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SCIENCE TEACHING IN IRISH SCHOOLS 1860-1970

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The history of the teaching of science subjects in Irish schools is traced from 1860 onwards in terms of major institutional and organisational changes which affected it Public bodies and their actions are the focus of attention This provides a context in which to view current reforms of curricula and teaching methods in science subjects

THE BEGINNINGS OF SCIENCE TEACHING

Prior to the Relief Acts of 1782 and 1792, the Catholic population of Ireland had no access to organized secondary education, while the various Protestant grammar schools in existence did not teach science at all (16) During the period 1783 to 1870, forty-seven Catholic intermediate schools or colleges were founded and one of these, St Kieran s College, Kilkenny (founded in 1783) became the first Irish secondary school to have a connection with the South Kensington Department of Science and Art when students of the college sat for the Department's examination for the first time in 1874 (1) This Department had been established by the British Government in 1853 to foster technical training, after the Great Exhibition of 1851 caused public attention to be drawn to the fact that Britain was falling behind other countries in her rate of industrial progress The Department encouraged the teaching of science in schools through a system of payment by results under which teachers in schools recognized by the Department received a fixed sum of money for each pass secured by their pupils in the Department's examinations The system was criticised because it led to cramming, but it did foster science teaching in Irish schools to the extent that in 1879, one quarter of the total monies distributed by the Department went to 251 schools in Ireland (25)

This support was largely restricted to national schools and was brought to a halt by changes in the rules governing the system of payment by results According to evidence given to the Intermediate Education (Ireland) Commission of 1899, the rapid progress of technical schools run by local authorities in England led the Department to turn its attention to the secondary schools and the middle classes there For this reason, examination standards were considerably increased, thus 'cutting off the night schools and the national (primary) schools (25, p 367) The amount spent in Britain continued to increase because of increased secondary

school participation, but this did not happen in Ireland because all secondary schools were by this stage working towards the examinations of the Intermediate Education Board (set up in 1878) and teachers found 'they could not interfere with their intermediate work to earn a small grant from the Department of Science and Art (25, p 368)' As a result, 'the large grant which continued to be given in England to secondary school or middle class pupils for science education had no equivalent in Ireland the industrial classes (national school pupils) had been cut off and left stranded (25, p 368)'

In fact, some secondary schools continued to combine study for both the examinations of the Intermediate Board and the Department of Science and Art, but the former examinations did take priority Secondary schools were established in 1878 as a means of promoting intermediate education in Ireland, they operated on the basis of a 'payment by results' system not dissimilar to that of the Department of Science and Art Under the system annual public examinations served the dual purpose of differentiating between students and determining the amount of the results fees paid to the various schools the pass of each pupil 'represented a definite sum of money earned by him for the manager of his school (25, p 14)', and these sums of money were the sole income received by schools from the state Subjects for examination were grouped into seven divisions, of which the natural sciences formed one and candidates could not present themselves for examination in less than two divisions The examinations were first held in 1879 in three grades—junior, middle and senior, and 3,954 candidates presented themselves, of these, approximately one-quarter were examined in either physics or chemistry (19) Botany and physiology formed a third science subject for which only girls presented themselves from 1881 onwards (21) The total numbers presenting for examination in the three grades rose to 5,561 in 1880 (20), and fluctuated between 5,000 and 6,000 until 1885 when the numbers began to increase, growing to nearly 9,000 in 1896 and 11,000 in 1907 This number remained roughly constant up to 1924, when the newly independent Irish government revised the educational system

The numbers taking natural science increased rapidly during the first five years of the Intermediate Board s existence, until in 1890 approximately two-thirds of the candidates were examined in either physics or chemistry However, the examiners do not appear to have been happy with the standard of answering, and in the Board's report of 1882—the first in which examiners' reports were incorporated—the examiner in natural philosophy (physics) comments 'candidates have been prepared solely by reading books without, in the great majority of cases, having had any

opportunity of becoming practically acquainted with even the most elementary experiments' (junior grade), and again 'many of the candidates in both grades (middle and senior) had clearly never seen experiments performed, and had simply committed portions of the textbook to memory (21, p 41)' Thus dissatisfaction on the examiners' part was reflected by a failure rate of 48 per cent in the junior grade, for which the great majority of candidates had presented themselves (21)

