# Science in Primary Schools

## Summary

The revised primary school curriculum introduces a greatly expanded science syllabus into Irish primary education. The Irish Council for Science, Technology and Innovation believes the coming changes can contribute significantly to integrating science into the mainstream of Irish culture. The introduction of the new science syllabus has important implications for the standing and the understanding of science in Ireland and for the education of future graduates in science and of citizens who are better informed about science. Greater confidence in dealing with science and technology is an important condition for technological innovation in the community and the development of an economy capable of maintaining its citizens into the 21st century.

This statement from the Irish Council for Science, Technology and Innovation underlines the need for effective support of primary schools in preparing for the science syllabus and putting it into effect. It stresses the role of the wider community, in particular the scientific community, in supporting the schools in this task.

Among the recommendations from the Irish Council for Science, Technology and Innovation are the following:

- that the Minister for Education and Science ensure that implementation of the new curriculum begins quickly with in-service training of primary teachers from the school year, 1998-99;
- that the science syllabus be given priority attention in training for the new curriculum;
- that the Department of Education and Science draw up an inventory of educational resources to support the science syllabus;
- that the Department of Education and Science provide for the appointment of resource teachers who can support science teaching in schools from the network of Education Centres and other appropriate agencies;
- that a corps of primary schools science specialists be appointed to lead the in-service training of primary teachers;
- that colleges of education and other third-level institutions establish Diploma and Master's courses in Science Education (Primary) and short courses in schools science;
- that science-based industries, professional bodies and third-level colleges prepare posters, leaflets and videos and organise 'open days' in support of primary schools' teaching of science;
- that local colleges and enterprises support primary school science through the offer of presentations to pupils and school visits to their facilities;
- that schools include on their boards of management locally based scientists, engineers or technologists to assist them in the implementation and support of the science syllabus;
- that the Department of Education and Science advise primary schools to be flexible in timetabling science, allowing blocks of time for visits, talks and demonstrations

  and

- that the Department of Education and Science study primary school pupils' current awareness of science as a baseline for measuring the impact of the revised curriculum.

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## Important Changes

The introduction of the revised primary school curriculum has significance not merely for the education system but for Irish society as a whole. The primary school system imparts the knowledge and values which are considered essential in our culture. The content, methods and practice of education at this level can have a determining influence on people's educational development throughout their lives. As knowledge and information come to play an increasingly important role in the economy and in society, and life-long learning becomes a general need, primary schools become more, not less, important.

The introduction of a new science syllabus to the primary schools has important implications for the status of science in Ireland, for public awareness of and access to science and for the education of future science-qualified graduates and science-informed citizens. Greater confidence with science and technology is an important condition for technological innovation in the community. The availability of more people with science training is a prerequisite for the development of an economy capable of maintaining its citizens into the 21st century.

The previous primary school curriculum, introduced in 1971, contained some elements of nature and environment studies. The revised curriculum includes a subject, Social, Environmental and Scientific Education (SESE), which covers a wider range of topics than the natural sciences in SESE: Science. The methods and the content of this syllabus tie in with other parts of the curriculum, principally mathematics, geography and health education. In these and other elements, the primary school curriculum seeks to promote in children an understanding and appreciation of the methods of scientific inquiry. It seeks to develop their capacity to apply the skills of scientific inquiry.

Good educational practice indicates clearly that science education at primary level is not primarily, or to any large extent, about learning the laws, theories and principles of physics, chemistry and biology. Science education at this level aims to develop pupils' curiosity, their capacity for observation, and their analytic and problem-solving skills. These latter skills are also crucially developed through the teaching of mathematics.

The science syllabus stresses the teaching of a systematic approach to observation, investigation, experimentation, analysis and prediction based on the use of materials derived from, and phenomena observed in, the local physical and social environment. It is organised in four strands: Living Things, Materials, Energy and Forces, Environmental Awareness and Care. Study of the applications of science in a familiar context and practical activities are the cornerstones of primary schools science. "Working Scientifically" and "Designing and Making" are continuing threads of the syllabus from infant classes upwards.

