing the physical sciences has become a matter of discussion in conferences (*Science Education in Crisis?* 2000,

Chemistry for a Changing Marketplace 1999) and in the media, as a recent article on "The Irish science and education paradox" (Sweetman 1999) shows. Figure 1 shows that from 1987-1999 there has been a marked swing away from the physical sciences, which are the foundations of the new technologies and industries. The real decline in numbers has occurred against an increasing cohort doing the Leaving Certificate and thus the drop in percentage terms is more dramatic: Chemistry has dropped from 20.8% to under 11% since 1987 and Physics from 21% to 14.5%. Less people are taking the physical sciences in school now than a decade ago, despite greater participation rates and a greatly improved jobs market.

The same decline in numbers doing science has also happened at third level and demand for science courses has dropped dramatically in the last 2-3 years in degree (around 10%) and sub-degree courses (around 30%). This decline in science at second and third level is due to a number of factors:

_ massive emphasis on ICT by government and media

_ large expansion of third-level places in ICT

_ influence of 'points' on third level entry leading to students choosing easier subjects and avoiding the physical sciences

_ unattractive school science syllabus at age 12-16

_ poor science careers advice and information in schools

_ the imbalance among science teachers in favour of biology

_ inadequate laboratories and funding for practical work

_ schools not offering all science subjects

_ very little practical work done by students in schools

_ no assessment of practical work or credit for coursework

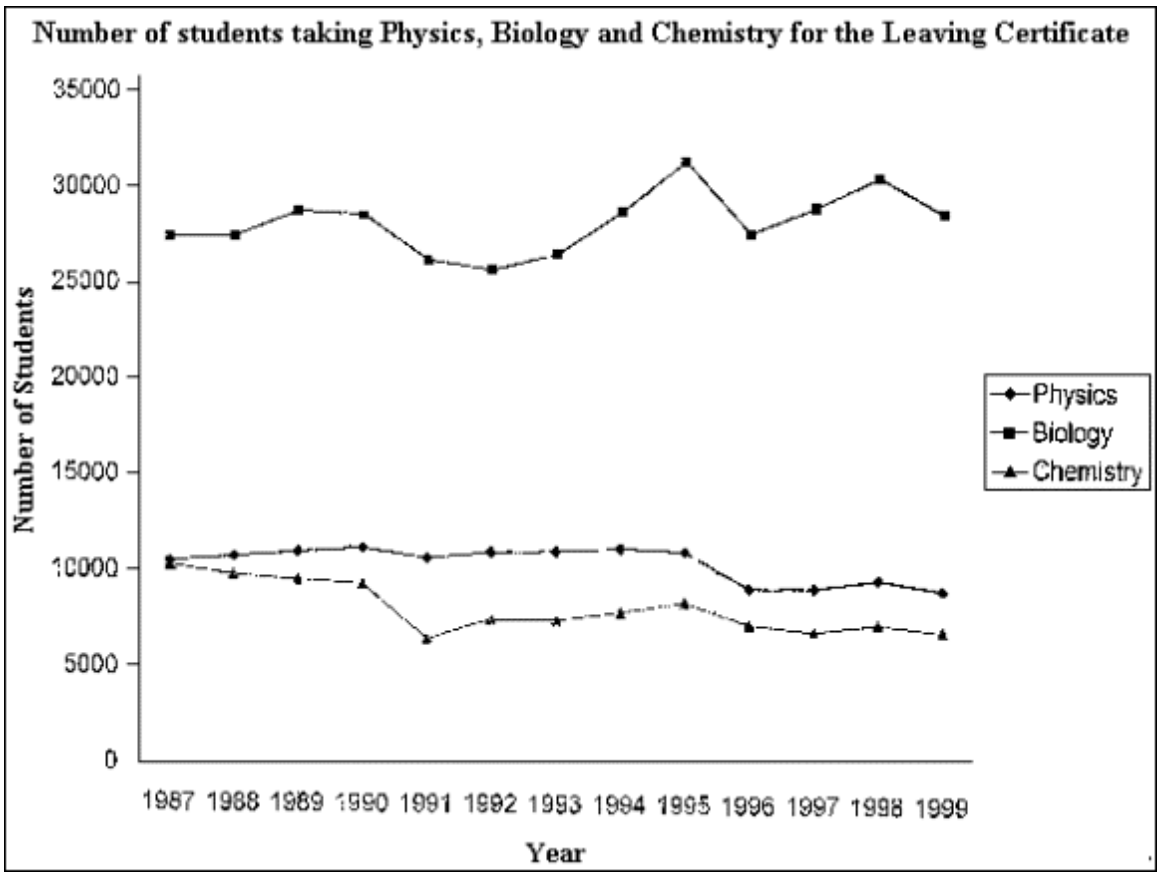
_ heavy teaching loads and no technical assistance in schools for science teachers