The examiners continued to comment unfavourably on the teaching of science in succeeding years Thus in 1886—a year in which over 55 per cent of junior grade candidates took physics—the examiner in that subject, Professor W R Barrett, commented that 'the majority of the candidates displayed a mere book acquaintance with physics (22, p 23)', and in the following year, the same examiner tells us that 'the absence of any real living acquaintance with the things examined is conspicuous in the large majority of candidates in the middle and junior grades' (23, p 25)' This tendency for book-learning to predominate was undoubtedly strengthened by the Intermediate Board's practice of setting alongside the examination syllabuses the numbers of chapters in named textbooks—Ganot's *Natural philosophy* for physics and Roscoe's *Lessons in Elementary chemistry* for chemistry—during the years 1878 to 1886

From 1887 until 1901, the numbers of students taking science subjects steadily declined, probably as a result of the continued low pass rate and consequent low payments for these subjects (25) In spite of the decline in numbers, the quality of answering showed little improvement In 1896, when the percentage of junior grade students taking physics had fallen to 30 per cent, the examiner in physics commented that 'the teaching of elementary mechanics is too much a matter of getting up work from books (24, p 66)' His colleague in chemistry confirms this 'in the majority of cases, it is evident that the candidates know nothing of chemical science they have wasted their time committing portions of chemical books to memory (24, p 67)' The study of botany in the schools draws similar strictures from the examiner in that subject 'the answers seem to indicate that although the students have a good knowledge of the words of some textbooks of botany, their acquaintance with the subject is in most cases superficial They appear to be without practical experience of the objects and processes of which they have mastered the description with commendable accuracy (24, p 72)'

THE PROVISION OF EQUIPMENT

The first step towards remedying these defects in science teaching came in 1898 when the Intermediate Board, by a unanimous resolution, pointed

out to the Lord Lieutenant that there were many grave defects in the Intermediate system with which they were powerless to deal under the existing statutes As a result, the Board was appointed as a commission of inquiry into the system and its practical working The commission sat in 1899 and submitted its report in the same year the tenor of the recommendations made regarding the examination system in general was that a capitation grant based both on 'average results' and on inspection be given to individual schools in place of payment on individual results, these recommendations were not, in fact, put fully into effect until 1924

The recommendations specifically relating to science were

> that the Board should satisfy itself that, in schools where Natural and Experimental Science are taught, proper equipment and appliances have been provided and used for teaching these sciences practically,

and secondly,

> that the Board should be empowered to advance money to managers of schools upon approved security, to enable them to provide proper equipment and appliances for the teaching of practical science (25, p 24)

The practical implementation of these recommendations was secured by the establishment in 1900 of the Department of Agriculture and Technical Instruction The Act establishing the Department also transferred the administration of the science grants handled by the South Kensington Department of Science and Art and the new Department quickly took the initiative in developing science teaching in Irish schools, issuing its programme for the administration and distribution of grants for experimental science in secondary day schools early in 1901 Consultations between the Department and the Intermediate Board led to the Board deciding to adopt the Department s programme in science and drawing from 1902 onwards the separate subjects of physics (natural philosophy), chemistry and drawing in the Intermediate programme were replaced by one combined subject entitled Experimental Science and Drawing and the Board decided to accept the inspection and examination of that subject by the Department

The immediate effect of the Department's activity was a marked increase both in the provision of laboratory facilities and in the number of pupils studying science Thus, during the period 1900 to 1904, the number of

schools possessing laboratories increased from 6 to 214 for a capital outlay of approximately £50,000 while the number of boys taking science grew from less than one thousand in 1900 to 6,300 in 1908 (5) Assessment of the nature of the science teaching is hampered by the cessation of the Intermediate Board's practice of publishing examiners' reports in the various subjects, and from 1902 (to the present day) comment on science teaching in the schools is found only in summary form in official reports

