

Making
the
best
of
third-level
science



ROYAL IRISH ACADEMY
Discussion Document

Foreword

In February 2009 representatives from Irish universities, institutes of technology, industry and other relevant bodies were invited to participate in a discussion on how Irish higher-education institutions have accommodated the recent increase in science undergraduate numbers; moreover the adverse (or otherwise) impact of this increase on the quality of undergraduate science education was discussed. The meeting comprised six short presentations followed by a panel discussion and open forum.

This discussion document provides a summary of the main issues, challenges and opportunities facing third-level science education in Ireland at the present, which were identified in the course of the meeting and in subsequent written contributions. These include concerns regarding 'mission drift' and grade inflation within the university sector; renewed emphasis on the importance of a quality teaching and learning experience for undergraduates; and the imperative of maintaining the highest possible standard of degrees, a point stressed particularly by industry.

The Academy trusts that the concerns expressed and suggestions offered herein will inform and contribute to policy discussion and implementation in support of Ireland's goal of becoming a world leader among the 'knowledge' economies of the future. The report is timely in that the National Strategy for Higher Education Group, appointed by the Minister for Education and Science to oversee the latest review of Irish higher education and formulate a new national strategy for the sector, has but recently commenced its deliberations.

Finally, the Academy extends its gratitude to those many colleagues who kindly gave of their time to participate in this important forum discussion. Particular thanks are due to Professor Rory More O'Ferrall for suggesting this meeting and for his unremitting support throughout the process, including his major contribution to the drafting of this document.

Professor Peter Mitchell
Science Secretary
Royal Irish Academy

Introduction

Higher education in Ireland has long played a significant role in underpinning government policies to promote economic growth. In the past ten years measures to enhance the supply of graduates in science, mathematics and engineering have encouraged universities to increase substantially the number of undergraduate places in science. This increase has gone hand in hand with a wider policy promoting greater access to higher education. At a time of uncertainty in the economy, it is pertinent to enquire how this increase has affected the quality of undergraduate education, especially in the sciences. A particular challenge for Ireland is to combine in a cost-effective manner increased participation with a demanding educational environment for its brighter students.

In February 2009 a committee chaired by the Royal Irish Academy's Science Secretary arranged a meeting of institutions responsible for higher education to consider these issues under the rubric 'Making the best of third level science'. Seventy senior representatives of universities, institutes of technology, industry and other bodies, including the Higher Education Authority; Department of Education and Science; Irish Universities Quality Board; Higher Education Training and Awards Council; and the Irish Universities Association, attended the meeting. Six short talks were presented followed by a panel discussion and open forum conducted under the Chatham House Rule. This report draws on these presentations and discussions, as well as written submissions following the meeting, to consider how successfully Irish higher-education institutions have accommodated the growth in undergraduate numbers in science.

Perspective

A meeting on undergraduate education in science was prompted partly by lectures to the Academy in 2007/08 by Professor Joseph Ritzen (President of the University of Maastricht) and Professor James Slevin (President of the Royal Irish Academy, 2005–08). These considered respectively, the expansion of higher education in a wider European context and the response to a comparable expansion in the United States.

Since the late 1970s policies to promote greater access to higher education have been widely pursued across Europe. These led to an expansion of third-level institutions, with some negative consequences, which at first were not generally recognised. The expansion occurred gradually and encountered little opposition; however, it led to increased class sizes with students of widely varying abilities being taught in an environment geared to high academic standards. A resulting erosion of educational standards was partly concealed by 'grade inflation' and, in the UK and Ireland, by loss of the distinction between honours and general degrees, which made good degrees easier to achieve. Governments, preoccupied with increasing access to higher education as a social goal, were less focused on quality. Even students seemed reasonably satisfied, perhaps because attendance at lectures was seen to be optional and opportunities for employment within an expanding economy were plentiful.

