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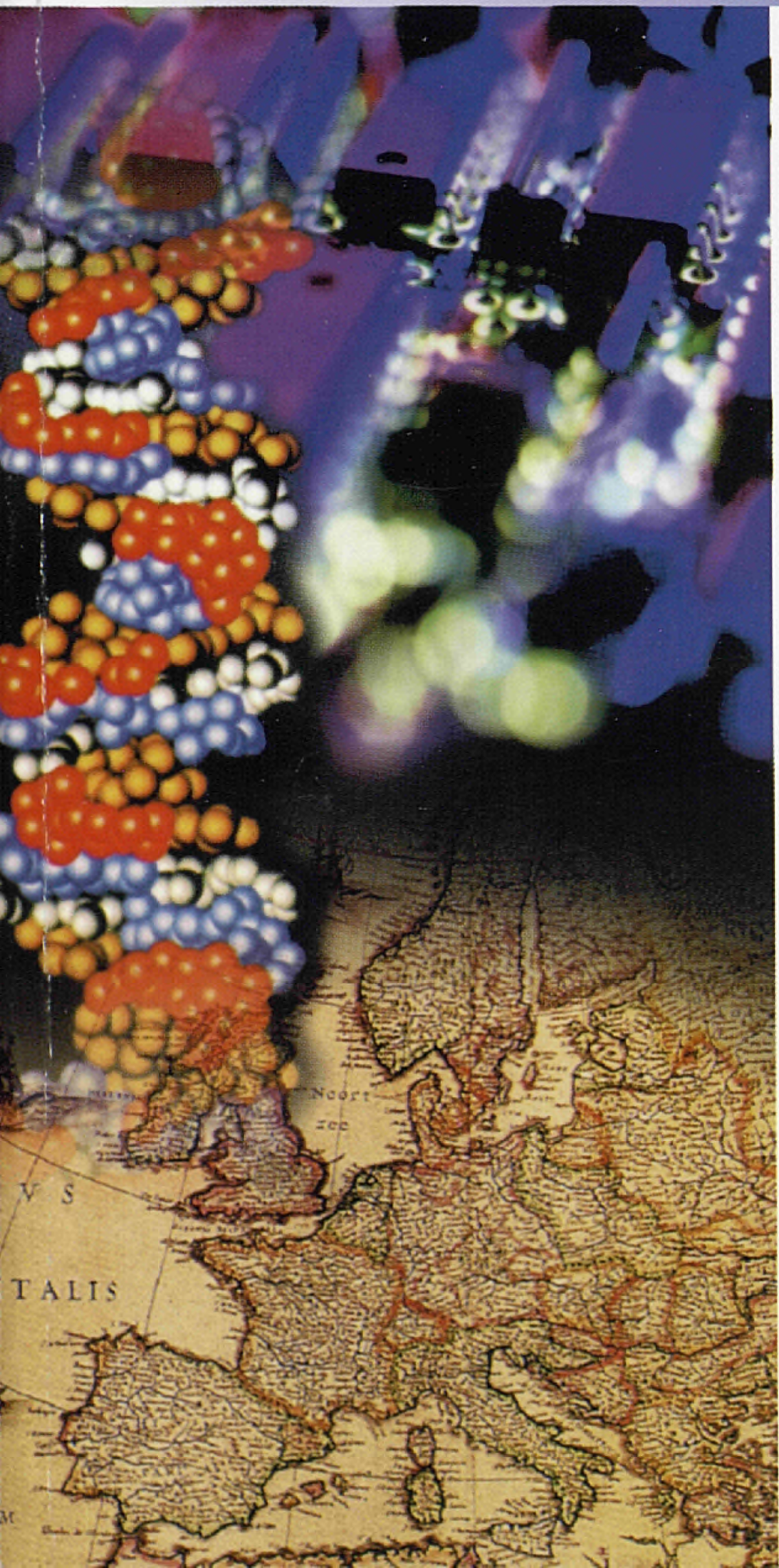

Science in School and the Future of Scientific Culture in Europe

Edited by Joan Solomon
and Jose Mariano Gago

Lisbon 14-15 December 1994

EUROPEAN COMMISSION

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Editor's Note

Joan Solomon

These reports were compiled during the years 1993 and 1994. Considerable care was taken to make them as accurate and up-to-date as possible at the time of writing. However these are changing times in education and every year sees some new departure in the science education programme of all countries. For example the changes brought in, against considerable teacher hostility, in England, have now been not only accepted by teachers (see page 690) but also changed again by the new government. In Portugal an important new programme in science education has been introduced. This is "Ciencia Viva" which aims to increase the amount of practical work carried out in primary and secondary science classes. In France the introduction of the project called "La Main à la Pâte", supported by Georges Charpack, which aims to encourage the teaching of primary science along with suitable experimental work, is similar.

However the report is still valuable for two very important reasons. In the first place it was upon this composite report that the White Paper on Science Education was prepared and written in 1995/6. Secondly, because the report aimed to include descriptions of the forces for change within science education, these innovations were all clearly foreshadowed in the report. Indeed the ways in which science education for the majority of our school students in Europe has moved forward in the last three years is a proof of the validity of some of our discussions and predictions.

Foreword

José Mariano Gago
Minister for Science and Technology of Portugal

When we decided, five years ago, to launch the debate on the future of scientific culture in Europe, and we selected scientific education as the prime sphere of action, we were well aware of how difficult this task would be.

The difficulty was, firstly, one of lack of opposition. The debate surrounding scientific culture revolves, first and foremost, around the conditions of citizenship in the modern world. Thus, it is a political debate and a political struggle. Nonetheless, by its very nature, it is ill-suited to the ephemeral interplay of the politics of choices. Naturally, opinion appears to have been entirely won over. Is it not obvious that basic scientific education, for all, is an essential condition of future employability and, moreover, of citizenship, serving to inform choice and votes? But, without opposition, the prime social protagonists cannot be mobilized. And so, far from gratifying us, this fact, this entirely unanimous support, in effect demonstrates the depth of the problem. Indeed, the fact that scientific education should have as its cornerstone the criteria of the formation of wide-spread scientific culture *is not obvious* , as is apparent from the absence of the banal and lasting consequences that would be its natural sequel: more wide-spread experimentation in teaching of sciences; "live" scientific education from primary school level; systematic educational partnership between basic schooling, research institutions, museums or information dissemination centres.

The difficulty is also one of duration. It is not a matter of an immediate, binary choice that can readily be incorporated into the schematic duration of parliamentary terms, and even less of electoral campaigns, but of in-depth combat, apparently with no adversaries, no goals, no timeframes. Tackling the matter of duration, calls for convictions rooted in stable social practices. For this reason, we need to emphasize the political dimension of this debate which is not, and never was, a problem of choosing between different pedagogical methods or techniques.

And hence the third and last difficulty: the fight for scientific culture can only be stated and brought to notice through denunciation, through a specific attack on what is wrong, not only of the immediate and circumstantial, but also of the structural and pervasive barriers between science and the general population. Nonetheless, it is easy to respond to a denunciation with the demagogy of idealism, with the subliminal inculcation of cultural fatality. Hence, any endeavour to combat the anti-democratic perversity of such stances requires that the concrete denunciation should be juxtaposed with the effective implementation, the concrete proof of the possibility of a more democratic scientific culture, here and now, and not in a postponed future of rosy dawns.

So this is where we are now.

This collective publication, which was made possible by the generosity of the European Commission and of the Calouste Gulbenkian Foundation, is a survey and a reflection. The White paper on Scientific Education in Europe, which was also the product of this activity, was conceived as a manifesto and an appeal for action.

Two Europe-wide lines of action should urgently be constructed, in parallel. On the one hand, reflection and research should be conducted in greater depth, and political sciences and economic and social sciences should be brought together to work on science education and on scientific culture. In addition, concrete programmes of action in Europe should be constructed, bringing real science to the concrete universe of learning opportunities for the majority of young people, particularly in primary education and at other levels of basic schooling. The essential place of experimentation, the twinning between schools and technological and scientific institutions, the use of telecommunications are necessary elements of such collective political action in which we invite you to participate.

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PART I

Science Education in Europe: a comparative view

Joan Solomon

1. Background and Introduction

Some comparative information about the national systems of science education within the countries of Europe will undoubtedly prove useful to the European Union. Organisations such as EURYDICE and CEDEFOP have already produced similar surveys in different fields (e.g. *Structures of the Education and Initial Training systems in the member states of the European Community*. OOPEC Luxembourg 1990). A comparison specific to school science would clearly be a valuable addition to these reports.

However the present study is more ambitious: it sets school science education in the context of the future Europe-wide scientific culture of citizens. Many countries are already using out-of-school resources, such as films and interactive science and technology centres, as well as visits to local science-based industries, in a conscious effort to foster such a general culture. However we believe that the foundations on which the future of scientific culture in Europe is based must be built from the knowledge and attitudes transmitted to pupils in the school classroom. How these attitudes develop depends on several very broad factors:

- the perceived purposes of science education;
- the contents of the National Curriculum for science;
- the national attitude to how school education should be carried out;
- the national attitude towards science as an academic system of thought.

The first of these four items should have set the scene for all our work. However it is impossible for any country to define its ideology so clearly and uniquely that everything else follows from it. Science education serves several purposes including preparation for academic scientific research and training for work in many other fields which may include aspects of science. Our aim in this project was to look at just one specific purpose - that of forming the public scientific culture. At the end of this paper we shall examine how this may interact with other purposes for science education.

The four factors clearly overlap. For example the contents of the national curriculum might be expected to reflect both what national, economic and technological purposes science education is thought to serve by the relevant school educational authorities, as well as the nature of scientific thought as conceived by academic scientists. However national curricula rarely stipulate how science lessons are to be conducted in the schools, and this is clearly crucial to the formation of attitudes towards science. Not only is the conduct of lessons affected by the teachers' perceptions of the nature of science as a system of thought - abstract and mathematical or empirical and technical - it will also depend on educational traditions, such as whether children should be positively encouraged to cooperate in their study, and what is a suitable activity for a school teacher to perform. Even within a country there is often controversy on this issue, such as the well-known thesis of Bourdieu and Passeron (1977), and beyond national boundaries differences are likely to be greater still.

The fourth factor on the list above may seem surprising. Science, much more than literature for example, might have been expected to possess an academic commonality across the different countries in terms of both content and philosophy. At least since the Scientific Renaissance of the sixteenth and seventeenth centuries it has been common to speak about the universal Invisible College to which all scientists belong by virtue of their common field of study. This is the aspect of science referred to by the influential American sociologist of science, Robert Merton (1942), as the norm of 'universality'. However this scientific norm does not necessarily produce complete uniformity. Not only have there been notable and even scandalously chauvinistic controversies within Europe about scientific matters (e.g. the nature of light, or the invention of the calculus) there are other deeper differences. The cultural diversity within European thought may be denser and richer than that in any other comparable continent. First we may find quite general differences which affect broad personal and institutional factors in education such as national and political attitudes towards:

- standardization and uniformity (e.g. France);
- efficiency and market forces (e.g. UK);
- personal autonomy and moral education (e.g. Scandinavia).

In addition there are differences in preferred *regulative principles of thought* which affect all education, and science in particular. These might include:

- humanism;
- rationalism;
- inductive/ heuristic/ empirical approach;
- deductive/ abstract/ mathematical approach.

The evolution of these different streams of European thought is far too vast a subject to treat here (see Durkheim 1977, McClean 1995). Nevertheless, it is impossible to describe the differences in school science education, its purposes or its delivery, without being struck by the effect of these different modes of thought. There can be no doubt that they are an integral part of the national cultures of the member states.

Science is a comparative newcomer to the school curriculum. It has been received in a different spirit in the different countries. In Italy, for example, science education is still fighting for status against the classics, a battle fought and won nearly 40 years ago in some other European countries. As long ago as 1952, C.P. Snow showed how scientific thinking may be respected, and yet ignored by one half of the educated population, so as to form a separate culture. The future of scientific culture in Europe demands that science should be deeply and thoroughly linked into all educated thought. The essay of Jegede (1994) on the effect of scientific education on the indigenous African cultures shows most valuably how hard it may be to create such links between different ways of thinking. Each national report provides data from which this European Report attempts to discern how well science is being integrated into the educational programme of the country's schools and so into the heart of its culture.

Education is becoming more of a political issue. The school budget and resources, which includes computers and laboratory equipment, often figure in political party manifestos. School pupils can 'read' a public view of the perceived importance of science in the organisation of their science education - its funding, its local standing and relevance, and the status accorded to its science teachers. These economic and sociological aspects of science education also have a place in each country's report.

Background to post-graduate collaboration or a basis for scientific culture ?

Other EU projects such as SOCRATES and TEMPUS which encourage collaboration at tertiary level may seem to depend crucially upon a common level of learning in science. In the pre-war period working scientists moved freely about Europe from one university to another and this propagated an image of science in which an invisible college of practitioners transcended national frontiers.

Only the very tiny proportion of any nation's population that become either research scientists or science teachers can resonate to such an image. For the vast majority of people the research perspective may not be personal enough to prove attractive or relevant. In schools where the full range of ability study, the science on offer may need to be much closer to everyday problems and of more general appeal if it is to be interesting and meaningful to students and so be absorbed into the general culture. This implies that our study should report more than just the contents of the national curricula. The fundamental purpose is to explore scientific education as the basis on which the general population understands the nature of science as a system of thought, and builds up its scientific picture of the world. This implies both implicit messages about evidence, attitude and belief, as well as explicit messages about knowledge content.