_ essentially no science at primary level from 1934-2000

_ shift towards degree courses away from sub-degree courses

Figure 1 Numbers taking Chemistry, Biology and Physics (1987-1999)

(Source: DOES Statistics)



Promoting Science Education: New Initiatives

The realization in the last 2 years by industry, government and academia that falling numbers doing physical sciences may have serious economic consequences has led to action. Several conferences have been held in the last year to consider the 'Crisis in Science Education' enabling the issues to be discussed publicly (*Science Education in Crisis?* 2000, Chemistry for a Changing Marketplace 1999), and the problem has been aired repeatedly in the media. A number of encouraging and positive developments to promote science, and the physical sciences in particular, are described below.

a) **Government Initiatives**

The Minister of Education reacted quickly in March 1999 with a £15 million investment to upgrade laboratories, fund in-service courses for science teachers, review and revise existing science syllabuses and pay a £10 premium to schools for Physics and Chemistry students (Press release 1999). The Junior Science syllabus, taken by over 90% students, has been identified as a problem in putting students off science and in giving a poor foundation for further study in Physics and Chemistry. Most Irish science teachers are biologists by background and they thus dominate the teaching of Junior Science. The imbalance between the three main science subjects - Biology, Chemistry and Physics - is much more marked in Ireland than in many countries (see Table 4 and Figure 1). However, the broadly-based curriculum at Junior and Senior cycles means that a greater proportion of Irish students do at least one science (as well as Mathematics) than say in the U.K., where the percentage doing A level science is around 5-6% (Childs 1999).

b) **Curriculum Development**

New LC syllabuses in Physics and Chemistry, which have been ready since 1994, are finally being introduced in September 2000. These were last revised, with great hopes, in 1983 just before numbers started to drop in the physical sciences. The new syllabus in Chemistry (McCarthy 1993, The New LC Chemistry Syllabus 1995) includes more emphasis on industry and environmental Chemistry, a mandatory set of experiments, case studies of Irish industry, and 30% devoted to social, economic and historical aspects. The syllabus committee hopes to make Chemistry (and Physics) more attractive to weaker students and less demanding compared to other subjects than previously. The Biology syllabus is also being revised, having been in operation since 1970.

Syllabus revision is the responsibility of the National Council for Curriculum and Assessment (NCCA), which advises the Minister of Education on the curriculum. This body has done a lot of work in the last decade on researching and evaluating different aspects of the curriculum but it is not autonomous and it is only an advisory body. Control of the Irish school curriculum is highly centralized in the Department of Education and Science and the Inspectorate. There is almost no opportunity for innovative or experimental projects, nor are there charitable foundations supporting such initiatives in Ireland (like the Nuffield Foundation or Salters' Company in the U.K.). A pilot project to evaluate in-school assessment of practical work in Chemistry and Physics was commissioned and completed in 1998-99. The report indicated that school assessment of practical was feasible but implementation has been shelved by the Department of Education and Science.