An essential element in accommodating wide access to third level emphasized by both Ritzen and Slevin is the differentiation of higher-education institutions to cope more effectively with differences in levels of academic preparation, likely career paths and requirements for supervision of students. An example of such differentiation is provided by the Californian

higher-education system, which evolved in response to demands for mass higher education in the United States following the Second World War. In California, the upper 12.5% of high-school graduates is eligible to attend the University of California (7 campuses), the top 33% is eligible to attend the California State University (23 campuses) and other qualified students are eligible to attend community colleges (>100 campuses). Mobility between institutions is impressively high and the system has gone far towards achieving its declared aim of 'access for all but fostering excellence'.

Trends in higher education in Ireland

Ireland's higher-education sector includes a number of institutions differing in 'mission and focus'. It comprises 7 universities, 14 institutes of technology, and more than 200 post-Leaving Certificate colleges. The comparatively large number of institutions reflects the significant growth in participation rates in higher education in the past twenty years. At present, 50–55% of 17–18 year olds enter higher education, substantially more than the European average. The government is committed to further widening access and the National Skills Strategy specifies a target of 72% participation by 2020.

Since the introduction of Ireland's first National Development Plan in 2000 the increase in the number of students at undergraduate level has been paralleled by significant increases in public funding for scientific research and postgraduate education. Nearly €2 billion has been invested through Science Foundation Ireland (SFI) and the Programme for Research in Third-Level Institutions (PRTL). In comparison, the funding base for third-level education remains relatively low. Growth in student numbers has meant that resources per student have declined in recent years. OECD data show spending per student in third-level education at approximately \$10,500 per annum in Ireland compared with an OECD average of \$11,500 and, for example, \$13,500 in the UK and \$24,000 in the United States.

Undergraduate education in science

The expansion in the number of science students in Ireland has mirrored that of third level as a whole. Indeed, it has been complemented by the government's provision of additional places in science. Full-time undergraduate enrolments in science increased from 7,900 in 1999 to 10,610 in 2007. In 2007 full-time undergraduate science courses accounted for 13% of total enrolments with universities accounting for 60% of these. At the same time, the entry point requirements for a typical university science course have fallen (see UCD case study, opposite page).

Significantly, this expansion has led to the enrolment of a cohort of school-leavers whose levels of preparation and attainment are less than those of students who entered universities and institutes of technology in the early 1990s. The increase in undergraduate science places combined with the removal of university fees in 1995 and the loss of financial support from the European Social Fund for students at institutes of technology has led to greater competition among universities and institutes of technology for science students. Thus, offered a choice, school-leavers have increasingly opted for a level-8 course at a university in preference to a level-6 or 7 course at an institute of technology. As a consequence universities are now recruiting a body of science students who hitherto would typically have entered third level through an institute of technology.



A case study of first-year science at UCD

The entry level and performance of students within first-year courses is critical to the overall quality and standard of science at third level. A consequence of the increasing proportion of school-leavers entering science in UCD has been a decline in entry standards since the 1990s. Shown below are the 2006 CAO points of students entering third level. Particularly noteworthy is the minimum entry requirement of 300 points, which corresponds to recruitment from the top 55% of students passing the Leaving Certificate. In comparison, the minimum entry requirement in 1998 was 420 points, which, according to Childs' analysis of 'points inflation', corresponds to approximately 460 points in 2006.

480	Top 15% of Leaving-Certificate students (with 480 or more CAO points)
450	Average points obtained by students entering UCD
420	Average points obtained by science students entering UCD
300	Minimum points required for science students entering UCD

The lowering of entry requirements is also apparent in student performance in mathematics. In 2007 only 23% of students entering first-year science had a B3 or higher grade in higher-level Leaving Certificate mathematics, reflecting a decline from 40% in 1999.

The first-year science class at UCD now comprises 450 or more students, nearly double the number of twenty years ago. Unfavourable consequences of such large numbers include the following:

- Difficulty in addressing the wide range of abilities within the class;
- High failure rates mitigated in part by lowering of standards;
- Branding of science as a subject with a low points requirement;
- A culture of non-attendance at lectures;
- Constrained lecture accommodation;
- A lack of qualified science students and unfilled places in institutes of technology;
- Negative effects on morale of teaching staff and educational experience of students.