The nature of science in an educational context is not exactly a school version of the philosophy of science. Rather it is an implicit message conveyed by the comments and attitudes of the teachers (Brickhouse 1993), and the methods by which the students are expected to study (e.g. transmission and dictation, or hypothesis and experiment). A feel for how science education varies in this respect from country to country was conveyed by discussion between the authors of the national reports.

The contents of students' scientific picture of the world will range widely from an understanding and feel for different materials, and enough knowledge of the human body to appreciate some of the new advances in medicine, to an educated sense of wonder about the stars and the universe. In this European Report, as in the reports from each individual country, attempts are also made to highlight those extra-school learning activities (e.g. visits to hands-on or field study centres, the inclusion of technology or the history of science) which might have an important effect on the scientific image of the world received by the school students.

Culture is, as Clifford Geertz remarked in his influential book *The Interpretation of Cultures* (1973), a very complex web of meanings.

Believing with Max Weber, that man is an animal suspended in webs of significance he himself has spun, I take culture to be those webs and the analysis of it, therefore, to be not an experimental science but an interpretative one - in search of meaning. (p. 5)

For our purposes this web has to include the meaning and value of education (e.g. the value placed on pupil autonomy, on standardisation tests, and on new ways of learning) as well as the meaning of science. What is thought to be appropriate to the educational enterprise in one country may not be so in another. The influence of culture will not just operate from the classroom to the general population; popular concerns will also influence classroom practice. This interactive influence is Geertz' all-important 'web' structure of culture linking school science with other school subjects and out-of-school living.

Meaning in this cultural sense, includes attitudes towards science, as well as understanding of the meanings of its concepts and theories. It is to be expected that more and more issues will arise during the life-time of the present school students which will require them to make decisions involving both scientific knowledge and a positive, unfrightened attitude towards science and technology in general (Holton 1992). Hence the future scientific culture of Europe is of fundamental importance to the EU and will depend to a very large extent on the present state of science in its schools.

2. Science in the National Curriculum

The first section in the national reports begins with a survey of the number and duration of science lessons in both the primary and secondary schools.

All EU countries now have a national curriculum which stipulates the science content and recommends the number of lessons in which it is to be taught in its secondary schools. Often it is the minimum number of hours, rather than the total, which is prescribed.

In Germany, Belgium and Switzerland, the whole curriculum is stipulated region by region (Länder or Canton). In the UK the situation is similar with respect to England and Scotland, whereas in Spain the national curriculum is only 40% of what is taught. The rest is determined by the autonomous regions. In France, by contrast, great emphasis is placed on the centrality of 'Le Programme', which is uniform across the whole country.

The Science content of these curricula is very similar whether or not it is integrated or strictly divided into the separate disciplines (physics, chemistry or biology).

The boundaries of science change from country to country. In Portugal Social Science, History and Geography are all included under the heading Science, and in France science and mathematics are taught together in the upper secondary school. While the overall content learnt by students is generally unchanged by variations in these subject boundaries, attitudes towards the nature and meaning of science may well be affected by its broader definition.

No country stipulates exactly how science should be taught although official recommendations are often made. In almost every country these include exhortations to teachers:

- to make this content as relevant to the student's everyday life and concerns as possible; and
- to have their students carry out practical work in the school laboratory.

Practical work occupies a special position in understanding the nature of science. Rather than considering it as a way of teaching science, several countries, such as the Netherlands, identify and teach the separate process concepts. Only the UK also assesses the students' grasp of them by standardised tests at 7, 11 and 14.)

Science has recently become a compulsory subject in primary schools in most European countries, or else is just about to become so.

In most countries (e.g. Sweden, Spain, Denmark, Portugal, Germany, Greece and Poland) an integrated or 'topic' approach is recommended for the teaching of science at primary level. Often the emphasis is now on 'the environment' (Scandinavia) or on 'nature study' (France). A range of arguments and concerns surround this integrated delivery of primary science. This movement began with the regime of 'object-centered' lessons but has now become focused on natural finds and environmental concerns.

It is often argued that the integrated environmental approach is more appropriate for young children, who learn holistically, and gain a better understanding when knowledge is embedded in everyday contexts. It is also thought to be more appealing to the sensitivities of young children and their concerns with animals and plants. It does therefore have clear implications for the formation of attitudes towards science (see section 5).

This integration may mean that it is hard to tell exactly what science content is covered. In countries with a strong humanist tradition in education it may be presented exclusively as personal, moral or social education. There is quite wide concern (e.g. in Spain, Belgium, Ireland and Sweden, Norway) that the physics and chemistry content, in particular, may have been 'integrated away'.

The environmental bias may even encourage the casting of science in the role of the 'environmental villain'. In Italy, the Netherlands, and the UK the science to be taught is listed under headings which are recognisable as chemistry, biology and physics. The option to integrate during teaching, however, still remains. This approach fits very easily into the common primary school practice of having one teacher deliver all the subjects to her or his class. Clearly this practice could be used to build links between science and other subjects and hence enhance the cultural component of science. However, this may also imply the need for substantial retraining of all serving primary teachers.

There is enormous diversity in the teaching of technology and indeed in its very meaning. It is based within the science curriculum at various levels of secondary school in Sweden, Greece, France, Denmark and the Netherlands; in other countries, such as Poland, Spain, Portugal, Belgium and the UK, it is a separate subject in the national curriculum. In Switzerland, Ireland, Denmark and Germany technology does not figure at all in the compulsory school curriculum.

In Sweden there has been a recent move away from technology as applied science so that it now has all three of the meanings below, as a separate curriculum subject.

1) a study of the main industrial means of production (e.g. Italy) with or without a discussion of social effects and civic implications (see section 3);

2) Information Technology and the use of computers;

3) acquisition of workshop skills for the designing and making of technological artefacts (e.g. the Netherlands, Denmark and the UK at junior secondary level).

The use of stories and controversies from the history of science during teaching is mentioned in some advisory documents but rarely at the mandatory level. The exceptions to this are Denmark (in physics at higher levels) and the UK at junior secondary level (although rarely observed in practice).

National curricula are social and political artefacts. Few, if any, are based on educational rather than political ideology (see section 8). Any change thought to have occurred in the public's attitude towards the standard or quality of the nation's science education may be used by the government as a trigger for 'educational reform', 'raising standards' or 'back to basics!'. On these occasions the link between politics and school science stand out very clearly. In some countries such rhetoric drives out science in favour of the basic skills of literacy and numeracy. In others it stimulates the provision of more resources for science education. In yet others the proponents of 'back to basics' seem to begrudge the time needed for experimental work and advocate more lessons devoted to learning about abstract scientific concepts and yet more mathematics.

At least five points from this section may be expected to affect the future of scientific culture in Europe:

1) the perceived relevance of science to everyday life;

2) its relation to technology;

3) early science teaching in primary school;

4) integrating sound physics and chemistry teaching into the topics taught in primary school; and

5) the lack of an historical dimension to the science theories being taught throughout schooling.

The third and fourth points are particularly worthy of note since what primary children learn is often shared with their parents and so has a chance to penetrate otherwise 'unscientific' homes and seed a growth in scientific culture (Solomon 1994).

An historical dimension can not only offer insight into the nature of the scientific process; it also provides stories and 'hero-figures' from the past with whom the pupils can identify. Thus it is able to connect with the broader culture of the nation and its past, and thus also demonstrate aspects of the interaction between science and society with the benefit of hindsight.

In sub-section 1.3 there are some data in each national report on how realistically the specifications of the national curriculum are carried out. These data have not been easy to collect but they are essential not only to the veracity of the picture we are painting, but also as testimony to the hidden conflict which may be waged between schools, government and other interests. It is clear that much more data of reliable quality is required on this point (see section 4).

Although few countries specify exactly how science should be taught, there is always an official view that practical laboratory work should be carried out by the pupils, and that the links between science and society should be illustrated. It may be hard to separate the rhetoric and advice from the actual practice but when a change is genuinely underway, it rarely goes without comment. In the Netherlands (mostly in technology), France and the UK, the role of industry in education has sharply and visibly increased in the last few years, with visits to local firms being strongly encouraged. In Spain the suggested introduction of the optional separate subject 'laboratory work' has been called for by teachers wanting additional time for science. Much of what does happen in the school laboratory depends crucially on the funding of schools, and the availability of time. (It will figure again in section 2.)

In each country some kind of testing exists to monitor students' progress in science. Only in the UK does this include the primary school. Most countries leave the testing of students to the teachers, and recognise nationally only the school leaving examination, which may also serve as a qualification for university entrance. Where regular evaluation of the quality of school science teaching and learning is carried out centrally, a frequent conclusion (e.g. the Netherlands, France, Switzerland, Sweden and Poland) is that the content of the science syllabus at secondary level is too demanding for the generality of students who now all take science. If this results in many of the students leaving school without a pass in science on their certificate, it may have an adverse effect on the general perception of the accessibility of scientific knowledge which could well, in turn, be damaging to the participation of citizens in the discussion of public issues, and the development of a wide scientific culture.

3. The organisation of science education - local or central?

Control of education is a recognised way of affecting the affiliation and national consciousness of the next generation. As mentioned in the last section, sizeable sections within member states press hard for some measure of educational control. Countries such as Belgium, Germany and the UK contain stable and distinct communities who have claimed the right to design their own syllabi. In Spain and parts of the UK (Northern Ireland), the regions have only partial control over their own curricula. Indeed the whole subsidiarity (diversity) debate becomes especially heated when control of education seems to be passing out of the hands of any cultural community, whether large or small.

It is not always easy to discern the real location of power in education. The government will generally pay teachers' salaries and design most, if not all, of the national curriculum. But the day-to-day lessons may vary from region to region, from town to town and from school to school. In Italy, for example, the curriculum is centrally determined, and yet there are very large differences in the educational provision in the rich northern regions and the poorer southern ones. The UK system prior to 1989 had been predominately run by local authorities with different educational policies but a national examination system. Now, going against the EU trend, power has largely been taken over by central government, even though there is devolved management of budgets to the schools themselves.

In many countries (e.g. Norway, Italy and the Netherlands) there are movements underway to decentralise power either to the schools or to a local board. In Greece, Ireland, Spain and Portugal, where the school-leaving age has only recently been raised to 16, control is still exercised centrally, but reform is being discussed. Poland is emerging from a centralised political system and trying to organise a more local structure of control, and Ireland is moving in the same direction. Even French education, once a model of central control, is now allowing schools a little more autonomy in the delivery of the curriculum within their timetable. Sweden and the Netherlands have removed some of the detailed state regulation and transferred it to local authorities and schools. (It is important to note that decentralisation may result in local groups exerting just as much control over the management of schools as central government did before the change.)

Schools have increased in size wherever the populations of towns have grown at the expense of the villages. Large schools inevitably become more powerful units of management. Sometimes they see themselves as representatives of their community, and may designate themselves as centres for community education (e.g. the UK and Sweden). In such cases school laboratories and other scientific resources can act as a vehicle for spreading scientific culture. This will depend on whether they are controlled by the governors of the school, by a local interest, or by the central government.

There are two significant aspects of local control of education:

1) Local influence might provide pupils with a science relevant to local interests.

2) Local control may allow the community to express their evaluation of science education in the most tangible way - through increased resources, parental involvement, and local industrial influence.

This whole process both expresses and formulates scientific culture. What is a part of everybody's business, rather than being left to a remote government bureaucracy, may become a part of everyday significance.

Resources for science education

Not only do increased resources improve science education, which is arguably one of the most expensive subjects in the school budget, and change its nature by providing laboratory work, they also provide students with a covert message about the value accorded to science education by those in power. The adjuncts of science teaching - equipment, laboratories, computer control and interfaces, field work etc. - are now so expensive that there is not one country, from France to Greece, where complaints about the underfunding of science education are not voiced. Indeed, it is a common excuse for not following official recommendations for more laboratory work.

The fairest way to assess a country's funding of education, and the one which most clearly shows the level of a government's commitment to education, is to measure the expenditure on education as a percentage of GNP. Some of these figures are to be found in the Appendix (Table 1). Substantial variation is seen in these data, with the Scandinavian countries figuring near the top of the list. However, the EU will be interested in the effects of such government provision on the experience of individual students, and indeed may see this as an area for action. These more realistic data are presented in Table 2 and clearly depend not only on the absolute wealth (GNP) of a country, but also on the size of its student population (see the report from Ireland), and the age-range of compulsory education.

However, lack of resources may not entirely account for the implementation, or otherwise, of the official recommendations. Actual practice may depend on another power structure - that of the teachers' prestige and judgment. Sweden, for example, has decided that methods of implementing educational policy should remain entirely in the hands of teachers. The most recent version of the UK national curriculum leaves 20% of lesson time free for teacher or school innovation. In Germany and Switzerland the high prestige of science teachers leads to lecture-type lessons and impressive demonstration practicals carried out by the teachers in front of the class, rather than pupil-centered investigations.

When recommendations for new practice come from the science teachers they have the strongest motivation to put them into practice. If the recommendations come from a remote central inspectorate or a university department, the teachers' attitudes are likely to be less favorable. In the terms used in the USA, no curriculum innovation can be 'teacher proof'; it must centrally involve the teachers. Teachers have to put new ideas into action and will need to expend very considerable effort in terms of planning and reorganisation. (It may be instructive, in this context, to note the years of refusal by English school teachers to operate a government system of school tests at age 14 even after several changes to the national curriculum content. This action was eventually withdrawn after simplification and government funding to cover the costs of marking these tests.)

Countries differ in how they train teachers (see section 6) and in how much innovation they expect from them. The UK, Ireland, the Netherlands, Germany and all the Scandinavian countries have active Science Teachers Associations affiliated to ICASE, which are often a rich source of new teaching ideas. Greece and Portugal positively encourage teacher-led projects while other countries, such as Poland, are more likely to keep the reins of innovation in the hands of the university staff. Another pointer to the vigour of the science teaching force as a source for innovation is authorship of school science textbooks. This topic will be considered in conjunction with other aspects of teacher status and morale in section 6 of this report.