*The Irish Council for Science, Technology and Innovation welcomes the introduction of a new science syllabus, which, with effective support and constant review, has the potential to contribute significantly to the integration of science into the mainstream of Irish culture. Primary schools can now contribute more effectively to increasing confidence in dealing with science and technology, including developing curiosity and the skills of methodical inquiry. This will help prepare students for their future responsibilities as citizens and prepare some of them to pursue higher education and careers in science and technology.*

The OECD has stated that "interest in science, technology and mathematics essentially develops at the primary and secondary levels of education.... it is very difficult to fills gaps left in early years". The OECD also states that "neither science nor technology has achieved a recognised and central place in primary schools ... [but] with the recent move in many countries towards adopting a core curriculum and national standards, science teaching has taken on greater emphasis at the primary level".

When a child reaches secondary school in Ireland she or he will already typically have experienced eight years of schooling. By this stage, students will have developed their

attitudes to science and technology. As the continuing decline in the numbers of students taking science subjects in the Leaving Certificate indicates, many young people feel indifferent towards science or believe it is beyond their understanding. Yet there is also a very general belief in the positive benefits to be derived from applying science and technology. This contradiction has serious consequences for a society in which many central public policy issues revolve around scientific and technological developments and for an economy which requires a continuing supply of people with advanced training in science and technology.

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## Challenge for the Whole Community

A major challenge faces all those involved in the Irish primary school system in bringing the new curriculum into effect. This is not a task for the teachers alone. As one of the new elements in the curriculum, science may appear to present particular difficulties to teachers, pupils and parents.

*The Irish Council for Science, Technology and Innovation is committed to helping the partners in primary school education to integrate science and technology effectively in the curriculum. It believes this challenge should be taken up by government and by the community at large, in particular by the scientific community - professional bodies of scientists and technologists, research institutions, third-level colleges and universities and science-based enterprises. All of these can help ensure that Irish society derives the full benefit from this important change in our educational system.*

The scale of the change facing primary schools cannot be over-stated. The total primary school curriculum, incorporating eleven syllabi, some of these encompassing several subjects, has been revised. For each subject there are over 100 pages of documentation. All 21,000 primary school teachers are required to be familiar with the whole curriculum. There must be a severe risk of teachers being overloaded - unless the planning and implementation are handled carefully and coherently.

Already, there have been delays in completing the revision of the curriculum. The then Secretary of the Department of Education said in May 1994 that the new primary school programme was intended for implementation from September 1995. Now there are warnings that the implementation may not be ready to begin in autumn 1998. It is vitally important that a coherent plan is put in place for the implementation of that curriculum. It must be a matter of concern that, at the time of writing (May 1998), no such plan appears to exist, though the recruitment of a national co-ordinator for support of the curriculum is under way.

It will take several years for the full curriculum to become effective throughout the country's primary schools. Thus, it will be well into the new century before the first students emerge from the primary school system who will have followed the revised curriculum from start to finish.

ICSTI looks to the Minister for Education and Science to give new impetus and urgency to the implementation of the revised primary school curriculum. The minister should put in place immediately the procedures and resources for retraining primary teachers so that this process can begin in the school year 1998-99.

In planning the implementation of the curriculum, the minister will have to consider whether and how its introduction should be phased. It will not be possible to introduce the full curriculum at all levels in all schools at one time. Several options for phasing arise - to introduce the curriculum at different levels (e.g. infants, first and second classes, etc) over several years, to bring in different elements at different times on a regional basis, or to introduce subjects individually or in groups of linked subjects. Regional phasing would allow specialist curriculum trainers responsible for preparing primary teachers to follow their subject(s) around the country. This would have the further advantage of allowing syllabi to be piloted.