The first detailed comments on the system of science teaching set up by the Department are found in the Report of Dale and Stephens (5), in 1905, in which certain defects are noted the principal of these were the lack of organic connection between scientific subjects and the general curriculum, and the possibility of excessive emphasis on science studies at the expense of literature studies in consequence of the double subsidy the former received However, the general tendency of the new system in encouraging practical work was approved The main obstacles in the way of achieving a fully satisfactory system of science teaching were, as in Britain, the lack of fully equipped laboratories and the small supply of trained teachers As we have seen, the fitting out of laboratories was greatly facilitated by the Department's system of grants, and the teacher supply situation was eased by the institution of summer courses for teachers thus, 107 teachers had completed a 5-year teaching course in 1906 (13, pp 86-90) These developments continued apace, so that in the Department's 15th Annual General Report in 1915 we read

> The great majority of boys schools take either or both of Physics and Chemistry, Botany, Physiology and Hygiene (these last two forming a combined subject) are confined to girls' schools The summer courses for teachers have had a most valuable influence on the teaching As a result, generally speaking, the teaching of Experimental Science in Secondary Schools in Ireland has attained a high standard (7, p 86)

The 1916 Report states that 'the quality of the work done is very satisfactory and appears fully to justify the methods used since 1901 (8, p 72)'

At this stage the school managers requested that changes be made in the system on the grounds that they wished to see a greater uniformity of standard in the schools generally after a four years' course in science, and also to enable them to classify their pupils in accordance with the grades of the Intermediate Board's programme (11) Previous to this the Department of Agriculture and Technical Instruction had 'insisted on science being taught under favourable conditions and made the assessment of

the work done depend, not upon written examination, but primarily upon the satisfactory attendance and progress of the pupil as tested by inspection (5, p 28) ' This 'system under which every student (was) forced to familiarise himself with the procedure of investigation by experiment (5, p 29) was now modified to include written tests administered as part of the grade examinations of the Intermediate Board The change had immediate effects, as can be seen from the 1920 report

> There has been a considerable increase in the number of pupils enrolled for Physics and Natural Science however, the number attending Preparatory grade classes has decreased, probably because under the revised regulations of the Department and of the Intermediate Education Board, Experimental Science is no longer obligatory in this grade In Experimental Science the standard of teaching unfortunately seems to show a tendency to decline The teaching in habits of close observation, and the development of originality in devising and skill in fitting up apparatus does not now appear to receive as much attention as heretofore This lowering of the standard of teaching is considered to be mainly attributable to the detrimental effect on the Practical Work in science of the requirement of a written test in that subject for the purpose of passing the Intermediate Board's examinations (10, p 91)

This complaint is repeated in subsequent reports up to 1924, when the Department s 22nd and final report (dealing with 1921-22) was presented to the newly formed Oireachtas of the Irish Free State In this report we read

> The difficulties in the teaching of Experimental Science consequent on the changes of 1917 are not diminished as time goes on—the laboratory work on the whole has deteriorated more time is spent on theory, not from any belief in the value of the change, but simply because a high percentage of passes is of such importance to the School (12, p 71)

SCIENCE TEACHING IN THE NEW STATE

The administration of the educational services for the area of Saorstat Eireann had been taken over by the Provisional Government in February 1922, and the new government's Department of Education took over the function of the Intermediate Education Board in 1923 Following this,

the 'results system was replaced by a capitation grant to schools as recommended by the Commission of 1899, and a new programme for secondary schools came into operation in August 1924 This replaced the three grade examinations of the Intermediate Board by the two certificate examinations still in existence the Intermediate Certificate, intended to testify to the completion of a well-balanced course of general education for pupils leaving school at about the age of 16, and the Leaving Certificate which was to testify to the completion of a good secondary education and to the fitness of the student for further studies (16)