4. Going beyond school

This section of the reports is devoted to exploring how far extra-school events influence pupils' learning of science. Apart from organised visits to museums, there was very little contact between school science and the outside world before the 1960s. The growth of school television, and of hands-on science centres affiliated to the ECSITE movement, have been one aspect of the rapid change. Prizes and competitions, like the international Physics, Chemistry and Biology

Olympiads, or industrial prizes, are becoming more common and may exert some influence on school science teaching as well as promoting contact between pupils across the community.

The national reports begin by recording the use of out-of-school resources. Field centres for biological work, which may fit very easily into school work, are one of the best established of these resources. The most recent addition to the list is the hands-on science centres found in almost every European nation. These differ from museums in being interactive so that students can perform quasi-experiments. These centres aim to amuse as well as educate, thus taking another route to bolster scientific culture. Occasional voices have been raised, both in England and Portugal (Trinidad 1993), questioning whether any real learning takes place. Recent research answers in the affirmative. Where they are well established, e.g. France, Denmark and the UK, these centres usually provide a special service for schools. There is evidence that the experiences they provide for students are memorable, and that the science experience they offer can be shared with all the family. In this sense they provide rather direct access to that sub-set of national culture which is the home environment.

At a deeper level, the question of the 'relevance' of science and science education (sometimes in opposition to its supposed 'validity') began to be argued out during the 1970s and 1980s. This debate originated in the Netherlands where the term 'in Society' began to be found in the title of new science syllabi. Out-of-school influences may enter the classroom because the course calls for the discussion of public issues which are science-based, such as preserving the environment or sanctioning biotechnological processes. The prevalence of this varies very much from country to country and follows cultural forces. Where public debate on these issues is encouraged, as in Sweden, Germany, the Netherlands, Denmark and (more recently) Poland, discussion will figure in the school syllabus. Where scientific controversy occurs more rarely, as in France, Ireland and Italy, it hardly figures at all in the schools. In this way it is national culture which drives the science curriculum. It should be added that if discussion of controversies is apparently encouraged, but not included in the national examinations, as in Sweden, the UK and the Netherlands, there will be little incentive to teach it. There is also considerable evidence that teachers may resist its introduction because of the extra time and expertise needed to run properly balanced classroom discussions of science-based issues.

The perception of the role of science and technology as generators of economic power and national wealth may also influence the science curriculum, by introducing work experience, vocational training, or a study of science in industry into the school classroom (e.g. Switzerland and Germany).

Traditions of work-based or school-based training differ markedly between countries. Most countries (e.g. Germany, France, Poland, Greece, the Netherlands and Ireland) provide a vocational alternative to the national curriculum at, or about, 16 years of age. Germany, which has been a leader in this respect, now offers vocational courses to 60% of its school population post-16, and Sweden has just introduced three-year vocational courses into their new upper secondary schools. In many other countries, however, where these courses are optional, they often have little status, attract pupils of lower than average ability, and usually do not include much science. Portugal is an exception in this respect, and Spain seems to be on the point of change. The UK recently introduced a new post-16 vocational science qualification which provides an alternative route into higher education. All vocational study, whether new or old-established, is threatened by the present industrial recession and high levels of unemployment in those industries requiring moderate levels of scientific or technical knowledge. This has led to the breakdown of many industrial apprenticeship schemes, and of other projects that require industry to shoulder some of the cost of technical scientific education.

On the positive side, the increase in vocational education for science-based industry has led to the formulation and teaching of core skills. Where these skills link communication and numeracy to scientific education they too can broaden study in valuable ways (e.g. industrial role-play) which may affect the students' scientific culture.

5. Students' achievement vs. society demands

EC member countries spend between 3% and 8% of their GNP on education (see Table 1) and naturally look to value for their money. 'Payment by results' is a long out-moded slogan in education, and yet the eagerness for testing and assessing students may show that the sentiment is still strong. The motive could simply be quality assurance, and some countries, e.g. Spain and the UK, have been putting forward schemes for better quality control in education.

Eleven out of the twelve member nations of the EU (in 1993) expressed an interest in participating in the Third International Mathematics and Science

Survey (TIMSS) organised by the International Association for the Evaluation of Educational Achievement. The government, school and public reaction to students' scores in government statements and newspaper articles provide interesting evidence for national pride in scientific achievement. Ireland was particularly shocked by a rather poor rating in the last IEA survey of 13 year-olds and deduced that more primary science would improve the situation. In the Netherlands, by contrast, high scores in science were seen by the government as a vindication of their policy. In Germany, France and the UK there is a common perception that 'standards are falling', but little direct evidence supports this verdict in science. In Poland, which achieved high student scores for scientific knowledge, there was some national satisfaction; but note was taken of the lack of practical skills. Finally in Greece, where there is a vocal although not always well-informed public critique of education, the IEA results simply reinforced the view that yet more private 'cramming' schools were needed to supplement the normal run of teaching which takes place in the crowded classrooms of the state schools.

Competition of all kinds touches on national pride, and reactions to success in science education may also demonstrate the public's evaluation of science as a component of the general culture. It still lags a long way behind sport in popularity! The reason for supporting science education, which is put forward in the media and even in government circles, is often the hope for 'wealth creation'. Public reaction to students' scores in this international arena may be based on the belief that the economic health of a country and its ability to compete economically with its neighbours, depends crucially upon the scientific education and training of its workforce. This view of science education, its apparent promise of public wealth and lucrative careers, fuels public concern. In practice, however, data from most European countries show that there is, in general, no shortage of trained scientists, although it is important to note that shortage has been predicted for the years 2010-2020 when many of our present school students will be looking for work. New waves of employment may also make new requirements for scientific knowledge. At present market forces are not pushing up the salaries of research scientists, and so there is no market evidence for believing that such a shortage actually exists.

6. Pupil interest and motivations

The topic is crucial to our estimation of scientific culture. Compulsory education in science achieves little if it leaves students with a lack of interest or even an active distaste for the subject. There have been some large-scale American studies of students' *attitudes* and interest in science which have tried to calculate the correlation between attitude and achievement. The resulting figure has usually been curiously low. The scale used was derived from the usual kind of Likert test where students respond on a scale of 0-5 how much they agree with certain statements. Finding so little correlation between achievement in science, and liking for it, has cast doubt on the validity of the methodology used as much as on the actual link between achievement and liking. More recent work on student motivation has shown that students often give a long-standing interest in science as their reason for choosing it, even when this is coupled with poor self-esteem for learning this subject which is generally perceived as 'difficult'.

In general we can see that both age and gender affect interest in science. There is also some evidence to suggest that practical work, either in the school laboratory or in the field, increases student enjoyment of science. Younger students in primary schools have an active curiosity about the natural world and are often more interested in science than are older ones. In most European countries primary science is set in an environmental context for this very reason. A recent study of pupils' interest in biology conducted in Germany and Poland indicates that it decreases with age for both genders - as indeed does enthusiasm for most other school subjects.

Another factor which may be important is the prominence of mathematics in the science being learnt. Potential employers often use mathematics as a criterion for selection to, for example, 'les Grandes Écoles' (France) or high finance (UK). This practice serves to keep up a level of difficulty in mathematics, and in science, which is not helpful for their public image. The science generally considered to be the most difficult, physics, is also the one involving the highest level of mathematics. It is also the science in which there is most gender differentiation.

The designation of physics as a boy's subject, and biology as a girl's subject is widespread and has been the object of much discussion, especially in feminist circles. However, it is not uniform across Europe. The division scarcely exists at all in Portugal, Spain and most Eastern European countries. It is strongest in Britain, Sweden, Italy and the Netherlands, in the same way as it is in the USA and Australia. Clearly then it is a cultural artefact and one which the EU might do well to consider. (See Table 2.)

One dilemma in this survey is that national reports can only provide numerical data on students' preference for science if there is room for student choice of subject. Where this choice does not exist, the data can only be anecdotal or based on action research. In the latter case the samples used will tend to be small. Preferences by gender are not only illustrated by the statistics provided where the possibility for choice exists, they may even be generated or emphasised by this provision of choice. The national reports should be read in this light since there is evidence from both the British and Australian experiences (Byrne 1994) that the gender preferences actually become more accentuated when students are allowed to choose which science to study or opt out of studying science altogether. In Belgium and the Netherlands selection at about 12 years into different schools may effectively force pupils into 'science or non-science options'. In Belgium there is a minimal science programme in all schools but some have little practical work.

Pupils' perspectives on science have been the subject of research. Some of this derives from children's drawings of 'A Scientist'. The usual cartoon figure of the mad professor is common to most European countries, but must be seen as a caricature drawn in fun, much as a Martian monster might be, rather than as a real portrait. Research suggests that most children think they have never seen a scientist, except their own science teacher or a remote authoritative figure on television.

Interest in a career in science is variable. Most young people do not even recognise the common careers which involve science as an essential preparation, such as hospital technician, or food technician. On the other hand, names like 'doctor', 'engineer' and 'technologist' summon up the image of a stable career with high prestige and rewards, which is particularly appealing to students and their families in less affluent regions. In many countries this produces very strong motivation for learning science, accompanied by intensive coaching programmes in out-of-school hours (e.g. Greece).

It is sometimes feared that serious risks to health associated with, for example, nuclear weapons or genetic manipulation would make science itself unpopular. On the other hand, there are the 'good' aspects of science represented by environmental control through scientific processes and knowledge of ecology which increasingly figure in the school science curriculum. There is evidence for example that German and British school children almost universally approve of the activities of Friends of the Earth. The question whether these environmental movements add lustre to science is unanswered. Renate Bader (1993) has written about the adult public perception of science in Germany in the following terms:

Ecology is not necessarily seen as a science, but as a new holistic approach to all aspects of life and nature. It is precisely those most disenchanted with, and critical of, traditional research and its applications who are drawn towards the 'Greens'. Science for them equals risk; ecology is the saviour. (p. 49)

However, the popularity of environmental biology at school and university level, of natural history programmes on television, and the employment of scientists and scientific pronouncements by Green movements, may cast some doubt on this statement. There is little available evidence about how the role of science in the environmental debate is perceived by young people in the different European countries.

Finally this section should make reference to science in the media with which our students are familiar. Data for this are thin but in Switzerland, the UK and France there is some evidence that good science nature programmes on television are increasing interest in science among both young and old. More information is needed on this subject, leading possibly to an interchange of the most successful science-based television programmes for young people.

7. Training, status and morale of scientific teachers

For the purpose of assessing the image of science among our school students, the status and morale of their teachers is most important. Research has shown that most young children mention their own science teacher first when asked to 'name one scientist alive today'. Hence the status of their teacher is tied to the standing of science itself.

To assess the position of science teachers in any country the following factors need to be taken into account:

- The standing of their scientific and professional qualifications;
- Comparative salaries of teachers, both primary and secondary;
- Supply of teachers, which often relates to recent changes in the birth rate and the school leaving age. Associated with this are regulations as to the pupil/teacher ratio and to the tenure of teaching jobs;

- Teachers' entitlement to continuing education, sabbaticals or secondment for further study;
- Involvement of teachers in educational innovation and reform;
- The strength of the science teachers' associations.

There are two ways in which the science background of teachers may vary across the EU - the academic (science knowledge) and the pedagogic (professional training as a science teacher). While this dichotomy is to be found in the training of many professionals, such as doctors, lawyers and engineers, who need both a degree and a professional qualification, the variation is sometimes greater for teachers, leading to separate university courses in several countries (e.g. Scandinavia and the UK).

In most countries the qualification for teaching at primary level is a degree level course in Education. This is at least partly because of the breadth of general subject knowledge required for primary teaching. This raises the status of primary teachers. Training may take place within the education faculty of a University or at a college for teacher training. The two locations make a substantial difference to the status of teachers but rather less to their practical knowledge of science. Considerable worries about the amount of science, if any, in these courses have been widely expressed and the impression is that the science content may be increasing, but only slowly. The question of whether to teach by topic (see section 1) has bearing on this point. If the integrated topic approach is maintained, all student teachers need a thorough education in science, as well as how to teach it (e.g. pupil investigations, etc.). If the integrated approach were to be abandoned in favour of specialist teaching (a point of debate in the UK) fewer students might need to be trained. However such a decision would imply that at least one specialist science teacher would be installed in every school. This is almost impossible to implement in small rural schools which are common, much prized by the local community, and often reach a better standard than those in the inner cities (Norway). It would also run counter to the aim of linking science to general knowledge, and so spreading scientific culture.

For secondary science teachers the situation is more complicated. In the first place, some countries, such as the Netherlands, Belgium, Denmark and Poland, subdivide this phase of education, with different requirements for lower and higher secondary teachers. Secondly, the degree required may be in either Science, or Science Education. In the latter case the student needs to make a firm career decision before embarking on a degree, or at some mid-point in it

(Belgium). Where there is over-supply of science teachers and a high rate of general unemployment, such as in Germany, it may even be more difficult to gain acceptance on a professional education degree programme (e.g. biology education, or medicine) than on a science one. Thirdly, although several countries (Ireland, UK, and the Netherlands) require one year of post-graduate professional study after taking a science degree, other countries, like France, Italy, Switzerland and Denmark, require none at all for senior secondary school. This lack has implications for the acquisition of professional skills including those for conducting practical classes. Portugal requires two post-graduate years of training before teaching, and Belgium, Poland and Spain favour a Master's degree in one of the science disciplines for those who teach science at the higher levels of secondary school. These matters of qualification all affect the status of the science teacher.