*ICSTI recommends that the science syllabus be given priority attention both in respect of the effort given to preparing primary teachers and in respect of the timetable for the curriculum's implementation. It takes nothing from the importance of other elements of the curriculum to state that this subject deserves particular consideration because of its novelty and because of its relationship to current and expected social and economic developments. It should be a key part of the primary school curriculum implementation plan that Social, Environmental and Scientific Education is in place, along with the most closely linked subjects, at all levels, and in all parts of the country, at the earliest possible date.*

## Practical Approaches

The preparation of primary school teachers for teaching the revised curriculum should be geared towards eliminating any apprehension about tackling unfamiliar material and towards generating enthusiasm for the subject, which the teachers will, in turn, convey to the pupils. In the report referred to earlier, the OECD states that many primary teachers feel "poorly equipped" to teach science and technology but that when these subjects were incorporated into a national curriculum and "teachers received considerable in-service work and resource development, they rapidly came to view science teaching in a much more favourable light".

This latter point is supported by evidence from Australia, which, since 1989, has been promoting science and technology in the primary school curriculum. Reporting in 1997, the Australian Science, Technology and Engineering Council underlined "low teacher confidence" as the first point of concern. On that basis, ASTEC recommended a review of pre-service and in-service education for teachers.

The new Irish primary school science syllabus outlines a practical approach, which, in common with much else in the revised curriculum, stresses the process of discovery. It also allows teachers to take advantage of the very considerable international experience in demonstrating scientific processes and principles through experiments with everyday materials. Teachers can, further, take advantage of the vast range of educational resources - books, videos, television programmes, interactive software packages, CD-ROM reference works, WorldWide Web sites, and much more - which have been developed internationally to support science education.

Some of these products may need to be adapted to Irish circumstances. This task should be taken up by software publishers and re-publishers in association with practising teachers. Book publishers can be expected to take the opportunities to prepare books in support of the syllabus but it is important that the delivery of the science syllabus does not become excessively dependent on textbooks.

There is a role here too for the wider scientific community, in supporting the teaching of science in primary schools by preparing, or supporting the preparation of, educational packs on particular topics. ICSTI urges science-based industries, professional bodies and third-level colleges to prepare posters, leaflets and videos and to organise 'open days' to let pupils meet scientists and see them at work.

There are many examples internationally of this kind of initiative, such as the publication by two British research councils and an industry association of leaflets, posters and work sheets on life sciences for primary school pupils. Further such projects include the staging of Public Science Days in Philadelphia's junior schools on the occasion of the 150th anniversary meeting of the American Association for the Advancement of Science in that city and visits of science demonstrators to schools in Leeds during the British Association meeting there.

The Irish Council for Science, Technology and Innovation is committed to easing the transition to the revised science syllabus by promoting awareness in the scientific community and in science-based industry of the coming changes. The Council urges the leaders of the scientific community to study the primary school science syllabus with a view to identifying those areas where they could contribute to meeting associated resource needs.

ICSTI is aware that many research institutions, professional bodies and high-technology-based companies already undertake initiatives to promote science awareness among school children. The Council believes that, in order to reduce the risk of unnecessary duplication, these efforts should be co-ordinated at national or regional level. ICSTI will commence this work by commissioning a survey of science and technology resources for schools. Business interests and the social partners should consider initiating an industry-for-education body which could act as a clearinghouse for projects supporting primary school science and technology and as a

channel for individual enterprises to contribute financially to such projects, where they cannot or do not wish to carry them out themselves.

*ICSTI recommends that the Department of Education and Science draw up an inventory of relevant educational resources to support the science syllabus. The Council recommends that the National Centre for Technology in Education (NCTE) be asked to research the application of computer-based teaching resources to teaching primary science and that preparations for implementing the science syllabus should be closely linked to the Schools IT 2000 programme in which the NCTE, with others, is centrally involved.*

## In-Service Training

Sufficient time must be made available, in the implementation phase, for teachers to learn about the syllabus, about the support resources available and how to use them. At least one week of training per year will need to be given, over the several years of implementation, to ensure that teachers are comfortable with the curriculum. Those who have worked on the development of the science syllabus should be charged with, in the first instance, training a corps of specialist trainers who would, in turn, take responsibility for preparing the larger teacher body. New lecturers in schools science should be appointed to the universities and selected institutes of technology, with responsibility for overseeing a regionally distributed primary science teacher training programme over the next three years.