A new in-service training programme has been launched to bring in-service education on the new Physics and Chemistry courses to every science teacher. This has been done through a number of sessions, held on a regional basis and taught by experienced teachers seconded

for the purpose. The new aspects of the syllabus are emphasized and sessions will include hands-on practical work to equip teachers to teach new aspects of the course e.g. simple instrumentation. Attendance at these sessions is still voluntary although they have been offered to all teachers of Physics and Chemistry.

c) **Promotion of Chemistry in Schools Project**

As part of the chemical education activities at the University of Limerick I launched a Promotion of Chemistry in Schools Project in 1998, part-funded by the Irish Pharmaceutical and Chemical Manufacturer's Federation (IPCMF), to evaluate various strategies for encouraging 15/16 year-olds to study Chemistry in school. This has involved a postgraduate student, Ms. Elaine Regan, travelling round schools giving a Chemical Magic Show. During the academic year 1998-99 she visited 67 schools and presented the show to over 8,500 students. Their views on Chemistry are being evaluated before and after the show, as well as the responses of their teachers, and the long-term take-up of Chemistry in these schools compared to non-intervention schools will be assessed (Regan, Elaine 1999). In addition an attractive Chemistry magazine, *CheMystery*, has been produced to send to schools to encourage an interest in Chemistry and its effectiveness will also be evaluated.

Other activities at the University of Limerick to promote the teaching of Chemistry in schools include the publication three times a year of the magazine *Chemistry in Action!*, an annual conference for Chemistry teachers (ChemEd-Ireland) and the Schools Information Centre on the Irish Chemical Industry (SICICI). The University of Limerick also promotes science and technology in schools by producing an interdisciplinary magazine, *Elements*, send free to schools and also available on the internet (www.ul.ie/~childsp/elements). The 4th. issue was produced at the end of 1999 and 40,000 copies of a tabloid version, linked to the full internet edition, were sent out to all second-level schools.

d) **New Multimedia Careers Package**

FAS is the Irish industrial training authority and the section responsible for the Chemical and Allied Products Sector has been very concerned at the drop in the number of students training to be science and engineering technicians, and the wholesale desertion of middle-ability students from the physical sciences. In late 1998 FAS set up a widely-based task force to produce suitable careers materials aimed to promote the study of Physics and Chemistry in particular, and targeted at the 15/16 year age group. This was completed and launched in February 2000 and sent to every second-level school. It comprises a video highlighting careers in science, for use by the careers guidance counsellor or science teacher, and a CD-ROM containing information on careers and games aimed at individual students, which will be linked to the FAS website containing more career information. The CD-ROM is being distributed in bulk to make it more widely available. The initial reactions to the multimedia package have been very favourable but it remains to be seen whether it will have a measurable affect on recruitment.

e) **The ‘Points’ Problem**

Part of the problem in choosing LC subjects in Ireland lies, not in the intrinsic appeal or value of different subjects, but in student perceptions of which are easiest, which take least time to do, and which offer the best chance to maximise grades and hence university entry points. Since the best six subjects are counted (Mathematics and English being compulsory as well as often another language), and a single unspecified science subject is all that is required for entry into

science and engineering courses, students choose subjects to maximize their points aggregate. Biology or Domestic Science are thus preferred as Science subjects to Chemistry and Physics (which are longer, more 'difficult' courses, and more mathematical) except for some high-demand courses where Chemistry is compulsory (medicine and pharmacy). The result of this points-driven entry system (where subjects are not in fact equivalent in length, difficulty or grading) has been the dramatic decline in numbers doing Chemistry and Physics in the last decade (Figure 1). These students are less likely then to take further courses needing these subjects at third level and a vicious feed-back loop has been created. One proposal made during 1999 was for selective bonus points for Chemistry and Physics (Childs letter 1999) and although this proposal has received support from Deans of Science, it was turned down by third-level administrators, and no action has yet been taken. A government think-tank on science and technology, ICSTI, has produced a report on the state of school science with several recommendations (*Science in Second Level Schools 1999*).