Under the regulations of the Department of Education (first issued in 1924), the course leading to the Intermediate Certificate was to be of three or four years duration, and the student was required to pass in five subjects, of which either Science or Latin or Greek or History and Geography had to be the fifth In the first year, 1,079 of 1,841 boys studying the Intermediate Course took science, but only 196 girls out of 1,062 did so The number of boys taking a science subject in the Leaving Certificate Course was 479 out of a total enrolment of 750 in this course, while no girls took a science subject at this level (14)

The inspection of instruction in science in secondary schools was carried out, at least during the years 1925 to 1927, by the inspectors of the Technical Instruction Branch of the Department of Education, however, no report on the actual quality of the science teaching was published, so from this time on, departmental regulations and syllabuses issued for science subjects are the main available sources of information on what was taught and on the method of teaching

In 1924 the Department issued detailed syllabuses in the various science subjects (three courses in general science for the Intermediate Certificate and courses in physics, chemistry and botany for the Leaving Certificate) which remained essentially unchanged until 1942

The teaching of science was encouraged by a system of laboratory grants, based both on the number of science classes and the number of pupils per class, which continues to the present Difficulties seem to have occurred in increasing the provision of laboratory facilities, since an early proposal of the Department to make science a compulsory subject by 1929 is omitted from the 1928 report, never to recur in subsequent years The same difficulties led to the introduction of lower courses (which did not entail individual experimental work) in 1934, and of a 'non-experimental science (Syllabus E) in 1942

During this period the number of boys taking science in the Intermediate Course increased to about 50 per cent in 1930, at which level it stayed constant until the late 1940s, when a steady growth to the 1970 level of

87 per cent participation began The number of girls studying science remained relatively low, and their participation rate fluctuated between 15 and 25 per cent during the entire period from 1925 to 1960 Since the Intermediate Course prepares students for the Leaving Course, these participation rates set an upper limit to the number of students studying science at the higher level, within these limits there has been a growth at the Leaving level corresponding to that at the Intermediate level The numbers taking each subject will be examined later, here it is sufficient to state that numbers have gradually increased since 1925, until approximately 40 per cent of boys and nine per cent of girls took some science subject at Leaving Certificate level in 1966 (3)

Information regarding the quality of science teaching from 1925 onwards is difficult to obtain, since department reports consist almost exclusively of examination, attendance and financial statistics However, the lack of new thinking and the absence of outside influences is shown by the fact that department syllabuses in the science subjects remained unaltered from 1925 to 1942 In the latter year, Pass and Honours Leaving Certificate courses in the then existing science subjects (physics, chemistry, botany) were introduced, and a new subject—combined physics and chemistry—inaugurated The new courses involved a revision of the syllabuses but the basic structure was not very much altered Similar treatment was accorded to the major Intermediate science syllabus—Syllabus A—in 1949, but no new concepts were introduced into the topics or in the way in which they were outlined

THE DEMAND FOR CHANGE RECENT DEVELOPMENTS

Some minor additions were made to the Leaving Certificate courses in physics and chemistry in 1954, but these did not affect the basic content of these courses, total revision of these and other science courses did not occur until the 1960s, when a variety of influences combined to produce a demand for change in Irish science teaching These influences were not confined to Ireland An excerpt from a report on the teaching of science in Wales, published in 1964, shows that the state of science teaching in Wales was similar to that in Ireland, it also draws attention to a 'widespread demand for change', which occurred in Europe and the United States at this time

> Scientific discovery and its applications to the problems of everyday life have advanced further and faster in the twentieth century than