The same kind of special effort being made to train teachers in the use of information technology, as part of the Schools IT 2000 initiative, should be made in the implementation of the science syllabus in primary schools. The 21,000 primary teachers should each be given an intensive course aimed at showing them how to do impressive science simply, to excite pupils' curiosity and to develop analytical thinking.

There will be a continuing need for material and moral support beyond the implementation phase. The network of 27 Education Centres has an important role to play in this. The 'magnet schools' model being applied by the Irish National Teachers' Organisation and Telecom Eireann in the Schools IT 2000 programme, whereby designated schools are identified as offering examples of good practice, should also be adopted in the delivery of the science syllabus.

*ICSTI recommends that the Department of Education and Science appoint resource teachers, with a particular knowledge of the science syllabus, who can operate from the Education Centres in supporting science teaching in schools. ICSTI notes with concern that many of the Education Centres are severely under-resourced. The Department of Education and Science should fund them to a level which would allow them to purchase equipment and educational materials (e.g. videos, software) which could be made available to the schools in their catchment areas.*

The Australian Science, Technology and Engineering Council has recommended that science and technology teacher 'co-ordinators' be available for about one day a week in schools of appropriate size throughout the school year to assist other primary school teachers in teaching science and technology. Among the duties outlined for the co-ordinators are formal and informal assistance to teachers, networking with other schools, keeping up to date with available resources, encouraging participation by community members and community-based organisations in schools' programmes and encouraging parental involvement in science and technology education. In Ireland, 'lead' teachers of this kind could play a vital role in larger schools, or clusters of schools, in supporting and stimulating their colleagues in teaching the science syllabus.

There will be a continuing need in the longer term for primary teachers to develop their skills and knowledge in the teaching of science. The planning should begin immediately on strengthening the science elements in established teacher training courses.

*The Department of Education and Science should make it clear that the Education Technology Investment Fund is available to colleges of education for the upgrading of their science teaching equipment. But, more important still, the Department should sanction additional science lecturer posts in the colleges of education. In view of the demands of the revised curriculum in general, and the science syllabus in particular, consideration should be given to extending the teacher training courses to four years, thus bringing them into line with the norm for primary degree courses. Science graduates should be specifically targeted as candidates for the shorter conversion courses by means of which graduates are trained to become primary school teachers.*

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The Department of Education and Science should provide immediately for an increase in the total number of places on conversion courses and on standard teacher training courses. The demographic projections which have influenced the reduction in the number of those places appear in need of revision. There is, in any case, a continuing need to reduce the pupil-teacher ratio.

For those teachers already in the system, there is a need for new courses which would allow them to enhance their competence in science. ICSTI urges colleges of education, institutes of technology and universities to establish short courses in science for schools and part-time and full-time Diploma and Master's courses in Science Education (Primary). Primary teachers have long shown a willingness to engage in such professional development. It is the responsibility of the Department of Education and Science to strengthen and, where necessary, create incentives for them to continue to do so.

The Department must, further, ensure that sufficient replacement teachers are available to minimise disruption in schools during the necessary retraining of teachers in the revised curriculum. This could be achieved through an extension throughout the country of the area-based panels of supply teachers.

## Networks of Support

The Teacher Guidelines for the primary school science syllabus refer specifically to the involvement of parents in delivering the curriculum, for example, by "helping to identify and understand natural environments in the locality that might form part of the programme"; sharing knowledge and expertise; helping to organise visits to places of interest; working with small groups of children. The Guidelines stress the need for consultation in planning for science teaching and suggest that a written policy statement on the individual school's policy for science should be drawn up as part of the school plan.