f) **The Training of Science Teachers**

Science teachers in Ireland are trained by one of two routes: the concurrent and the consecutive models. In the concurrent model students take science, education and teaching practice integrated over four years. Until 1999 only the University of Limerick offered this route but Dublin City University has started a concurrent science education course to produce Physics and Chemistry teachers. The consecutive route, offered by five institutions, involves students taking a first degree in science (usually 4 years) followed by a one year Higher Diploma in Education (H.Dip.Ed.). Relatively small numbers of students have opted to teach science using this route in recent years, and a majority of them have had biological backgrounds. The H.Dip.Ed. route has traditionally been the main route by which all second-level teachers, including science teachers, were trained. A majority of existing science teachers are thus biologists. Stronger job markets in science have reduced the number and quality of trainee science teachers by the consecutive route, particularly those with Physics or Chemistry degrees. In contrast, there is high demand for the concurrent science education courses at the University of Limerick (which enables students to take any two of the three main sciences as teaching subjects) and the quality of these students is equivalent or better than those starting straight science degrees.(Childs 2000) There is thus no shortage of science teachers (even of Physics and Chemistry) when students trained by the two routes are combined. The teaching profession is aging and the job market for new teachers is, however, not very good at present although the Minister of Education and Science has announced several hundred new teaching jobs in the last year. This might provide an opportunity to recruit more teachers with a Physics or Chemistry background and to introduce or reintroduce the physical sciences into schools which don't offer it at present. However, the fact that the majority of science teachers produced in the last 20-30 years have had biological backgrounds has almost certainly contributed to the weaker status of Physics and Chemistry in schools, particular when these subjects are presented for the first time at second-level by biologists in Junior Science courses. This also feeds into the feedback loop identified above which distorts the uptake of science subjects in favour of Biology. An Irish Association of Science Education Lecturers (IASEL) has just been formed to coordinate efforts in this area. There is a need for a National Centre for Science Education to promote the teaching of science, and research and development in science education.

g) **Primary School Science**

Ireland had science in the primary school curriculum up from 1897 until1934 and it was then dropped (and replaced by Irish). Although a new curriculum introduced in 1971 included Social & Environmental Studies, in practice very little science was taught and most primary teachers

have poor backgrounds in science. A local Primary School Science Project ran in Limerick for several years in the late 80s-early 90s, providing useful experience and ideas on how primary science could be implemented in Ireland. A new primary curriculum has now been approved, and is due to be introduced on a phased basis over five years from September 2000. This does include a core section including Science. However, it presents major challenges to the in-service and pre-service training of science teachers to equip them to teach science effectively and in the right way. Few primary teachers have any science background and science has a minor part of the primary teacher's curriculum.

It will also present problems in coordinating the experience of science at first and second levels as students move from one system and one type of school to another. The science curriculum in Ireland to-date has been designed from the top down, without any real coordination or integration between the science curricula at different levels. The lack of science in the education of most Irish children before the age of 12/13 partly explains the poor performance in the various international attainment tests that have been produced. It is hard to master what one hasn't been taught! Better science education in primary school might help develop more positive attitudes to science in second level (Editorial 1999).

h) **Extra-curricular Science Activities**

One shining star in the Irish science education scene is the annual Young Scientists Exhibition (Science Fair) running for 33 years and sponsored for most of that time by Aer Lingus, and for the last 3 years by Esat Telecom. In January 2000 the event attracted over 1000 students and 650 projects from secondary and primary level schools in Ireland(North and South). The annual winners of the top award have been very successful in international competitions and the Irish entrant has frequently won the European competition, disproportionately so given the size of Ireland. Several other local or regional Science Fairs are also run annually. One reason why the success of this event is so surprising is that in general there is almost no project work done in school science, except for such competitions, and there is a low level of practical work done in school science at Junior Certificate and leaving Certificate levels. It does indicate, as does the illustrious but unsung history of Irish science and technology, that there is an immense reservoir of scientific talent waiting to be tapped in Ireland, but which for many reasons described above is largely wasted.

i) **Public Awareness of Science**

Ireland has been relatively slow in jumping on the 'Public Awareness of Science' platform which is influential in most European countries. Ireland still has no national interactive science centre or museum, although there is a small, private centre - ScienceWorks - in Tralee. In September 2000 the government announced that it was going to set up three interactive science centres - in Dublin, Cork and Galway. Forfas, a state body with a brief to promote scientific enterprise, has been given responsibility and a budget since 1997 to promote Science and Technology Innovation (STI) and for the last three years they have coordinated a national Science Week Ireland to promote science and technology to the general public. This has been a very successful venture and in the last Science Week in November 1999 a new activity was launched -a Primary Science Day - involving 500 schools, and a package of teaching materials was produced for this event.