> ever before, but the present syllabuses in Science are very much what they were 50 years ago Many of the topics are out of date and unrelated to the world in which pupils now live In an age of space travel and plastics, pupils spend too much time on tedious geometrical optics, specific gravity determination, and the properties of compounds of metals which have little significance for them Some additional material has been added, such as a small amount of atomic structure, valency theory and electronics, and a few topics have been taken out, but such changes have been made without any due consideration of their effects on the formative aspects of science teaching, and on the co-ordination of one subject with another
>
> The current awareness of the defects in school science syllabuses has led to a widespread demand for change The Association for Science Education has taken a welcome initiative in this country and produced new syllabuses Similar efforts are being made in the United States of America and elsewhere (2, p 54)

The origins of the demand for change are varied, but two notable influences can be suggested One was an increasing awareness of the economic importance of science in a modern society and a consequent demand for better training of scientists and technologists And secondly, there was the mental blow sustained by western scientists and policy makers when the USSR unexpectedly became the first nation to launch a satellite into space (Sputnik I) in 1957 Up to this date, scientific superiority over the rest of the world was taken for granted by the English-speaking countries, particularly the United States of America, now the visible evidence of Russia's scientific achievement both confirmed the possibilities of scientific progress and forced re-appraisal of western educational systems Most countries, including Ireland, had long accepted that science was a useful and necessary school subject, now the effectiveness of its teaching was called into question Probably this would have occurred sooner or later, but Sputnik I accelerated the re-evaluation

Whatever the contributing causes, extensive and well-funded programmes of research into the teaching of physics (Physical Sciences Study Curriculum) and chemistry (Chemical Bond Approach and Chemical Education Material Study) were initiated in the United States in 1956, 1958 and 1960, while the Science Masters Association in Britain produced proposals for curriculum reform in 1957, which eventually led to the setting up of the Nuffield Science Teaching Project in 1962 (27)

In the European context, the first organized steps towards a review of science teaching came with seminars on the teaching of school physics

and of school chemistry, organized by the Organization for European Economic Co-operation in 1960 The seminar on the teaching of chemistry was held in Greystones (near Dublin) under the chairmanship of the late Professor T S Wheeler of University College Dublin, and may be taken as marking the definite impact of new ideas concerning school science teaching on Irish educationalists

The basic import of these new ideas as they appear in the Organization for Economic Co-operation and Development (the successor to the Organization for European Economic Co-operation) and Nuffield Project documents is that school science teaching should be directed towards imparting an understanding of the contribution of science to society and of the methods employed by scientists, in other words, pupils are to be taught the *why* and the *how* of science, in addition to and by means of the *what* This is to be accomplished by selecting topics which will necessitate lessening the quantity of information imparted and presenting a unified framework of theory based on experiment, in order to acquaint the pupil with science as a purposeful activity carried out in a certain way (27, 28, 29, 31, 32)

Among the events in Ireland immediately following the Greystones seminar were the establishment in 1960 of a School Scientific Education Trust to enlist the aid of Irish industries in providing funds for the improvement of equipment available for science teaching in Irish secondary schools, and the founding of the Irish Science Teachers Association in January 1961 In addition, a new scheme of capital grants was introduced by the Department of Education to assist schools in providing laboratory facilities and equipment and work commenced on the revision of Leaving Certificate syllabuses in the science subjects (31)

Revised courses in Leaving Certificate physics and in Leaving Certificate chemistry came officially into operation in September 1962 and pupils were first examined on these courses in June 1964 New courses in Leaving Certificate botany and the joint subject physics and chemistry were issued in 1964, while a school television series on physics was the first product of the newly formed Telefis Scoile division of the Irish Television Service in the same year

A new syllabus for Intermediate Certificate Science was produced in September 1967 This Intermediate Certificate course gave cause for revision of the Leaving Certificate courses in physics and chemistry and new courses in these together with a course in biology were issued in the summer of 1969 It is now the stated intention of the Department of Education to continue revision of the certificate science courses on a cyclic basis, and semi-permanent syllabus committees have been

established for this purpose * Other developments during this period included a grant to schools enabling them to attract science graduates into teaching by augmenting their salary† and an increase in the number of summer courses designed to upgrade the skills and knowledge of those already engaged in teaching science