*ICSTI recommends that school policy statements should present an open and positive disposition towards science and towards collaboration with science-based institutions and enterprises in the school's local area or region. Local colleges and enterprises should give moral and material support, through the offer of presentations to pupils and school visits to their facilities. The schools should seek to include on their boards of management locally based scientists, engineers or technologists to assist in the implementation and support of the science syllabus.*

The total, notional allocation of time to the full SESE syllabus in the new curriculum is three hours a week, of which one may be devoted to science. This seems modest: England and Denmark have doubled their time allocation to science from higher bases. Israel has developed a new subject, Science in a Technological Society, for which the recommended time is two hours per week in the lowest grades, ranging up to four hours per week in the final two grades. But the allocation of time to science in the revised Irish primary school curriculum must be seen in the context of the linked elements of scientific observation and inquiry in other syllabi, such as geography and Social, Personal and Health Education (SPHE). It will be important that a balance is maintained between these linked elements and between the strands of the SESE: Science syllabus itself.

As with any such formal documents, the science syllabus and the curriculum as a whole are open to being interpreted and implemented with different emphases. The time allocation leaves considerable discretion to individual schools. This is already evidenced by the current offering of science in some primary schools and by other schools' initiatives in organising 'science festivals' or 'science days'.

*ICSTI recommends that the Department of Education and Science advise primary schools to approach the timetabling of science flexibly, allowing blocks of time for visits to places of scientific interest or for presentations to pupils of lectures or demonstrations. The Department must ensure that schools have the resources to arrange such events and that schools do not always have to fall back on pupils and parents to fund them.*

The ScienceWorks Roadshow, which has been visiting primary schools, has revealed a strong interest among pupils and teachers in demonstrations of scientific experimentation using everyday materials. The Roadshow's short experience points clearly to the value of this kind of interactive display. Even with limited exposure, the Roadshow faces enough demand for their school visits to sustain several teams. The Department of Education and Science should provide resources for the extension or replication of the ScienceWorks Roadshow or similar initiatives throughout the country.

A network of science centres around the country would be an invaluable support for the teaching of science in schools, at all levels, and for the promotion of greater public awareness of, and access to, science and technology. In a forthcoming statement from the Irish Council for Science, Technology and Innovation the role of science centres will be examined.

## Conclusion

It will be important to assess the impact of the revised primary school curriculum. To ensure that the science syllabus, along with all other elements of the curriculum, are effectively implemented, the primary schools inspectorate of the Department of Education will require additional staff and new training for the existing staff. Inspectors should see their role as that of adviser and promoter of good practice.

*ICSTI recommends that the Department of Education and Science study primary school pupils' awareness of, and attitudes towards, science and technology. The initial study should be conducted during 1998-99, as a baseline for a further study five years after implementation of the new curriculum and additional to studies currently conducted.*

Ireland has been relatively late in recognising the need for science education to be included in the core primary school curriculum. This gives it the advantage of being able to learn both positive and negative lessons from the experience of others. The Department of Education needs to assure both primary teachers and the scientific and technological community that it has learned those lessons and that it has a coherent programme to guarantee the success of the science syllabus as part of the revised curriculum.

It is only on the basis of a partnership between teachers, parents and the wider community that this important change in the life of the primary schools and of the general culture will be effected in a manner to deliver the possible benefits. The Irish Council for Science, Technology and Innovation undertakes to play its part in seeking to build that partnership.

## Appendix

### Science in the Draft Primary School Curriculum

The revised curriculum (draft) for primary schools comprises six subject areas. These are Language (English and Gaeilge), Mathematics, SESE or Social, Environmental and Scientific Education (i.e. History, Geography and Science), PE or Physical Education, Arts Education (i.e. Drama, Music and Visual Arts) and SPHE or Social, Physical and Health Education. The curriculum documentation will include an overarching statement; a curriculum statement in each subject; teacher guidelines for each subject; support booklets (for (i) information and communications technologies and (ii) language across the curriculum); parental guidelines and special education documents.