There has been an increased profile for science in Irish media in recent years, with a weekly science page in the influential *Irish Times* and public science lectures in Dublin and other activities. There is still much work to be done in this area.

j) **Irish Science Teacher's Association**

One of the most active subject teacher's associations in Ireland is the Irish Science Teacher's Association (ISTA). This organization is run by volunteers and has a membership or around 1100, although this does not include all science teachers. In recent years primary teachers have been encouraged to join. It produces a magazine, *Science*, three times a year, has a very successful annual weekend conference and resources exhibition, has local branch meetings through the school year and organizes in-service courses and produces teaching materials. Over the years the ISTA has made several reports to the Minister for Education highlighting problems like safety, shortage of resources, poor laboratory facilities, and the need for science technicians to assist teachers in schools. At long last it seems that some of these needs are being recognised and met, as the success of the 'Celtic Tiger' means that are funds available now to tackle such problems.

Conclusions

What is the connection between Ireland's economic boom and science education? It is hard to quantify any such connections, but the evidence suggests that today's Celtic Tiger was a result of the economic and educational policies of two to three decades or more ago. Garret Fitzgerald, ex Prime Minister and an economist, has commented:

"For it is widely known that our economic success has owed an enormous amount to the rapid upgrading of the average educational level of our working population." (Fitzgerald, Garret 2000)

Educational change has a long lag time and an increase in numbers doing chemistry at school, for example, would take at least six years to appear on the jobs market. In 1987 a much higher proportion of students and larger numbers had a background in Physics and Chemistry than in 2000. Today's success is built on the foundation laid in the 70s and early 80s, so Ireland in a sense has been living off the past.

The decline in the 90s of numbers choosing science courses and careers is bearing fruit in the new millennium in severe actual and future skills shortages. The IPCMF Report published in 1998 forecast a skills shortage in the industry of nearly 900 people by the end of 2001 (Fitzgerald, Garret 2000), and Forfas report on Future Skills Needs (2nd. Report 2000) concluded that extra science places and technician places need to be created to solve the current Irish dilemma of 'more jobs, less people'. The declining science uptake at second and third level, combined with the growing skills shortage in an expanding high-tech. economy which is now apparent, suggests that serious attention, effort and resources must be put into identifying and nurturing Ireland's young scientific talent if the world-famed Celtic Tiger, like the Asian Tigers before it, is not to go into decline. The reasons for the lack of popularity of the sciences in school still need full elucidation although some work has been done (Childs 1999).

There are welcome signs that the problem has been recognised and some action has already been taken. The chemical industry federation, IPCMF, has set in September 2000 a Skills Review Working Group to address the problems. Ensuring that enough young people see the excitement and rewards in pursuing courses and careers in science in the 21st. century is Ireland's challenge in science education at the start of the 21st. century.

The current economic success has been built on decisions made back in the 70s and 80s which came to fruition in the 90s, not least the relatively high numbers doing science in the

last 80s and early 90s. The effects of the decline in numbers taking science in school have now filtered through to third level and are starting to impact on industry. In addition there will a long-term decline in the number of 18 year olds over the next decade, and the weak Euro and increased inflation are also worrying signs.

We need creative and imaginative short-term and long-term solutions as any improvement at school level may take anything up to a decade to affect skills shortages in industry. There is no single or simple solution as it is a multi-faceted and complex problem. Its solution thus requires many and varied initiatives and activities at different levels in the education system and by different bodies - from government, industry and education - as illustrated by the activities described above. The encouraging thing at the start of 2000 is that everyone seems to have finally woken up to the need to do something. It remains to be seen whether our efforts will be successful in reviving science education in Ireland and ensuring continued economic success, which has made Ireland the envy of the smaller and less-developed countries, for whom the Celtic Tiger is both an inspiration and an aspiration.

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