Despite these changes, recent researches on the practice of science teaching in Ireland indicate that the teaching and learning of science is still heavily biased towards 'memorisation' rather than understanding In part of their work on the Leaving Certificate Examination of 1967, Madaus and Macnamara (26) analysed the papers set in the subjects of physics and chemistry The overall conclusion reached was that the ability most heavily stressed in the examinations was 'knowledge' the assessment of students was based mainly on the recall of specific information to the neglect of higher order, more generalised abilities This conclusion is reinforced by a 1971 questionnaire survey of science teachers which indicates that in current practice 'knowledge' is regarded as the main goal of science teaching rather than 'understanding or 'experimental skill' (30)

In the report of the Department of Education for 1960-61 we read

> One of the greatest problems for school managers who wish to expand the teaching of science in their schools is the difficulty of obtaining properly qualified teachers (however), the position is to some extent relieved by the employment of teachers who have successfully completed Department summer courses in various branches of science (15, p 61)

The theme of the shortage of qualified teachers and the necessity for summer courses to supply the deficit recur in all surveys of science teaching In 1961-62, 311 graduates in science provided approximately 64 per cent of the science instruction in secondary schools (4) Since then, the number of science graduates has increased to 447 in 1964-65 and to 551 in 1966-67 † A recent survey indicates that during 1971, 70 per cent of science teachers in secondary schools were science graduates, and 22 per cent had an

*The composition of the Syllabus Committees in science subjects is one representative for each of the following the National University of Ireland, Trinity College, Dublin, the Subject Committee of the Association of Secondary Teachers of Ireland, Irish Science Teachers Association, Vocational Teachers Association, Vocational Education Committees, two representatives each for School Managers and the Department of Education

†This incentive consisted of a grant of £150 payable to any school in which a teacher who had taken science as a degree subject taught science the school used this extra grant to increase the salary of teachers with degrees in science until new salary regulations were issued in 1968, and the grant lapsed (15)

†Personal communication from the Department of Education

honours degree (30) It may be noted in passing that the vocational schools, which have recently begun to prepare students for the Intermediate and Leaving Certificate examinations, state that all their science teachers are qualified graduates (33) This is borne out by the 1971 survey figure of 96 per cent graduate science teachers (30)

The marked increase in the number of science graduates entering teaching from 1963 onwards can be attributed, at least in part, to a rapid growth in the number of students taking science at university level In 1958-59, the total number of undergraduates in Irish universities increased by 700 (a 10 per cent increase on the previous year), while the science faculties increased their share of the student population from 11 6 to 14 1 per cent From this date, the total number of undergraduates has continued to grow at a rate of approximately 10 per cent per annum, resulting in a doubling of the numbers enrolled over the period 1957 to 1967—from 7,052 to 14,897 The relative percentage of those taking science declined in 1970 to its 1957 level of approximately 11 per cent after reaching an all-time high of 15 1 per cent in 1961-62 The net result was a three-fold increase in the number of students graduating in science in these ten years although their proportion in relation to the total number of graduates has declined

The effect of this rapid increase on the supply of science teachers is evident from an examination carried out by the writer of the number of science graduates who studied for the Higher Diploma in Education in University College Dublin from 1949 onwards Since the diploma is an essential prerequisite for registration as a secondary teacher, these figures may be taken as representative of the national trend in recruitment of science teachers into secondary schools During the period 1949 to 1961 in University College Dublin an average of twelve science graduates took the Higher Diploma course each year The number of science graduates in the course rose sharply in 1962-63 to a total of twenty-eight and has continued at this higher level, rising slowly to the 1968-69 figure of forty students The composition of the group of science graduates has changed noticeably in two ways During the period 1949-61, approximately 50 per cent of the group had first-class or second-class honours degrees, this proportion has now fallen to approximately 25 per cent The proportion of the group affiliated to religious bodies has also fallen from a 1949-61 average of 60 per cent to a 1961-70 average of less than 30 per cent[1] These changes can be accounted for by attributing the more than threefold increase in numbers over the period 1949-69 to an influx of lay graduates with general degrees, which in turn reflects the rapid growth in the number of students taking science at university level previously referred to