The defining features of the curriculum include a focus on learning, on an integrated approach and on skills development. The aim is to achieve flexibility within a clear framework. Assessment is an important part of the new curriculum, as is the cross-curricular use of information and communications technologies.

The SESE curriculum has been prepared by the Curriculum Committee for Social, Environmental and Scientific Education established by the National Council for Curriculum and Assessment (NCCA), whose membership included representatives of teachers' associations, school managers, the management of colleges of education, parents' organisations, university teachers and the Department of Education and Science.

Within SESE, science education involves the development of conceptual and procedural understanding. This is achieved through the acquisition of scientific knowledge and understanding and the experience of working scientifically. The aims of science education, as stated by the NCCA, are:

- to develop knowledge and understanding of scientific and technological concepts through the exploration of human, natural and physical aspects of the environment;
- to develop a scientific approach to problem-solving which emphasises understanding and constructive thinking;
- to encourage the child to explore, develop and apply scientific ideas and concepts through designing and making;
- to help the child to appreciate the contribution of science and technology to society;
- to foster the child's natural curiosity, so encouraging independent enquiry and creative action;
- to cultivate an appreciation and respect for the diversity of living and non-living things, their interdependencies and interactions;
- to encourage the child to behave responsibly and to protect, improve and cherish the environment, to become involved in the identification, discussion, resolution and avoidance of environmental problems and so promote sustainable development and
- to enable the child to communicate ideas, present work and report findings using a variety of media.

Environment is defined as denoting the surroundings or external conditions with which an individual (person or other living organism) or community interacts. Natural environments include the earth's physical features, flora and fauna. Human environments encompass not only built environments but also social environments (e.g. patterns of behaviour, political and economic systems) and cultural environments (e.g. artistic, religious, ethnic, scientific, technological and recreational).

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The science subject is divided into skills to be developed and strands of knowledge to be gained for each of four groups: infants, 1st/2nd class, 3rd/4th class and 5th/6th class. The approach is described as spiral, by which is meant that each class adds to the knowledge and experience which it has gained in the past, although not necessarily with every strand being taught in every class. This applies to other subject areas also.

Skills development is divided into "working scientifically" and "designing and making". Working scientifically involves questioning, observing, predicting, investigating and experimenting, estimating and measuring, analysing and recording and communicating. For infant classes, analysing means sorting/classifying while for 5th/6th class it includes recognising patterns and interpreting. Designing and making involves exploring, planning, making and evaluating. In the development of skills, it is the level at which the activities take place which differs for each class group.

The four strands of the science course are:

1. *Living things,* which breaks down into myself and plants and animals;
2. *Energy and forces,* which covers light, sound, heat, magnetism and electricity and forces;
3. *Materials,* i.e. properties and characteristics of materials and materials and change and
4. *Environmental awareness and care,* i.e. caring for myself and my locality.

Throughout the document, the flexibility for schools and teachers in the selection of content is highlighted. It is not expected that a child should have covered every objective of the course but rather that the teacher would select objectives from each strand unit. Throughout the text, links are made to other elements of science, to other subjects within SESE and to non-SESE subjects. For example, environmental awareness and care is a cross-curricuLar area also covered in geography and sound is a topic under science and under music.

The teacher guidelines for science describe it as being concerned with the development of knowledge and understanding of the biological and physical aspects of the word It is acknowledged that, for many teachers, primary science has its roots in nature study and environmental studies. The aim of the guidelines is to help teachers to build on this foundation.

The topics covered in the teacher guidelines are:

- science in the primary curriculum;
- the content of the science curriculum;
- school planning for science;
- classroom planning for science and
- approaches and methodologies.

The guidelines contain many exemplars for teachers and a glossary of terms. The exemplars cover the identification of the problem/topic being investigated, background information, descriptions of relevant experiments, a list of resources required and suggested methods of assessment.