The generally poor quality of undergraduate laboratories and increasing prioritisation of research over teaching underlines the impracticality of attempting to combine remedial teaching with aspirations for excellence in university science courses. The drop in standards and poor attendance at science classes contrast with the position in medicine.

(More O'Ferrall, 2009)

The intake of inadequately qualified science students has been characterised as 'mission drift' on the part of the universities. A contributory factor is the allocation of government funding between institutions based on numbers of students without regard to educational performance. In so far as the national budget for higher education has not increased in proportion to numbers of students, this has led to increased competition between institutions for the available funding, and thus enrolment of students. The situation is exacerbated within universities by a division of funding between disciplines, which is normally also based on numbers of students.

In summary, key issues for undergraduate courses in science include:

- Increase in places available;
- Fall in entry point requirements;
- Evidence of erosion in quality of degrees;
- Poor preparation and widely varying ability of students.

Institutes of technology and mission differentiation in higher education

Over the past 30 years institutes of technology have made an increasing contribution to Irish higher education in science and technology. In the past decade, however, a competition has arisen between institutes of technology and universities for enrolment of science students which suggests a need for further consideration of the relationship between these institutions. It seems clear that a significant fraction of students performing poorly in science courses in universities would benefit from the smaller class sizes and individual attention of undergraduate science teaching in the institutes of technology. The point was made that a student should only be accepted for a course from which there was a reasonable expectation that he or she would graduate. In this context it was suggested that the universities and institutes of technology should agree, with the HEA, strategic objectives for each institution.

If a strict analogy with the University of California system was observed, only the top 12.5% of passing Leaving-Certificate candidates would be accepted at university, with the implication that students with less than 480 points would enter an institute of technology. A distinction between institutions based solely on points at entry, however, is clearly simplistic. Important differences in mission exist including a greater emphasis on research in universities, and on professional courses and collaboration with industry in institutes of technology. The importance of recognising such differences was raised in connection with the perception of students submitting applications through the CAO. As they enter third level, students should be assisted, perhaps in some cases with the help of an interview, in making informed choices relevant to their preferred career.

Quality of science degrees: views from industry and government

The quality of Irish university education has been an important factor in attracting foreign investment in science-based industries and commercial enterprises to Ireland. There are signs, however, that the poorer educational preparation of an increasing proportion of recent graduates is beginning to attract adverse attention. So far, declining standards have been partly masked by inflation of CAO points and a strategic decision by universities in the beginning of this century to increase the proportion of first-class and upper second-class degrees awarded in line with prevailing norms in the UK. In this regard, it is noteworthy that a fall in standards has not been highlighted by quality assurance reviews. This may be because the reviews have been geared to addressing procedures and 'good practice' in academic programmes rather than the consequences of changes in the numbers and range of abilities of entering students.

There is clearly a degree of inconsistency between falling entry-level requirements and grade inflation in undergraduate science courses on the one hand, and government commitments to strongly supporting postgraduate education and research on the other. Postgraduate education depends on the availability of well-qualified graduates. The 2009 National Competitiveness Council report recognises this explicitly noting that, 'The quality of undergraduate teaching is an important determinant of the quality of researchers at fourth level and skill levels of the labour force more generally'. In practice, the recent increase in postgraduate numbers has been sustained partly by an influx of overseas students and postdoctoral fellows. While this has greatly benefited fourth-level research in Ireland, it is noteworthy that now more than 50% of SFI-funded PhD students are from overseas.

The expectations of industry and government in relation to quality of graduates can be articulated as answers to the question 'What education do we need for Ireland to be successful as a nation?' In practice, industry favours an education with a strong science base, which provides graduates of high quality, some of whom possess cross-disciplinary expertise, such as a science subject and a language. Rigour and flexibility are deemed more important than subject area. The requirement for flexibility is implied by the need for more than a good education in science and technology. Important keys to maximising economic benefit of a higher education include a focus on commercialisation, an ability to manage distribution of commercial products and the capacity to deal effectively with intellectual property issues. The position of the government differs little from that of industry, which sees the supply of highly qualified science graduates as integral to securing national competitiveness. *Building Ireland's smart economy* (2008), which outlines government policy with respect to economic renewal, identifies an ambitious group of actions with respect to education, research, innovation and commercialisation, which is seen as key to achieving economic growth.