There seems to be approximate comparative parity of salary across Europe: the rewards for secondary science teachers are lower than those for doctors and engineers - even where the number of years of training is similar - and are often pegged to civil service scales. It is important to note that a teaching career often provides an important first step in social mobility and is favoured by women more often than by men. In some countries, such as Greece and Portugal, where primary teachers have to take a course at education college which is of equal duration to the course for secondary teachers, the salary structure of both levels of teachers is the same. In other countries, secondary teachers are better rewarded than their primary colleagues. Salary inevitably effects both the morale and status of all teachers, whether of the sciences or the humanities. There has been some discussion in countries with a shortage of science (principally physics) teachers of paying them larger salaries as an incentive, but it has been resisted by the generality of the teacher force.

Working practices may reflect the mode of training. Those who have come through the education route (e.g. Scandinavia) contribute very fully to the life of the school in a pastoral as well as an academic role. Those who come through the academic route with little or no educational training (e.g. France, Belgium and Italy) may see themselves more as 'lecturers' than as 'teachers', do not supervise leisure or playground activities, provide no pastoral care, nor have any substantial contact with students out of science lessons. Often, as remarked earlier, such high-prestige teachers prefer to demonstrate experiments rather than to supervise students while they attempt to carry out their own. Textbooks written by the two groups also reflect their different backgrounds.

The age-structure of the teaching profession partly reflects its predominantly female membership, and partly population changes (e.g. Ireland and Italy). Women often take to teaching while bringing up their children, and education courses have a higher than average number of mature female entrants. The proportion of women is always greater for the younger aged pupils. While it is easy to see that women might well be more gifted with these younger children, the predominance of men as Headteachers of primary schools, suggests that it is the perceived lower status of primary and early years teaching, rather than any particular skill, which results in the large numbers of women teachers in these classes. The days of disapproval for married teachers are long past: the state provides maternity leave and may even recognise the advantages of the experience which mothers bring to their teaching by stipulating a late age of entry to the profession (e.g. Italy). The only problem with this *'feminisation'* of the teaching force is the lack of confidence displayed by some women for teaching physics, chemistry and technology.

Neither training nor salary are sufficient to account for the status of the science teacher. Three more factors need to be added to the equation. One is the entitlement to time for further study. This is increasing in most European countries, although it has decreased sharply recently in the UK as a result of devolving funding for teacher education to the schools. It has remained level in the Netherlands where the devolution of funding has also taken place. Italy provides for 5 days per year for teacher study, and a sabbatical year is available in Greece for those taking a Ph.D. while teaching. Poland provides the option of taking a Master's degree after three years of teaching and in Spain some sabbatical leave may be given to develop a project which will help the school. Considering the pace of change required in science teaching, the provision for teacher secondment and study seems very inadequate.

The second factor is the strength of science teacher associations. An increasing number of EU countries have local associations which are federated to the International Council of Associations for Science Education (ICASE). In general these associations are stronger than any other comparable subject teaching association and provide, through their local meetings, a measure of in-service education as well as solidarity. However it must be said that, in general, teachers do not have any professional body to compare with those of doctors or lawyers.

Professional teaching qualifications, for example, are set and examined by government officials rather than by any national Teaching Council. A strong case has been made for a Europe-wide General Teaching Council (GTC).

The GTC should be an overarching professional body to determine or advise on the necessary standards for public recognition as a teacher entrusted with helping to educate future generations... and recognise training received in the EC and abroad. (Sayers 1993, p. 139)

Finally, we need to take account of the effects of individual national cultures on the status of the school teacher. The consensus opinion is that this is falling in most countries. In the last century the status of a school teacher, whether of science or any other subject, was high: it is often less so today. In Greece and some other countries the teacher is still very highly regarded by children and their parents in rural communities. However, in the inner cities of many European countries cases of classroom assault on teachers are becoming only too common. This occurrence, and the fear of it, is creating stress amongst the teaching profession which has been the subject of study in several countries (e.g. UK, France, Italy). Pupil discipline is particularly important in the laboratory for simple reasons of safety.

Teaching as a career has advantages such as security of tenure and the length of school holidays which may compensate for increase of stress. Rates of drop-out from teaching depend upon the general level of employment, the comparative salary, the status of teaching, and the stress involved. It varies widely from one country to another. The rate is low in Ireland, Poland and Italy, but higher in France and the UK owing, according to recent reports, to an increase in the work load and violence in the inner city schools.

8. Equality of opportunity?

The different European countries are all striving to provide good quality science regardless of the wealth of the students. The spread in assessment results gives some indication of the success of this effort. In many countries (e.g. Denmark and Greece) text-books for science, as for other school subjects, are provided free to all students. Difference between countries is most marked in the area of laboratory and computer provision.

Differences in average class sizes (from 15 to 35) in the reports appear to be less than might have been expected. This figure may conceal wide variations which are tolerated in some countries but not in others. Class numbers are usually higher in primary than in lower secondary school, with the exception of Spain and Portugal; and the numbers are usually even less in higher secondary classes than in lower secondary. Primary classes of 40 or more are not uncommon in Greece and Ireland, and not unknown even in the UK. These matters strongly affect the possibility of individual attention and thus the standard of school science education received by pupils. Considerations of safety in laboratories also dictate smaller numbers which sometimes leads to the subdivision of classes for practical work (e.g. Poland). Here too we have an area where the EU may well perceive the need for further research and action.

Does equality of opportunity imply identical classroom experience? This question lies at the heart of the separation by ability debate. Some member countries, such as Germany and the Netherlands, still have different schools throughout the compulsory age range which cater for children of high, medium, or low ability and provide different science courses. In other countries, such as France, the divisions between schools are disappearing. While schools may differ in their policies of streaming classes by ability, which does at least provide for internal promotion if a student develops slowly, in Denmark the prohibition of streaming as the antithesis of equality of opportunity, is enshrined in law. Differentiated teaching within the undifferentiated classroom is encouraged by educational authorities in several countries. It is clearly difficult to provide such skilled teaching in any subject, but it may be less so for experimental work in science than for theoretical teaching.

Adaptation to the students' needs in different localities is one approach to equality of opportunity. In Spain and Belgium (also parts of Norway and the UK at primary level) teaching takes place in the regional language. This is to be understood in terms of local culture. Providing alternative topics according to the locality, such as the teaching of 'Rural Science' in place of Biology, is more debatable. While it gives the science taught more relevance, it could also close the doors of opportunity into science-based careers for rural children.

Selection in science may be a serious obstruction to equality of opportunity if it is considered that physics and chemistry, for example, are only suitable for students with high ability in mathematics. Because laboratory provision for these subjects is thought to be expensive, the virtual exclusion of lower ability students from laboratories is comparatively frequent. Selection for different schools is also serious when 'technical' schools have a low status and little science provision of any kind.

The whole idea of parity between schools can be contentious. It is less so in rural communities where one school serves the whole population. In towns there may be a variety of schools within the reach of any one family. Even if the official policy is to try to ensure parity, the reputations of schools will vary. Variation of educational funding, in science as in other subjects, is quite marked on a regional basis (e.g. Denmark, Italy).

The commonest way to get enhanced education is to pay for it. Fee-paying schools are the minority in most EC member countries, but the national reports show that the proportions vary from one country to another. It is also instructive to notice those countries in which the proportion of students attending private fee paying schools is increasing since it is a barometric measure of public confidence in public schooling (e.g. the UK). Science is an expensive subject to teach and only large private schools provide adequate laboratory equipment.

Inner-city schools suffer in other ways than direct poverty of resources. These are the areas where truanting from school is most common, where family units are less likely to include both parents, and books are rare in the homes. Little data is available about science teaching in such areas but work done in Brazil, as well as a small study in Britain, suggests that science is much enjoyed by these deprived children, possibly because it can be more active and less language-dependent than other subjects.

Immigrant and migrant children can only rarely profit from their education to the same extent as other children. If they are integrated into mainstream schools there may be racial tensions. Special provision, where it exists, tends to concentrate exclusively on language acquisition in order to provide the basic skills of speaking, reading and writing. Where this involves removal from science lessons it becomes unfortunate. Not only does it exclude such children from the scientific culture of their new country, it also ignores a valuable medium for observation of nature and language development. In spite of this, many immigrant children turn to science, possibly because of its career opportunities.

Children with special educational needs can be in a similar situation to migrant and immigrant children. Although some countries are trying to integrate those with moderate handicaps into mainstream classes, this is by no means uniform.

Special provision also tends to concentrate on language teaching or on the provision of text-books in Braille for visually impaired children. If the handicaps of such children are physical, it may make any practical work more difficult to carry out, even simple observation of natural phenomena in the field.

Although the numbers of school students included in this last section of the national reports are small and their achievements likely to be modest, they stand as important indicators to the place of science in the national culture. If it is considered an 'extra', or if science is thought to be especially difficult and only accessible to the very gifted, no efforts will be made to introduce it in any form into the reduced curriculum of these less fortunate children. Only if it is well-integrated into the general culture will these minorities be expected, as of right, to learn about it. They are a litmus test of science's cultural acceptance.

9. Conclusion: the purposes of science education

This report is descriptive rather than prescriptive, but draws attention to factors which seem positive and significant for the future of scientific culture in Europe.

- Almost all secondary pupils are now learning a mix of at least the three main science disciplines, without the option to choose or discard any up to the age of 16;
- The use in lessons of science topics which are relevant to student's interests, to daily life and public issues, is increasing;
- Science of some sort is now being taught in most primary schools;
- There are various modes of teaching technology - making artefacts which employ scientific principles, using computers, and linking classroom science with the processes and concerns of industry. All of these seem important for scientific culture;
- Decentralisation of the control of schools is occurring in several countries. This could strengthen the ties between schools and the community, including local industry;
- Schools seemed to be taking more advantage of out-of-school sources of science knowledge which can stimulate enthusiasm and promote links with the families of students;
- In many countries the status of science teachers is improving owing to the provision of opportunities for continuing education, inviting teacher

participation in new curricular initiatives, and supporting science teachers' organisations.

Less happily, some aspects of science education which might have made a significant contribution to popular scientific culture are less frequently found fully implemented in science teaching. These include the following:

- Practical work carried out by the students themselves in ways that would promote better understanding of the nature of scientific knowledge and evidence, is rarely practised;
- There is a shortage of resources for science teaching - including equipment for carrying out practical laboratory-based work, and the ability to keep class sizes small enough for safety during students' experimental work;
- The environmental topics commonly taught in primary schools seldom include sound physics and chemistry teaching;
- Most vocational courses which prepare for science-based work have low status and seldom teach scientific concepts in topical contexts. All students need some appreciation of science-based industry;
- The widely-held perception that science, especially physics, is very difficult to understand, apparently linked with a similar or greater perceived difficulty in mathematics, is discouraging to many pupils;
- There is rarely any historical dimension to science lessons which might make cultural cross-curricular links, and increase pupil motivation.

These problems are not only due to the shortage of financial resources for equipment, laboratories and the training of teachers. They also arise because science education serves several different purposes as mentioned in the first section of this report. These are (a) cultural transmission of knowledge, (b) vocational entitlement, and (c) 'social reconstruction'.

The third of these, the process of restructuring society, is one which every generation of citizens undertakes, almost without knowing it. For this, a wide scientific and technical culture is essential in order for everyone to understand and appreciate new developments and to evaluate them for their own and others' styles of living. This requires linkage with other areas of thought (e.g. history) and more general attitude and sensibility, including morality, and simple enjoyment.

The first objective, cultural transmission, involves ensuring that the whole edifice of scientific knowledge is understood by the next generation of science scholars. It is only through this transmission that our young students could, in the words of Isaac Newton, 'stand on the shoulders of giants' and carry out valuable new research. That process has some requirement for practical work, and an historical dimension, but it also needs a very high level of abstract and mathematical capability which, as we have noted, is difficult and discouraging for the majority of students.

The second objective, vocational preparation in science, is harder to identify with any particular school science requirements. Of course practical work is essential for such students, but so also are core transferable skills which include communication of many kinds, familiarity with information technology, some mathematics and a sound conceptual understanding of science. For these students, as indeed for most citizens, science education should include some familiarity with science in its industrial setting.

Are there conflicts between the requirements for these three purposes for science education? The answer seems to be - surprisingly little. Vocational preparation requires more conceptual science teaching than it has often had, but so also does education for scientific culture. All three purposes require more engagement between the students' ideas and hypotheses and their laboratory activities. All three types of education could benefit from more awareness of industrial science, and more historical links. Only in one respect is there a substantial problem. The challenge seems to be how to teach valid and relevant science in the largely comprehensive schools of Europe without coming up against the barrier of mathematical difficulty. To that challenge this report can offer no solution, except an insistence that scientific culture must embrace all citizens and not remain the preserve of any intellectual or mathematical elite.

A report like this one has a duty to look forward as well as to the present. What is taught in school is, quite simply, the stuff of our future culture, whether it teaches what good literature or music is, or what constitutes a scientific experiment. We add to what we have learnt to appreciate as children, throughout all our adult lives, but often we build upon the foundations of knowledge and attitudes learnt at school.

Europe is rapidly approaching the position where there will be science education of some sort for all children from five or six years of age to nearly sixteen. That is a new situation and means that the scientific component of common culture may be expected to become more salient, even if not more enjoyed. The problems that face those of us who design syllabi and curricula for schools are what science should be taught, or could be taught, and in what ways, so that it may serve for a lifetime as a foundation for building upon. It needs to be an invitation to enjoy science, to participate in its public triumphs and dilemmas, and to look for scientific connections in all that most interests us.