The increase in the number of science teachers has been accompanied by an increase in the number of pupils in secondary schools In 1962-63, there were 557 secondary schools in Ireland with a total enrolment of 84,916 pupils, by 1971-72, the numbers had increased to 559 and 149,629 respectively * Thus, while the total pupil enrolment increased by 64 per cent, the number of graduate science teachers had grown from 340 to an estimated 700, an increase of approximately 100 per cent The gain in the pupil-science-teacher ratio is reflected by an increase in the proportions of secondary pupils taking science During each of the years 1970, 1971 and 1972, approximately 87 per cent of boys and 28 per cent of girls sat for science in the Intermediate Certificate examination, while the numbers taking science in Leaving Certificate level also increased In the 1972 examination, out of a total of 24,418 candidates, 4,973 (20 5 per cent) took chemistry, 3,199 (13 1 per cent) took physics, 5,406 (22 0 per cent) took biology and 1,318 (5 5 per cent) took combined physics and chemistry * If we assume that the relative proportion of boys and girls taking science does not alter appreciably after the Intermediate Certificate, then approximately three in four of the boys and one in four of the girls sitting for the Leaving Certificate examination in 1972 took at least one science subject

THE FUTURE OF SCIENCE TEACHING

In evaluating the significance of the changes in science teaching two points can be considered First of all, what is the likelihood of all science instruction at senior cycle level being given by science graduates from 1975-76 onwards as is advocated by the Higher Education Authority (18), and what proportion of pupils will be taught science? Secondly, is the present examination system conducive to the attainment of the higher level educational objectives advocated in recent documents (27, 28, 29, 31, 32)?

If we assume that approximately 80 per cent of science instruction is currently provided by the 700 graduates in science, an increase of the order of 200 graduates is required to replace those science teachers who are not science graduates In addition, the projected growth of second-level pupil numbers could be expected to generate a requirement for an additional 20 per cent On this basis, an estimated 1,100 science graduates will be needed in 1975-76 to maintain the present proportion of science instruction The attainment of this number would require an annual intake to teaching of approximately 100 science graduates, which is quite possible in view of the increased output from Irish universities (The number of graduates

*Personal communication from the Department of Education

conferred annually with primary degrees in science by Irish universities is currently in the region of 400)

However, these additions would do nothing to increase the proportion of pupils taking science, particularly in view of the capital expenditure involved in providing laboratory facilities in schools where science is not taught at present This situation could be alleviated to some extent by the sharing of laboratory and teaching facilities between schools Failing this, it is difficult to see how the proportion of pupils taking science at Intermediate and Leaving Certificate levels can rise much above three in four in the case of boys and one in four in the case of girls The latter figure is a matter for concern, in view of the importance currently assigned to the learning of science both as an integral part of a general education and as an essential preparation for many occupations now open to women

Any appraisal of the quality of science teaching over the period surveyed is in effect an appraisal of the examinations used It is clear that pupils are usually taught science in the fashion most likely to gain examination passes, and exhortations on the part of observers have had little or no effect as long as the tests remained unmodified The change from written examinations to practical inspection in 1902 and the reverse change in 1918 demonstrates this clearly, in each case the schools responded quickly and appropriately, even when the latter change was a step backwards The available evidence (26, 30) indicates that the present examination system continues to foster a bias towards memorisation of facts rather than towards practical understanding This is likely to continue until science courses are defined in terms of the aims they are designed to achieve rather than the subject matter they cover, and the examinations are explicitly changed to fit both the aims and the teaching methods used to attain these aims

Further research needs to be done on the amount and development of resources needed to bring about these changes At the individual school level such measures as the provision of technician assistance in school laboratories, the establishment of regional centres for equipment evaluation and demonstration, and an increased availability of inservice refresher courses could have a significant impact On the national level a greater involvement of teachers in syllabus and test construction, allied to the provision of resources for the development of new testing procedures are policy changes worthy of serious consideration