Interface with schools

The influence of educational preparation in schools on the performance of science undergraduates was addressed less fully at the meeting than the topic merits. Shortcomings with respect to the attainment of Leaving-Certificate students, particularly in mathematics, were acknowledged. Universities and institutes of technology are increasingly using outreach activities to promote science as a career. Such efforts are undermined, however, by perceptions of the low level of points required for entry into general science courses. The low levels of points not only attract students insufficiently prepared to undertake such courses but deter students who could and should. Unfavourable popular images of science and a lack of clear perceptions of career paths for scientists are further deterrents to pursuing an education in science. To counteract these negative perceptions, greater exposure of transition-year students to imaginative presentations of science should be encouraged.

The professional development of science teachers was also discussed. Among the problems which require redress was a lack of professional support for teachers with biology degrees teaching physical science subjects at Junior-Certificate level. It is also significant that 60% of school-leavers undertaking honours-level mathematics do not take a science or engineering subject at third level. A further obvious priority is the need to encourage greater take-up of higher-level mathematics at Leaving Certificate, particularly among female students. This in turn has implications for schools in the context of appointing suitably qualified mathematics teachers.

Opportunities

Despite difficulties there are opportunities for improving science at third level.

- A downturn in the economy is commonly associated with an increased uptake of science subjects.
- Commerce-based subjects now offer less attractive alternatives to a career in science.
- Introduction of graduate and interview-based entries into medicine are also likely to increase interest in science degrees.
- There is still considerable potential for recruitment of women into science careers through suitable actions in schools.
- There are a growing number of outreach and national activities, e.g. Science Week, actively promoting science to schools and the wider public.
- The quality of third-level science at universities and institutes of technology is likely to be a priority for the National Strategy for Higher Education.

Conclusions

Two principal conclusions emerged from the meeting. The first was an uncompromising message expressed by representatives of commerce and industry. 'Large numbers of poorly qualified university graduates will not assist in Ireland's economic development; a "dumbing down" of standards, especially in science and engineering, would be disastrous for the country'. The implication of these strictures is clear: while not compromising support for academically weaker students, priority must be given to providing the highest educational standards for students who will most benefit from them.

The second conclusion highlights the unfavourable distribution of science students between universities and institutes of technology. Competition for resources within a funding model in which core institutional grants are based on numbers of students has contributed to the over-expansion of universities' undergraduate numbers in science and a decline in the uptake of places by qualified students in institutes of technology.

A resolution of these problems may be made easier in the context of pending government initiatives likely to lead to substantial changes in undergraduate structures. One such initiative is the reintroduction of undergraduate fees, which is made probable by the present financial constraints on the sector and the economy. It was noted that if fees were introduced their confinement to the universities would restore an advantage enjoyed by institutes of technology before 1995 and encourage a greater uptake of places by qualified school-leavers. A second is the development of a national strategy for higher education, which is expected to address the institutional mix in the higher-education system, analyse demands made on the system and review the current use of resources.

Potential ways forward

A number of suggestions and proposals are summarised here. Several linked proposals relate to the distribution of science students between the universities and institutes of technology. Additional suggestions mainly concern first-year science courses.

1. **UNIVERSITY ENTRANCE.** A clear proposal is that the universities should substantially reduce their intake of science students. This objective would be achieved by restriction of entries to level-8 courses (especially in universities) with a consequent promotion of level-6/7 courses.

2. **PROMOTION OF LEVEL-6/7 COURSES.** The low preference of students for level-6/7 courses arises largely from the current availability of level-8 courses. The preference could be improved by a guarantee of transfer to a level-8 course on reaching a recognised standard. This currently applies in the 'add-on' facility operating in institutes of technology. That transfer could be to a university as well as within an institute.

3. **COORDINATION OF ENROLMENTS.** A straightforward proposal is that the top 20% of students would be offered a level-8 course in a university or institute of technology and that the next 20% would be offered a level-6 place at an institute of technology, with a university as a transfer option. Borderline cases could be subject to interviews, which would assist students in making an informed choice between institutions.