There are also operational aims. One of these is to prepare a future workforce to use scientific concepts, new or old, with understanding, in their employment. Another aim, the one with which we have been centrally concerned in this project, is to construct a scientific culture strong enough for ideas about science, its discoveries and uses, to travel from person to person within homes, schools, villages or towns, and also from country to country, as freely as they did, by all accounts, in the days of Erasmus. Then science would become a genuine part of what unites and defines the different national cultures of the new Europe.

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PART II

Report from Belgium

Jacqueline Hellemans

Introduction

Belgium consists of three 'communities': the Flemish, the French-speaking and the German-speaking community. Since January 1989, each community has, except for a few administrative areas, full autonomy in the area of education.

The areas upon which the Central Government still decides are:

1) compulsory school attendance;

2) the minimum terms for the delivered certificates;

3) the pension of the teachers.

Compulsory school attendance covers a period of twelve years, starting the year the child reaches the age of six and ending the year the child reaches the age of eighteen. It is full-time up to the age of sixteen. Between the ages of 16 to 18 at least part-time school attendance is compulsory.

Education is free of charge for children aged from 2.5 to 18 years.

The educational responsibilities of each community are vested in its own Education Minister (executive power) and the community Council (legislative power by means of Acts). Each community has its own educational system respectively dealing with 57.5 % (the Dutch-language system), 42 % (the French-language system) and 0.5 % (the German-language system) of the total number of pupils in Belgium.

Since the German-speaking community is very small we will not consider it in what follows.

The division of the Belgian Ministry of Education into separate ministries only happened six years ago, so the differences between the school systems of the different communities are small. This will be reflected in the data that will follow. It also implies that it is not necessary to collect all data on one hand for the Flemish community and on the other hand for the Walloon community. It is only recently that differences are showing.

In Belgium education is organized by three different networks:

1)"Community Education" (CE) is the education organized by the communities. The community schools consist of former state schools.

In Flanders, ARGO (Autonome Raad voor het Gemeenschapsonderwijs) is the network that organises the community education. In Wallony, it is the French community (CF) that organizes the community education.

2)"Subsidized Private Education" (PE) is the education organised by a private person or a private body. It includes denominational, mostly Catholic education, as well as Protestant, Jewish etc. schools, and non-denominational education, Steiner schools, Freinet schools,...

The organisation that provides education in Flanders for the largest group and that has the largest number of schools is the VVKSO (Vlaams Verbond Katholiek Secondair Onderwijs) which includes almost all Catholic schools. In Wallony catholic schools are grouped in the FESeC (Fédération de l'Education Secondaire Catholique).

3)"Subsidized Official Education" (PLE) includes Provincial Education, organised by the Provincial Authorities, and Local Education, organised by the Local Authorities (cities, municipalities).

Data on the educational networks are given in table 1.

Table 1: % of pupils in the different networks

Flanders 1991-1992 (regular)

	CE	PE	PLE	Others
Nursery +primary	13,3	66,3	20,4	
Secondary	16,5	74,9	8,6	
Higher + university	23,8	67,3	8,5	0,4

Wallony 1992-1993 (regular)

	CE	PE	PLE
Nursery +primary	10,3	43,5	46,2
Secondary	26,6	55,3	18,0
Higher + university	23,6	6,7	15,7

The educational system is divided into:

1) Elementary education

which consists of the nursery school (ages 2, to 6) and the primary school (ages 6 to 12). After the sixth year a primary education certificate is granted.

In Flanders, primary education was last reformed in 1973.

2) Secondary education is established for pupils aged 12 to 18

Four different types of secondary education can be distinguished:

1) General Secondary Education (GSE) emphasises theoretical aspects of each subject area.

2) Technical Secondary Education (TSE) focuses on technical aspects of the subject area. It can lead to higher technical education, but almost never leads to university education.

3) Secondary Artistic Education (ASE) focuses on the education of the arts. It may open to higher arts education.

In Wallony, this type of education is treated separately.

1) Vocational Secondary Education (VSE) places emphasis on a specific profession e.g. photography, electronics, chemistry, hairdressing, Table 2 gives data on the percentages of pupils in the first year of the third grade in the different educational systems for the VVKSO (September 1, 1994) and in the third grade in Wallony (1991-1992).

Table 2: Educational systems

Flanders VVKSO (September 1, 1994)

1st year, 3rd grade

GSE	TSE	ASE	VSE
43,7 %	34,0 %	1,6 %	20,7 %

Wallony 1991-1992

3rd degree Type I

GSE	TSE	ASE	VSE
44,9 %	30,2 %	2,5 %	22,4 %

A secondary education diploma is granted after the sixth year of GSE, TSE or ASE, this allows the entrance to higher education.

Since only the GSE diploma provides a solid basis for university education we will only consider this type of education in what follows.

3) University or higher education

During the school years 1991-1992 and 1992-1993 three different types of secondary education were organised.

1. Type II

This is a traditional type of education which was established in its first version in 1887. It consists of two levels: the lower level and the upper level, which both take three years.

From the first year on pupils have to choose a specific branch of study. At the start of the fourth year, a final choice has to be made. The options are listed in table 3.

Table 3: Flanders: options GSE - Type II

Latin-Greek
Latin-Mathematics
Latin-Sciences
Modern-Languages-Mathematics
Modern-Languages-Sciences
Economics
Social Sciences

Students can swap from one option to another during their studies, but the possibilities are limited.

2. Type I

Around 1970 secondary education was reformed so that an adaptation of the programme to the specific interests of the individual pupil was made possible. This resulted in a very complex structure with, for example, as many as 71 different orientations in the 4th year and 95 different orientations in the 5th and 6th year of ARGO. Schools were not obliged to follow this type.

In Flanders, ARGO switched to type I, PE and PLE kept both types.

In Wallony almost all schools changed to type I. There is a tendency to decrease the number of options due to the costs and the complicated practical organisation.

In table 4 percentages are given for the number of pupils in the different types of secondary education during the year 1991-1992 for Flanders and during 1992-1993 for Wallony.

Table 4: % in the types of secondary education

Flanders 1991-1992

	1st year	**2nd year**	**3th year**	**4th year**	**5th year**	**6th year**	**Total**
US	100 %	100 %	100 %				
Type II	***	***	***	17,2 %	14,4 %	18,9 %	16,9 %
Type I	***	***	***	72,8 %	75,6 %	71,1 %	73,1 %

Wallony 1992-1993

	GSE		**TSE**		**VSE**		**Total**
	Lower	Higher	Lower	Higher	Lower	Higher	
Type II	1,7 %	1,1 %	0,2 %	0,5 %	1,0 %	0,3 %	3,9 %
Type I	***	***	***	***	***	***	96,1 %

3. The Unified Structure (US)

Due to the competition of the Type I and the Type II Catholic schools and the competition between the ARGO and the PE schools, the Flemish Minister of Education introduced a new structure. This will replace the type I and type II schools in Flanders completely by the end of July 1995.

The diagram of the structure of secondary education in Flanders (US) and in Wallony (type I) are given in table 5. The different GSE options in the US are given in table 6.

Table 5

Flanders - Diagram of the Unified Structure (US) for secondary education

	General	**Technical**	**The arts**	**Vocational**
1st grade	1st year A			1st year B
	2nd year			2nd year
2nd grade	3rd year	3rd year	3rd year	3rd year
	4th year	4th year	4th year	4th year
				perfection
3rd grade	5th year	5th year	5th year	5th year
	6th year	6th year	6th year	6th year
	preparation for HE	specialisation	specialisation	specialisation

Wallony - Diagram of the new structure (type I) for secondary education

		General	**Technical**	**The arts**
1st grade	1st	1st year A-1st year B		
	2nd	2nd year		
2nd grade	3rd	gen	trans-qual	trans-qual
	4th	gen	trans-qual-re	trans-qual-re
	5th		voc/spec	voc/spec
3rd grade	5th	gen	trans-qual	trans-qual
	6th	gen	trans-qual	trans-qual
	7th		voc/spec	voc/spec

gen : general
qual : qualification
voc : vocational
re : reorientation
trans : transition

Table 6: Flanders: options GSE - US

1st grade - 2nd year
Latin
Modern Languages-Sciences

2nd grade
Latin-Mathematics
Greek-Mathematics
Modern Languages-Mathematics
Economics-Mathematics
Sports-Sciences
Greek-Latin
Latin-Modern Languages
Economics-Modern Languages
Social Sciences-Modern Languages
Economics-Social Sciences

3rd grade
Science oriented
Sciences-Mathematics
Latin-Sciences
Greek-Sciences
Modern Languages-Sciences
Sports-Sciences
Latin-Mathematics
Greek-Mathematics
Modern Languages-Mathematics
Economics-Mathematics
Non-science oriented
Latin-Greek
Latin-Modern Languages
Economics-Modern Languages
Social Sciences

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

1) Primary education

In primary school there is some science, mostly biology. Since it is integrated in the whole curriculum it is difficult to give the exact time spend on science. It should approximate 2 lessons per week or 7 % of the time.

In 1994 the Flemish Minister of Education published the minimum goals for primary schools, these will be effective starting September 1, 1996. In Wallony some kind of minimal goals (Socles) are stated but only for the 8, 12 and 14 year olds.

2) Secondary education

1. Flanders

Since most schools are organized either by ARGO or by VVKSO, we will restrict ourselves to these schools. As stated earlier we will only discuss the GSE system and we will only consider the Unified Structure (US) as from 1995 this will be the only type of secondary education.

In the US, part of the subjects is common for all pupils in the same year.

The optional part consists of a number of subjects from which a choice must be made. This choice defines the name given to each particular option. For most options there are also some complementary periods which a school can fill according to its own wishes.

The number of weekly 50 minute periods is set by the government to 32. In the new system science is compulsory for all pupils aged 12 to 18, the number of science classes varies with the option chosen.

The minimal weekly periods of science as set by the Minister of Education is given in table 7.

Table 7: Sciences in the curriculum - Number of weekly periods

B Biology
C Chemistry
P Physics
T Technology
PW Practical work
NS Natural sciences (b or c or p)
F B Fraction biology
F C Fraction chemistry
F P Fraction physics

Flanders - minimal program

	Non-science oriented				**Science oriented**				
	B	**C**	**P**	**T**	**B**	**C**	**P**	**T**	**PW**
1st grade									
1st year	1			2	1			2	
2nd year	1			1	1			1	2
	B	**C**	**P**	**NS**	**B**	**C**	**P**	**T**	**NS**
2nd grade									
1st year				2			1-0		2-4
2nd year				2			1-0		2-4
3rd grade									
1st-2nd year				2					6

VVKSO

	Non-science oriented				**Science oriented**				
	B	**C**	**P**	**T**	**B**	**C**	**P**	**T**	**PW**
1st grade									
1st year									
2nd year	1				1				3
2nd grade									
1st year						0-1			
2nd year					0-1				
3rd grade									
1st-2nd year							2-3		

ARGO

	Non-science oriented				Science oriented				
	B	**C**	**P**	**T**	**B**	**C**	**P**	**T**	**PW**
1st grade									
1st year	1				1			2/4	2
2nd year	1		1		1		1		2-4
2nd grade									
1st year		1			2	2	2		
2nd year	1	1	1		1	2	2		
3rd grade	**B**	**C**	**P**	**NS**	**B**	**C**	**P**	**T**	**NS**
1st-2nd year				2	2				

Wallony

FESeC

	Non-science oriented				Science oriented				
	Total	**F B**	**F C**	**F P**	**total**	**F B**	**F C**	**F P**	**PW**
1st grade									
1st year	2	2/3		1/3	3-4	2/3		1/3	
2nd year	2	1/2		1/2	3-4	1/2		1/2	
2nd grade									
1st-2nd year	2	1/3	1/3	1/3	4	1/3	1/3	1/3	2
3rd grade									
1st-2nd year	2				3-7				1-2

CF

	Non-science oriented				Science oriented			
	B	**C**	**P**	**NS**	**Tota**	**B**	**C**	**P**
1st grade								
1st-2nd year	1		1			1		1
2nd grade								
1st-2nd year	1	1	1			1	1	1
3rd grade								
1st-2nd year				2	3-7			

There may be small differences between the ARGO and the VVKSO programmes as indicated in table 7. Schools can always request for exemptions so that some schools might have still another programme.

Although the minimal programme states that integrated sciences can be taught, it is not introduced as such.

US secondary education is organised in three two-year grades.

1st grade

In the first year there must be at least one period of biology and two periods of technology for all the pupils as required by the minimal programme. In the second year one period of biology and one period of technology is compulsory for all the pupils.

Pupils in a science-oriented option must have at least two periods of practical work.

Table 7 shows how the VVKSO-schools and the ARGO-schools fill in the programme. Both systems include more sciences in the science-oriented options than required by the minimal programme.

During the following years there is no more technology in GSE.

2nd grade

In the minimal programme of the non-science oriented options, there are two periods of natural sciences in both the 2nd and the 3rd grade. In the science-oriented options there can also be one period of physics or an extra two periods of natural sciences.

VVKSO follows the minimal program. ARGO introduces more sciences than required.

3rd grade

In the minimal program there are two or six periods of natural sciences. In the non-science options in VVKSO there is one period each of biology, chemistry and physics.

In ARGO in the non-science oriented options there are two periods of either biology, chemistry or physics during one term.

In both VVKSO and ARGO, in the science-oriented options, there are two periods each of biology, chemistry and physics. There is one exception, the option science-mathematics in VVKSO has three periods of physics instead of two.

2. Wallony

In Wallony almost all secondary schools follow the type I system. It has a very complicated structure as already stated. Since most schools are organised either by FESeC or CF we will restrict ourselves to those schools, furthermore we will only discuss the GSE system. Data are given in table 7.