REFERENCES

1 BIRCH, P *St Kieran s College, Kilkenny* Dublin Gill, 1951

2 GREAT BRITAIN Central Advisory Council for Education (Wales) *Report on the teaching of science in Wales* London HMSO, 1964

3 GUINNESS SON & CO , Statistical Department *Science in Irish secondary schools and universities* Dublin Arthur Guinness Son and Co , 1968
4 *Investment in Education* Report of the survey team appointed by the Minister for Education in October 1962 Dublin Stationery Office, 1966
5 IRELAND Board of Education *On intermediate education in Ireland* Report of Messrs S H Dale and T A Stephens, His Majexty s Inspectors of Schools, Board of Education Cmnd 2546 Dublin HMSO, 1905
6 IRELAND Central Statistics Office *Statistical abstract of Ireland 1968* Dublin Stationery Office 1968
7 IRELAND Department of Agriculture and Technical Instruction *15th annual general report* Dublin HMSO, 1915
8 IRELAND Department of Agriculture and Technical Instruction *16th annual general report* Dublin HMSO 1916
9 IRELAND Department of Agriculture and Technical Instruction *18th annual general report* Dublin HMSO, 1918
10 IRELAND Department of Agriculture and Technical Instruction *20th annual general report* Dublin HMSO 1920
11 IRELAND Department of Agriculture and Technical Instruction *21st annual general report* Dublin HMSO, 1921
12 IRELAND Department of Agriculture and Technical Instruction *22nd annual general report* Dublin Stationery Office, 1924
13 IRELAND Department of Agriculture and Technical Instruction *Report of Departmental Committee of Inquiry* Dublin HMSO, 1907
14 IRELAND Department of Education *Annual report* Dublin Stationery Office, 1925
15 IRELAND Department of Education *Annual report* Dublin Stationery Office, 1961
16 IRELAND Department of Education *Report of the Council of Education The curriculum of the secondary school* Dublin Stationery Office, 1962
17 IRELAND Department of Education *Rules and programme for secondary schools*, Dublin Stationery Office, 1964
18 IRELAND Higher Education Authority *Report to the Minister for Education on teacher education* Dublin Stationery Office 1970
19 IRELAND Intermediate Board of Education *Annual report* Dublin HMSO 1879
20 IRELAND Intermediate Board of Education *Annual report* Dublin HMSO 1881
21 IRELAND Intermediate Board of Education *Annual report* Dublin HMSO 1882
22 IRELAND Intermediate Board of Education *Annual report* Dublin HMSO, 1886
23 IRELAND Intermediate Board of Education *Annual report* Dublin HMSO, 1887
24 IRELAND Intermediate Board of Education *Annual report* Dublin HMSO 1896
25 IRELAND Intermediate Education Commission *Report on intermediate education in Ireland* Dublin HMSO, 1899
26 MADAUS, G and MACNAMARA, J *Public Examinations A study of the Irish Leaving Certificate* Dublin Educational Research Centre, 1970
27 *Nuffield biology teachers guide* London Longmans/Penguin Books 1966
28 *Nuffield chemistry handbook for teachers* London Longmans/Penguin Books, 1967
29 *Nuffield physics teachers' guide* London Longmans/Penguin Books, 1966
', O BUACHALLA, S P Determinants of quality in science teaching at second level Paper read to Cork Scientific Council 19th February, 1972
31 ORGANISATION FOR ECONOMIC CO OPERATION AND DEVELOPMENT *School chemistry trends in reform* Geneva OECD 1963
32 ORGANISATION FOR ECONOMIC CO OPERATION AND DEVELOPMENT *New thinking in school science Teaching physics today* Geneva OECD, 1965
33 ORGANISATION FOR ECONOMIC CO OPERATION AND DEVELOPMENT *Reviews of national policies for education Ireland* Paris OECD, 1969