4. **FUNDING AND TRANSFERS.** An important obstacle to restricting numbers of first-year students at universities is that funding is based on numbers of students and a smaller enrolment would imply a loss of core grant to the institution. In amelioration, this loss would be reduced by a higher student retention rate (in an improved educational environment) and by confinement to science courses. In principle, an appropriate transfer system would allow addition of suitably qualified students after the first year. Transfer of students from universities to institutes of technology should also be facilitated.

5. **INSTITUTES OF TECHNOLOGY AND UNIVERSITIES.** It was considered important to address concerns that the institutes of technology might become feeder colleges for universities. It seems unlikely that this would happen on a significant scale where an internal transfer from a level-6/7 to a level-8 course is available. A further opportunity for transfer then exists following graduation and transfer to a postgraduate degree. In principle, competition between universities and institutes of technology in providing quality undergraduate teaching is desirable.

6. **UNIVERSITY FEES.** Although outside the remit of the meeting, it was suggested that were fees for third-level institutions to be reintroduced there would be a benefit in applying them only to universities, or at least differentiating in favour of institutes of technology. This might help redress the current imbalance in numbers in first-year science classes between universities and institutes.

7. **OVERSIGHT OF NEW COURSES.** The perception that there are too many student places available in science may imply a need for a national oversight of new courses offered.

Proposals for first science courses

At the meeting, emphasis was placed on the importance of first-year science courses and a number of suggestions related to these were presented.

- NUIG places a priority on first-year science courses. This includes streaming students with and without Leaving-Certificate physics separately. It has a major advantage in that it reduces class sizes.
- A significant suggestion was that part of any funding raised by fees be applied to improving (a) science facilities in schools and (b) first-year laboratories in universities and institutes of technology, which provide the interface with schools. This was recommended in the 2002 report of the Task Force on the Physical Sciences. The value of an excellent experience for first-year students at university or institute of technology being passed back to the schools was pointed out.
- The desirability of sustaining two foundation years in which a final commitment to specialisation was deferred so that students uncertain of their preference could transfer easily between subjects.

The purpose of the meeting on which this paper is based was to raise and clarify issues deserving further consideration. Thus less attention was given to implementation of proposals, which would need to be addressed at a later stage. It can, however, be reiterated that within the limited field of science there should be scope for inter-institutional cooperation and initiatives, which may be less easily undertaken by institutions as a whole.

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Tuesday
3 February 2009
Royal Irish Academy
19 Dawson Street
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TIME

SPEAKER

TITLE

2.00	Professor David Fegan _____ Senior Vice-President, Royal Irish Academy	Welcome & opening remarks
2.05	Dr Jimmy Devins, TD Minister for Science, Technology & Innovation	
2.15	Professor Jim Slevin _____ Director, ICHEC	In pursuit of excellence in changing times
2.35	Professor Rory More O'Ferrall _____ School of Chemistry & Chemical Biology, UCD	A case study of first science
2.55	Mr John Herlihy _____ Vice President, Online Sales & Operations, Google	An industry perspective
3.15	Professor Patrick Fitzpatrick _____ Head of College of Science, UCC	The science education challenge for universities
3.35	Professor Brian Norton _____ President, Dublin Institute of Technology	Informed choice and relevant programmes

Making the best of third-level science

3.55	Coffee Break	
4.20	Mr Tom Boland _____ CEO, Higher Education Authority	A perspective from the Higher Education Authority
4.40	PANEL DISCUSSION AND OPEN FORUM Chair: Professor Jim Browne President, NUIG Mr Kevin McCarthy Assistant Secretary, Dept of Education & Science Dr Teresa Lee Quality Enhancement Manager, IUQB Dr Pat Morgan Dean of Graduate Studies, NUIG Dr Philip Nolan, Registrar, UCD	
5.55	Professor Peter Mitchell _____ Science Secretary, Royal Irish Academy	Closing remarks
6.00	RECEPTION	

Participants list

Áine Allen	Institute of Technology Tallaght
Paul Barry	Waterford Institute of Technology
John Behan	Institute of Technology Tallaght
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