1st grade

In FESeC the number of science periods (50 minutes) is between two and four. In the 1st year there must be 2/3 of biology and 1/3 of physics, in the 2nd year there must be 1/2 of biology and 1/2 of physics. Technology is included in the sciences.

In CF schools all pupils have one period of biology and one period of physics. There is a strong tendency to replace this by two weekly periods of integrated sciences including technology.

2nd grade

In FESeC schools there are two periods of sciences for non-science oriented options and four periods for science oriented options; there is 1/3 of biology, chemistry and physics each. To the science oriented options two periods of practical work can be added.

In CF schools there is one period of biology, chemistry and physics each in the non-science oriented options.

In the science oriented options there are two periods of biology, one of chemistry and two of physics in the 3rd year, one period of biology, two of chemistry and two of physics in the 4th year.

To the curriculum of the science oriented options two periods of practical work may be added.

3rd grade

For non-science oriented options in FESeC there are two periods of integrated sciences; in practice this consists of 1/3 each of biology, chemistry and physics.

In science oriented options there is a minimum of three and a maximum of seven periods of science. There should be biology, chemistry and physics; the number of periods for each science can be chosen by the pupil. One or two periods of practical work can be added, but the total number of weekly periods should not be more than 32.

In CF schools there are two periods of integrated science for non-science oriented options.

For science oriented options there are between three and seven periods of non-integrated sciences, and practical work is integrated.

1.2 Which sciences are to be taught

As stated under 1.1, sciences are taught separately in contrast to what is stated in the minimal programme.

In Flanders, Technology is included in the first two years as a separate topic.

In the science curricula, it is advised to include examples from technology.

In Wallony, technology is not taught as a separate topic. STS is given much attention and should be integrated in the curriculum.

1.3 Realistic data on the above

In the type II schools (Flanders) only the Latin-Sciences and Modern Languages-Science options with 40% of the pupils (4th, 5th and 6th year, 1991-1992) are oriented towards sciences.

Due to the great number of options in the type I schools it is difficult to state exact numbers for this type of education. For the 5th and the 6th year (Flanders 1991-1992) it is approximately 39.5%.

Data for the first year of the third grade US (Flanders, 5th year) for the school year 1993-1994 and 1994-1995 are available (table 8) for VVKSO.

Table 8: Pupils in non-science/science

Flanders VVKSO - US - GSE
September 1, 1993 (22157 pupils) - September 1, 1994 (22760 pupils)

Non-science			Science		
	1993	**1994**		**1993**	**1994**
Lat.-m.l.	1411	1520	**Sc.-math.**	3458	3319
Gr.-lat.	730	772	**Lat.-sc.**	1379	1304
Ec.-m.l.	4797	5033	**Gr.-sc.**	49	55
Soc.sc.	1795	2023	**M.l.-sc.**	1917	1808
			Sp.-sc.	266	273
			Lat.-math.	2456	2431
			Gr.-math.	207	192
			Ec.-math.	2485	2686
			M.l.-math.	1207	1344
Total	**8733**	**9348**		**13424**	**13412**
%	**39,4%**	**41,1%**		**60,6%**	**58,9%**

In 1993, there were 39.4%, and in 1994 41.1%, of all pupils in non-science options.

In 1993, 60.6%, and in 1994 58.9%, of all pupils were in an option with a minimum of 18.8% of sciences. In the science-mathematics option with 21.9% of the science-oriented pupils, there are 15.6% and 14.6% respectively with 21.9% of sciences. There is a slight decrease (1.7%) from 1993 to 1994 in the number of pupils in sciences.

Some schools use the complementary periods for sciences, numbers are not available.

1.4 Recommended learning activities

In the type II teaching of science, there is almost no practical work. This changed with the introduction of type I. A large amount of time is spent on laboratory work, there are subjects entitled Laboratory Work in Biology, Laboratory Work in Chemistry, Laboratory Work in Physics.

With US, the pupil laboratory work as a separate subject has disappeared.

In VVKSO chemistry and physics teachers are now obliged to organize practical laboratories. For chemistry there should be 8 periods per year for science oriented options and 4 for non-science options. For physics there should be at least 5 practical lab work sessions per year in the third grade for the science-mathematics option and three lab sessions for the other science options.

In the curriculum of the ARGO and of the Walloon schools, it is indicated where practical work has to be introduced.

Fieldwork should form the basis of biology classes, practical work in biology is not obligatory.

In Wallony practical work can be added to the curriculum.

In the Flemish curriculum nothing is stated on the teaching of the history of science or the controversies in scientific history. Only in the chemistry of the 3rd grade, it is stated that the historical and social implications of chemistry should be mentioned. On the other hand, in the curriculum of the FESeC, it is stated that the history of sciences should be integrated.

1.5 Mandatory tests and examinations

There are no general examinations in Belgium.

Normally all schools organise autonomous examinations every tri- or semester. Pupils have to take exams on all subjects in the curriculum. During the year, there are tests that are also taken into account in the final assessment.

At this moment the Flemish authorities are preparing a list of minimum goals that most pupils should have attained when finishing secondary school. This concept of minimal goals must lead to the development of curricula offering the Flemish community sufficient guarantees as to quality, but simultaneously respecting the autonomy of schools. Since the curricula of the networks differ a lot, at this moment there are many problems with the statement of the minimum goals for the secondary school.

1.6 New trends and reforms underway

With the new secondary educational system in Flanders, the number of biology and chemistry periods increased in comparison with the type II system, and remained almost the same in comparison with the type I system.

With the introduction of the US, the Catholic schools (VVKSO) took the opportunity to drastically change the curriculum. In this curriculum, pupil laboratory work is compulsory for chemistry and physics.

In Wallony, the science curricula of FESeC changed a lot. For each science minimal and maximal objectives and limitations on the different topics are stated. The programmes not only give the cognitive contents but also states achievements that should be reached.

Recently the CF educational system introduced new curricula for the sciences.

In 1993 the VVKSO published two documents on the natural sciences. The first document focuses on fifty points of action that should enhance the teaching of the natural sciences. The VVKSO will constantly check the schools on this. The second document gives some recommendations on the minimum equipment for the science classroom.

Recently the Flemish Minister of Education appointed inspectors who will control all Flemish schools on the quality of the delivered education. The tasks of this inspectorate include:

- to check whether minimum timetables and approved curricula are complied with,
- to check whether the minimum goals are achieved, to look for the application of the laws on the use of languages, hygiene and cleanliness of the classrooms, didactic material and school equipment,
- to issue recommendations on the financing or eligibility for financing of institutions and divisions,
- to issue policy recommendations on education.

In Wallony, the Minister of Education published a list of competencies (Socles) that should be reached by pupils aged 8, 12 and 14. For the last group not only general competencies are listed but a separate list for the sciences is included.

2. How is science delivered?

2.1 Organisation and authority

The Minister of Education is a member of the executive power of the community. He is aided by a non permanent cabinet. The Minister and the cabinet are appointed for four years. The Department of Education consists of a permanent staff and is directed by a Secretary-General. The Minister heads the Department of Education. The institutions that organise education are recognised by the Ministry of Education when the legal requirements and regulations are met. The networks prepare the curricula and present them to the Minister in order to obtain official approval. The board of organisers consists of people responsible for the school. In many cases the director of the school is a member of the board of organisers.

Schools that are recognised get a subsidy and are assigned a number of teaching periods that can be organised according to the number of pupils in the school. Schools decide how they organise the education. The managing board of a school consists of the head of school and the deputy head. In the PE, personnel of the school can also be members of the managing board of the school.

Every school has a board of advisers made up of an equal number of members of the board of organisers, parents, personnel and local participants. This board advises on the general organisation, operation and planning of the school and on the general criteria with respect to the follow up and evaluation of the pupils. They advise on the division of the assigned number of periods, on the regulations of the school, the transportation, the safety and the health of the pupils.

2.2 Resources and funding

During 1991, 1992 and 1993 the Flemish community spent on the average 45.2% of its total budget on education. On average 44% of the budget of both the Flemish and the Walloon Ministries of Education is spent on secondary education.

Data are given in table 9, this table also gives the amount of money spent for pupils during primary and secondary school.

Table 9: Budget - Cost per pupil

Flanders: budget (in MBEF)

	1991	1992	1993
Budget Ministry of Education	183933	200934,2	210758,1
Budget Flemish Government	409111,5	431838,7	476584,6
Primary	45685,9	48492,9	51146,6
Secondary	81046,6	87311,7	91717,4
% educ.budget/total budget	45,0	46,5	44,2
% primary/educ.budget	24,8	24,1	24,3
% secondary/educ.budget	44,1	43,5	43,5

Flanders: cost per pupil (in BEF)

	1991	1992	1993
Primary	73490	78130	83357
Secondary	184538	201183	213622

Wallony: budget (in MBEF)

	1990	1991	1992	1993
Budget Ministry of Education	144519,4	151693,8	157389,8	159528,1
Primary			36467,9	39215,1
Secondary			67490,4	70799,1
% primary/educ. budget			23,2	24,6
% secondary/edu.budget			42,9	44,4

Wallony: cost per pupil (in BEF)

	1990-1991	1991-1992	1992-1993
Primary	74182	78660	84087
Secondary	190568	201734	211663

Teachers are paid directly by the Ministry of Education.

The school gets its subsidies from the Ministry of Education and decides on the spending. The head of school or the managing board can autonomously decide on spending on the teaching of science, i.e. on laboratory furnishings, apparatus, libraries, etc. It thus depends highly on the individual teacher and on the director if, and how much, money is spent on apparatus etc.

VVKSO gives some recommendations in the document of May 1992.

Ministry of Education inspectors can check the spending of the schools.

Individual schools decide on which text-book to use. Text-books are either bought by the pupils or hired from the school by the pupils. The cost of work-sheets is in almost all cases borne by the pupils.

There is no technical assistance available for the science teacher.

2.3 Methods of teaching

There are almost no pedagogic recommendations given to science teachers. Most of the teaching is given in the lecture-style. In the teaching of physics there is a tradition of demonstration experiments. For chemistry the use of demonstrations is becoming more important. The pedagogic advisors attached to the networks also organise in-service training for teachers.

Since the last changes of the VVKSO curriculum, more emphasis is put on pupil led investigations. In ARGO a lot of the student investigations disappeared.

In Wallony, practical work was introduced with the introduction of type I education.

In Belgium, pupils are used to homework, also science homework. In many cases it consists of exercises or writing reports on experiments.

2.4 Sources of pedagogic innovation

The educational networks are charged with organising in-service training activities for teachers. In each network there is a central body and a number of regional training centres. Most teacher training centres associated with the different universities organise in-service training for teachers.

The Flemish Association of Science Teachers (VeLeWe) and the Walloon Association of Physics and Chemistry Teachers (ABPPC) each have ± 450 members, and both publish a quarterly journal. These associations help organise single or two-day conferences for science teachers.

The Flemish Association of Biology Teachers (VOB) and the Walloon Association of Biology Teachers (Probio), the educational section of the Royal Flemish Chemical Society (KVCV) and the Belgian Association of Physicists (BNV) all organise activities for science teachers.

Educational research is mainly concentrated in universities. A number of broad subjects are selected as key issues for educational research in a certain period of time.

In Flanders, more and more, subjects are defined and research subsidised in response to acute policy problems. The Minister of Education will annually determine which research subjects should be prioritised in the years to come. He is advised by his administration and by the Flemish Educational Council (VLOR).

3. Going beyond school

3.1 Use of out-of school resources

The only science museum schools are able to visit is the Museum of Natural History in Brussels. Many schools visit the ground telecommunication center in Lessive and the recently opened Isotopolis in Dessel. The new Aerospace Center in Transinne is also a favourite. For biology, a great number of small museums and nature reserves are open to the public.

Some university science departments offer open-door facilities or organise activities especially for schools.

In 1994 the Flemish community organised a science week for the third grade of secondary schools. The community counted on the cooperation of schools for higher education and on the universities for this. The Minister plans to repeat this every two years.

The Flemish community's TV-station provides the school TV. It prepares programmes for use in schools or buys and translates programmes. At the Centre for Educational Media of the Ministry of Education in Brussels, teachers can obtain school-TV productions and many other programmes free of cost. This centre also negotiates on software with educational software houses; schools can buy software at the centre with a 25% subsidy.

Companies such as Solvay, Electrabel, etc. offer brochures and other facilities to schools.

3.2 Consideration of public science-based issues within lessons

In the first grade of secondary education of the Flemish educational system, all pupils have two weekly lessons of technology. The purpose of this is to make pupils aware of what technical work is so that they can make a weighted choice after the first grade of secondary school. In Wallony, technology should be included in the sciences.

In the grade 2 and grade 3 chemistry and physics curricula, it is advised that teachers should include technological applications. The chemistry curricula state that emphasis should be laid on the dangers and the safe use of chemicals and on the waste problem.

Ecology is an obligatory subject in biology. Sex education starts in primary school and runs all through the secondary school.

STS is being included in the curriculum.

3.3 Science education and vocational training

In the general secondary education the subjects taught and the way they are taught serve the general education of the pupil. The curricula are designed to provide a broad base.

The technical secondary education prepares pupils for specific jobs or for higher, mostly technical, education. Depending on the option, there is more or less science; mostly only selected topics are taught. In some options there is also a lot of practical work.

In the vocational secondary education, emphasis is put on the learning of a job. The science curriculum does not include the theoretical background but only the practical implications of science.

3.4 Science clubs and cultural associations

A limited number of teachers offer pupils the possibility to experiment after school. Science clubs are mostly limited to astronomy- or computer-clubs.

There are special awards from different foundations available for science projects produced by pupils or by groups of pupils. ABPPC, VeLeWe, VOB, Probio and KVCV support these initiatives in many cases. Some companies also support this kind of initiative.

Every year a great number of pupils (± 2500) take part in the Science Olympiads.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Results of examinations of the schools are never made public.

There is no national or community curriculum and consequently there is no national or community examination. Subsidised schools are inspected on the quality of their education. Once the minimum goals will be published, every school in Flanders should reach them.

4.2 Public or political concerns about educational standards

When the US was installed in Flanders, there was a lot of controversy over the number of history and gymnastics classes, but there never was any discussion about the sciences programme. In Flanders the teaching of languages is very important since Dutch is only spoken by a small group of people, the teaching of science is not considered to be important.

In Wallony also, the teaching of science is not considered of much importance.

The Flemish authorities consider it their task to make the minimal expectations of the community regarding education clearly known. For this reason a first draft of the minimum goals for the primary schools, prepared by the Educational Development Service (DVO), was made public by the Minister of Education.

Through the media there was a lot of confusion and of discussion on this subject. Even now that the final version is approved, the Minister is still changing the minimum goals. The Minister of Education is now having consultations in order to make a first version of the minimum goals for the first grade of the secondary education. It is expected that they will be ready by March 1995.

In Wallony, the introduction of the Socles, although restricted for the sciences to one age group, indicates that the French community is concerned about the quality of education and of the education of the sciences in particular.

4.3 Suggested reforms

1) Flanders

The announcement of the introduction of minimum goals for each grade of the secondary schools prompted complaints from both teachers and parents. The minimum goals, although not specifically aimed at specific subjects, will force a revision of the (only recently revised) science curricula since the two largest networks, VVKSO and ARGO, have curricula that are completely different.

The publication of the VVKSO documents and the follow up of the points of action will certainly change the teaching of sciences in Flanders.

2) Wallony

With the introduction of the Socles, it is expected that the quality of the teaching of the sciences will improve. The new programmes for the sciences of the FESeC and of the CF will drastically change the education of the sciences in the Walloon schools.

Both FESeC and CF recently started advising that the teaching of the different sciences in the 1st and 2nd degree should be done by only one teacher.

5. Pupil interest and motivations

5.1 Generally by age and gender

In primary schools, the teaching of science depends highly on the individual teacher. Normally there is no practical work but children go out and collect items to be studied in the class afterwards.

Since in secondary education the teaching of science is compulsory for every pupil, it is impossible to state if pupils would choose sciences in the curriculum if they were free to decide.

5.2 By type of science or topic by age/gender

Table 10 gives data on the options chosen in GSE-type II (Flanders) for the school year 1991-1992 according to age and gender. It should be remembered that in type II, pupils cannot easily change from one option to another.

Table 10: % of boys/girls in the different options

Flanders VVKSO - type II 1991-1992
1991-1992 (total = 32058; 49,2 % boys)

	4th year			5th year			6th year		
	B	G	% B	B	G	% B	B	G	% B
Lat.-gr.	349	473	42,5	312	459	40,5	341	494	40,8
Lat.-math.	698	452	60,7	722	409	63,8	731	395	64,9
Lat.-sc.	679	807	45,7	641	794	44,7	651	783	45,4
M.l.-math.	993	467	68,0	869	433	66,7	842	437	65,8
M.l.-sc.	1604	1562	50,7	1417	1350	51,2	1249	1282	49,3
Econ.	1175	1650	41,6	1061	1484	41,7	1044	1444	42,0
Soc.sc.	114	407	21,9	146	395	27,0	122	321	27,5

	4th year			5th year			6th year		
	B	G	% B	B	G	%	B	G	% B
Sciences	2283	2369	49,1	2058	2144	49,0	1900	2065	47,9
Non-sciences	3329	3449	49,1	3110	3180	49,4	3080	3091	49,9
Total	5612	5818	49,1	5168	5324	49,3	4980	5156	49,1
	B	G	% B	% B/Tot		% G/Tot			
Sciences	6241	6578	48,7	19,5		20,5			
Non-sciences	9519	9720	49,5	29,7		30,3			

It should also be stated that in 1991-1992, 10.4 % of all Flemish secondary schools were girls-only schools and 8.7 % boys-only schools.

The table shows that the percentage of boys in science oriented options is almost the same as the percentage of boys in the whole group.

Although the Latin-mathematics and modern languages-mathematics options in type II are non-science options, many pupils from these options will study engineering or physics at university. This has changed in the US.

The results of the first rounds in the Science Olympiads show that for biology there are on the average 50 % girls amongst the first fifteen, for chemistry this number is 33 %, for physics the average is 0 %.

5.3 Options for choice within science

Since the number of science periods and the kind of science taught are fixed in almost all secondary education, pupils cannot really choose between the different sciences.

5.4 Pupils' perspectives on the value of science

Table 11 gives data on the population of first year university students. Data are from the Catholic University of Leuven for the period of 1988-1989. Only 7.6 % of the students opt for the sciences. Students who finished a science option in secondary school do not all end up in science departments. A strong scientific basis is also needed in agriculture, engineering and medicine; even in economics, a good science knowledge is very useful. All these orientations make up 43.0 % of the students. This is almost the same percentage as the science oriented group in the third grade of the secondary school.

Table 11: Number of first year students (total = 4625)

Catholic University of Leuven 1988-1989
% over the period of 1984-1989

Sciences		**% male**	**% female**	**% total**
Biology	49	35,4	64,6	1,1
Chemistry	123	39,2	60,8	2,7
Geography	19	42,6	57,4	0,4
Geology	6	64,2	35,8	0,1
Computer science	64	74,1	25,9	1,4
Mathematics	52	34,6	65,4	1,1
Physics	40	64,1	35,9	0,9
			Total	**7,6**

Others		% male	% female	% total
Agriculture	240	59,2	40,8	5,2
Economy	969	59,8	40,2	21,0
Engineering	472	87,5	12,5	10,2
Law	655	46,1	53,9	14,2
Medicine	364	46,4	53,6	7,9
Pedagogics	81	21,2	78,8	1,8
Psychology	201	30,1	69,9	4,3
			Total	**64,5**

We can therefore state that students who choose a science option in secondary education are not demotivated by their science education and make a parallel choice for their university studies.

From table 11 we can see that more girls opt for mathematics and biology and less for geology, physics and computer science. It is actually mathematics and biology that lead quite often to a career in education.

6. Training, status and morale of scientific teachers

6.1 Initial training

A secondary school certificate is necessary to enter a teacher training school. Teacher training is organised separately for nursery, primary and lower secondary school teachers, and for higher secondary school teachers.

For nursery, primary and lower secondary school teachers there is a full-time training in short-term pedagogic higher education. The training of primary and lower level secondary school teachers will take three years including longer periods of probation in schools. Lower level secondary school teachers will qualify for the teaching of three related subjects.

The training of higher level secondary school teachers is given at university. Students can start the teacher training courses during the first year of the second university cycle. A Master's degree is necessary to obtain the teachers' certificate which states in which science subject the training was taken.

The training consists of three pedagogical subjects (60 hours), one science related educational subject plus practical work (60 hours) and 30 hours probation in a school. Universities are not subsidised for teacher training.

The June and October 1991 Acts of the Flemish community dealing with universities and higher educational institutions announced that a separate Act will deal with teacher training. Through the media, the Minister of Education recently announced his plans for changing the teachers' training at university. Recently those plans became explicit. Other courses (+ 90 hours) and practical work (+ 50 hours) will be added to the old programme. The training in a secondary school will extend to 60 hours.

6.2 Decision-making authority for the above

It is the Flemish or Walloon community that is responsible, through the Minister of Education, for the training of teachers and for the certificate needed in order to teach in a certain grade or year. It is also the Flemish or Walloon community that approves which subjects a teacher with a certain qualification can teach.

6.3 Continuing training

Most in-service training sessions are organised on school holidays since there is no time off stipulated for these kind of activities. Teachers can be released from teaching on a particular day of the week for training. Teachers are not obliged to take in-service training.

Schools get a budget for the in-service training of their teachers. The head of school or the managing board of the school decided how the money is spent.

There is no sabbatical leave possible for further training. Teachers with tenure are allowed to take a leave of absence for special reasons.

6.4 Number, teacher/pupil ratio, gender, age profile

In table 12 an overview is given of the number of schools, pupils and teachers and the pupils/teacher ratio.

Table 12: Number of schools, pupils, teachers

Belgium 1991-1992

Number of pupils

	Nursery	Primary	Secondary	Higher	Total
Regular	398005	711521	766299	256776	2132601
Special	2447	32511	27091		62049
Total					2194650

Flanders 1991-1992

Number of schools

	Nursery	Primary	Secondary
Regular	2072	2227	1063
Special	95	204	122
Total	2167	2431	1185

Number of pupils

	Nursery	Primary	Secondary
Regular	233261	404773	427380
Special	1615	20128	14085
Total	234876	424901	441465

Number of teachers

	Nursery	Primary	Secondary
Regular	12205	26197	54312
Special	330	3153	4330
Total	12535	29350	58642

Number pupils/teacher

	Nursery	Primary	Secondary
Regular	19	15	8
Special	5	6	3

Wallony 1992-1993

Number of schools

	Nursery	Primary	Secondary
Regular	1865	1877	671
Special	78	160	97
Total	1943	2037	768

Number of pupils

	Nursery	Primary	Secondary
Regular	163972	302393	333505
Special	905	12515	12834
Total	164877	314908	346339

Number of teachers

	Nursery +	Primary	Secondary
Regular	36531		58998
Special		8916	

Number pupils/teacher

	Nursery +	Primary	Secondary
Regular	15,08		7,73
Special		4,52	

For the regular education this number is 15 for primary and 8 for secondary school. For special education this numbers are respectively 6 and 3.

Table 13 gives the percentages of tenured and non-tenured teachers. In primary schools, 85.1% of the teachers have tenure, in secondary school 89.1%.

Table 13: Age profile of teachers

Flanders 1991-1992

Primary (regular)

	Tenure		Temporary		Total		%		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**Tot**
20-29	695	1674	493	2082	1188	3756	4,5	14,3	18,9
30-39	2537	5253	177	921	2714	6174	10,4	23,6	33,9
40-49	3686	5627	34	166	3720	5793	14,2	22,1	36,3
50-59	1417	1329	6	27	1423	1356	5,4	5,2	10,6
60+	29	43	1	0	30	43	0,1	0,2	0,3
Total	8364	13926	711	3196	9075	17122			
%	**31,9**	**53,2**	**2,7**	**12,2**	**34,6**	**65,4**			

Secondary (regular)

	Tenure		Temporary		Total		%		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**Tot**
20-29	367	552	1124	2213	1491	2765	2,7	5,1	7,8
30-39	6870	8688	856	1187	7726	9875	14,2	18,2	32,4
40-49	9237	10225	287	145	9524	10370	17,5	19,1	36,6
50-59	7623	4192	99	13	7722	4205	14,2	7,7	22,0
60+	491	129	10	4	501	133	0,9	0,2	1,2
Total	24588	23786	2376	3562	26964	27348			
%	**45,3**	**43,8**	**4,4**	**6,6**	**49,6**	**50,4**			

Wallony 1992-1993

Primary (regular)

	M	**F**	**Total**	%
20-29	839	6283	7122	21,1
30-39	1988	8849	10837	32,1
40-49	2157	8656	10813	32,0
50-59	1303	3526	4829	14,3
60+	26	116	142	0,4
Total	6313	27430	33743	
%	**18,7**	**81,3**		

Secondary (regular)

	M	F	Total	%
20-29	1592	3635	5227	10,9
30-39	5600	8712	14312	29,8
40-49	7570	9281	16851	35,1
50-59	5574	4962	10536	21,9
60+	735	342	1077	2,2
Total	21071	26932	48003	
%	**43,9**	**56,1**		

In primary school, 65.4% of the teachers are female, in secondary school the number is 50.4%.

The largest age group (an average of 35%) for both Flanders and Wallony is between 40 and 49 years. The second largest age group (an average of 32%) is between 30 and 39 years.

Table 14 gives the percentages of secondary school teachers according to their qualification (lower or higher secondary level). Well over 2/3 teach at the lower secondary level.

Table 14: Teachers' qualification

Flanders 1991-1992

	M	F	Total	%
Lower secondary	18337	19999	38336	70,6
Higher secondary	8627	7349	15976	29,4

6.5 Drop-out rates, late entries, maternal leave

No data on drop out-rates or on late entries are available.

As table 15 states, many teachers, especially women, work on a part-time basis. In primary schools, 27.4 % of the female teachers have a part-time job, in secondary schools the number is 40.9 %.

For the male teachers, these numbers are 7.9 % and 11.9 % respectively.

Every mother has the right to a maternal leave of 15 weeks. It is very easy to prolong this maternal leave for three months, without pay.

Table 15: Teachers: full- or part-time

Flanders June 30, 1992

	Full-time		**Part-time**		**Total**	**% full-time**		**% part-time**	
	m	f	m	f		m	f	m	f
Nursery	34	9488	103	2580	12205	0,3	77,7	0,8	21,1
Primary	8364	1392	711	3196	26197	31,9	53,2	2,7	12,2
Secondary	2458	2378	2376	3562	54312	45,3	43,8	4,4	6,6
Total	3298	4720	3190	9338	92714	35,6	50,9	3,4	10,1

	% male	**% female**
Nursery	0,1	13,0
Primary	9,8	18,5
Secondary	29,1	29,5
Total	39,0	61,0

Wallony 1991-1992

	Full-time		**Part-time**		**Total**	**% full-time**		**% part-time**	
	M	**F**	**M**	**F**		**M**	**F**	**M**	**F**
Nursery+ primary	5699	21056	703	5863	33321	17,1	63,2	2,1	17,6
Secondary	18265	17321	3164	9655	48405	37,7	35,8	6,5	19,9
Total	23964	38377	3867	15518	81726	29,3	47,0	4,7	19,0

	% male	**% female**
Nursery primary	7,8	32,9
Secondary	26,2	33,0
Total	34,1	65,9

6.6 Status and salary

The salary of a teacher is, on average, the same as a similarly qualified individual in another profession.

Table 16 gives the yearly salary of teachers in Flanders before taxes.

Table 16 : Teachers' salary (in BEF)

Flanders 1993

	Primary	**Secondary**	
Seniority		**1st grade**	**2nd-3rd grade**
0	657056	672892	842703
1	678171	694888	869978
2	699286	716884	897253
3	720401	738880	924528
5	749437	774954	975560
7	778473	811028	1026592
9	807509	847102	1077624
11	836545	883176	1128656
13	865581	919250	1179688
15	894617	955324	1230720
17	923653	991398	1281752
19	952689	1027472	1332784
21	981725	1063546	1383816
23	1010761	1099620	1434848
25	1039797	1135694	1485880
27	1068833	1171768	

These numbers should be multiplied by 1,1262 in 1993

The salary goes up with seniority and should be multiplied by the index adjustment figure which was 1.1262 in 1993. Primary and first grade secondary school teachers start at a seniority 0 at the age of 22, second and third grade secondary school teachers start at 0 at the age of 24. Payment is the same for all teachers with the same diploma in the same job.

A full time job implies a minimum of 22 and a maximum of 28 lessons for primary school teachers, between 22 and 24 for first grade secondary school teachers, between 21 and 23 for second grade and between 20 and 22 for third grade teachers.

In Belgium the summer-recess is in July and August. At Christmas and Easter, there is a two week holiday. There is a one week spring and autumn holiday. In addition there are some national, community and religious holidays.

The general status of teachers is not bad in Belgium. At the present time, teaching jobs are sought after because of the stability of tenure, the easy school hours and the amount of holidays.

7. Equality of opportunity?

7.1 Different status of the schools

In article 24 of the Belgian Constitution, the freedom of education was defined, implying that the organisation of educational institutions cannot be subjected to any restrictive measures. Consequently, schools can be established and organised without any relationship with the authorities. However, if schools want to deliver officially acknowledged certificates and diplomas and if they want to receive subsidies, they must observe some rules. This means that all schools are treated on an equal basis and receive the same subsidies and privileges.

Since all schools belonging to the same network have exactly the same curriculum, differences between such schools are small.

7.2 Regional differences

Since all schools have almost the same programme and since schools are inspected regularly, differences between schools should be small. Nevertheless some schools, in contrast to others, have a reputation for quality.

7.3 Immigration and migrant populations

In table 17, the percentages of non-Belgians in primary and secondary education are given according to the different provinces. In Wallony, this percentage is three times higher than in Flanders; this is probably due to difficulties migrants have with the Dutch language. From this table it is clear that non-Belgians have a larger chance to attend special education.

Table 17 : % of non-Belgians

Flanders 1991-1992

Primary	Regular	Special	Secondary	Regular	Special
Antwerp	8,6	12,0	Antwerp	6,5	12,9
Brabant	3,9	0,8	Brabant	2,5	4,8
West Flanders	0,9	1,6	West Flanders	0,9	2,1
East Flanders	4,7	6,5	East Flanders	3,2	6,0
Limbourg	12,3	16,3	Limbourg	11,4	19,9
Total	**6,0**	**8,1**	**Total**	**4,7**	**8,9**

Wallony 1992-1993

Primary	Regular	Special	Secondary	Regular	Special
Brabant	32,2	40,4	Brabant	30,0	43,6
Hainaut	14,1	18,6	Hainaut	20,1	28,5
Liège	12,4	17,0	Liège	14,2	17,1
Luxembourg	5,3	10,5	Luxembourg	12,0	19,7
Namur	4,3	5,5	Namur	6,0	7,0
Total	**17,3**	**24,2**	**Total**	**18,3**	**26,8**

In table 18, the origin of the non-Belgians is given. The non-Belgian population consists mainly of Europeans (57 %) and Africans (38 %).

Table 18 : Origin of non-Belgians

Flanders 1991-1992

	Primary	%	Secondary	%
Europe	14056	58,0	13506	66,9
Africa	8862	36,6	5932	29,4
America	402	1,7	214	1,1
Asia	911	3,8	536	2,7
Oceania	0	0,0	0	0,0
Total	**24231**		**20188**	

Wallony 1992-1993

	Primary	**%**	**Secondary**	**%**
Europe	28893	56,2	37940	63,4
Africa	20713	40,3	20627	34,5
America	631	1,2	443	0,7
Asia	1162	2,3	788	1,3
Oceania	13	0,0	10	0,0
Total	**51412**		**59808**	

In the first year of secondary education in Flanders, immigrants with language problems can follow the B-variant of this year, which is specifically established for them.

7.4 Special education for handicapped children?

Special education is meant for children and adolescents who cannot attend ordinary education. It is designed for the pupils' physical, sensory, psychological or intellectual handicaps. The main aim is to integrate pupils both into the world of education and into society. About 3.5 % of the total school population attends special education.

Special education is organised for all age categories. There is some special elementary (2.5 to 6 years), primary (6 to 13 years) and secondary education (13 to 21 years). In table 12, the ratio between the number of pupils and the number of teachers is given; it lies between 3 and 6 for special education. In table 19, data are given on the number of pupils in regular and in special education.

Table 19 : Number of pupils in regular and in special education

Flanders 1991-1992

	Regular		**Special**	**%**
Nursery	233261		1615	0,7
Primary	404773		20128	5,0
Secondary	427380	Lower level	13987	3,3
		Higher level	98	
Total	**1065414**		**35730**	**3,4**

Wallony 1992-1993

	Regular	**Special**	**%**
Nursery	163972	903	0,6
Primary	302393	12515	4,1
Secondar	333505	12834	3,8
Total	**799870**	**26252**	**3,3**

The structure of special primary and special secondary education features 8 types:

- type 1: for pupils with a slight handicap,
- type 2: for pupils with a moderate or severe mental handicap,
- type 3: for pupils with emotional disturbances,
- type 4: for pupils with physical deficiencies,
- type 5: for pupils suffering from protracted illness,
- type 6: for pupils with visual deficiencies,
- type 7: for pupils with auditive deficiencies,
- type 8: for pupils with serious learning difficulties.

The so-called integrated education (GON), the integration of the motorially, visually or auditively disabled, in a regular school is starting up.

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Report from Denmark

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Introduction

Denmark is one of the smallest countries in Europe. It has a population of 5.2 million.

Since the 1980s, the Danish educational system has been through reviews, evaluations and reforms which reorganised the government and administration of the schools and changed the educational aims, the content and methods of instruction.

In April 1994 the new Act on the Danish *Folkeskole* (grades 1-9 and an optional 10th grade covering age groups 7-16(17)) was adopted; and the process of change is not yet complete. The aims of the new act are more prescriptive in stating the obligation of the school to "prepare pupils for active participation, joint responsibility, rights and duties in a society based on freedom and democracy" (Appendix 1). These obligations are also reflected in the aims of science education.

The contents have been changed towards a more thematic curriculum reflecting the 'life world' of the pupils. The teacher is obliged to teach across all subjects. Creative and practical work and interdisciplinary topics, e.g. environmental topics, are included in all subjects taught, not just in science. Since 1996, the pupils in the 9th and 10th grade carry out an obligatory project assignment for which the assessment is given in the form of a written statement and, if the pupil so wishes, a grade. While the former acts have left the decisions about methods of instruction entirely to the teacher, the new act explicitly compels the teacher to differentiate the methods of instruction according to the needs and abilities of the individual pupil. The main structural change concerning science is the introduction of science education in the first 6 grades (age groups 7-13). This new subject is called Nature/Technology.

Danish children enter Folkeskolen at the age of 7 (optional pre-school or kindergarten from age 5) for 9 years of compulsory schooling. About 90% of all children are in the public educational system; the rest attend private schools, which are subsidised by the government. The Folkeskole is a comprehensive compulsory school for age groups 7-16 (17) (grades 1-9 with an optional 10th grade). About 55% of the pupils stay on for the optional 10th grade. In 1993, 525,720 pupils were in the public compulsory school system and 67,088 pupils attended private schools [22] [26].

After the 9th (10th) grade, a variety of educational options are offered and nearly everyone (92%) continues in upper secondary education. In 1990 about 50% attended various vocational schools, 6.5% went on to apprenticeships, while 33.5% of the students attended the general upper secondary schools (10-12 grade) for a certificate that gives them the opportunity to be admitted to further education at tertiary level [24] (See Table 1). These numbers have changed dramatically during the last few years. The attendance for the general upper secondary schools has increased to nearly 50% in 1995.

Table 1: The Danish School system (1990) [17]

Age	Gr	Type of school			ICED
19 18 17	12 11 10	Vocational schools (incl. apprenticeships)	Tech/comm Upp.Secon.	General Upper Secondary school	3
			↑		
		↑ 5.7% ↑	↑ 1.7% ↑		↑ 33.5% ↑
16	10	Optional 10th grade			
15 14 13	9 8 7				2
12 11 10 9 8 7	6 5 4 3 2 1	Compulsory comprehensive schools *Folkeskolen*			1
5-6	0	Pre-school			0

The school year begins in August and comprises 200 school days (examinations included). The duration of all lessons throughout the educational system is 45 minutes. The number of lessons throughout the day varies depending on the level of education.

It should be noted that acts on education, ownership, government, administration and teacher education for the compulsory level (at the 9th level of education) and the upper secondary level are strictly divided.

All education in Denmark, including tertiary education, is free. Within the first 12 grades all teaching materials (books, etc.) are free as well, and travelling expenses are subsidised.

In 1991, expenditure on education was 6.9% of GNP and 11.6% of GDP [21] [26].

The following is a brief account of the Danish school system. Extensive information and curricula in English are provided by the Danish Ministry of Education and appear within the list of references. Appendixes can only give very limited and brief examples.

Folkeskolen, the comprehensive compulsory school[1]

The *Folkeskole* provides pupils with primary and lower secondary education in mixed ability groups that usually stay together for the entire 9 years. There is no streaming according to ability or any other criterion in the comprehensive, compulsory school and there is a deliberate policy for integrating pupils with special needs for physical or mental reasons.

The average public expenditure per pupil in 1993 was DKR 34,160, equivalent to about 4,600 ECU. This is tending to fall [22] [26].

Very often the teacher teaches across the curriculum, especially at the primary level, and the same class teacher often follows the pupils throughout the primary years and even further. Pupils are usually not graded before the 8th grade. At the

1. More extensive information (including Provisions, Guidelines etc.) in English will be available through the Danish Ministry of Education in june 1995. Now available is: Consolidation Act No.311 of 25 April 1994 "Act on the Folkeskole". The Danish Primary and Lower Secondary School", Ministry of Education, 1994 [1].

end of the 9th grade pupils can attend a public examination for a leaving certificate. The examination covers what are considered to be the main subjects including physics/chemistry (the other subjects are mathematics, Danish, English, and German or French). After the 10th grade pupils can attend an examination for the advanced leaving certificate within the same subjects.

Upper Secondary Schools

The public upper secondary school offers a wide range of education within a very flexible system and the true picture is somewhat complicated. Roughly 93% continue their education after compulsory schooling. About 57% attend various schools for vocational training and apprenticeships, about 33.5% (as of 1993) attend the general upper secondary schools for a certificate and about 1.7% attend the vocational upper secondary schools for a certificate (Table 1). Recruitment has increased considerably in recent years. A certificate from either the general or the vocational upper secondary schools is necessary for further tertiary education.

Public expenditure per pupil in the general upper secondary schools is about DKR 46,000 (1990), equivalent to about ECU 6,000 [21] [26].

In order to be admitted to the general upper secondary school, the *Gymnasium*[2], the pupil's school of origin (*Folkeskole*) must declare the applicant suited for the *Gymnasium*, and the applicants must have taken the *Folkeskole* leaving certificate exam with satisfactory results. The *Gymnasium* is divided into two lines: the languages line and the mathematics line. There is a marked gender division. In 1993/94 about 23% of applicants for the language line were male and 77% were female. Of the applicants for the mathematics line, 54% were male and 46% female [24].

The two lines have a common core of compulsory subjects as well as subjects specific to each line. Some subjects are available at two or three levels: compulsory level, intermediate level and high level. Optional subjects are offered and vary from school to school. At least two and not more than three of all the offered high level options must be taken, and all students must write a major assignment. Besides the *Gymnasium*, the general upper secondary educational

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2. More detailed information in: *General Upper Secondary Education in Denmark*, Ministry of Education, 1992, and: *The Danish Gymnasium*, "General rules and Subjects", Ministry of Education, 1994 [6].

system provides a two year course called the Higher Preparatory Examination (Danish abbreviation: HF)[3], which is above all directed at young people and adults who have left the educational system and wish to return. Consequently only a very small number of pupils leaving the 10th grade immediately attend these courses. In 1993, 14,762 attended the Higher Preparatory Examination courses. Of the 33.5% (in 1990) of an age group attending the general upper secondary educational system, about two-thirds continue to tertiary education (23% of an age group) [24] [26].

An account of the various vocational schools and the demands for qualifications by applicants would be beyond the terms of reference of this report.

General Adult Education

The Act of General Adult Education provides free adult education at educational centres owned by the counties. Education is provided on all levels for qualification for further education and for achieving the competence to participate in the democratic processes in an increasingly complicated society.

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

The Act on the *Folkeskole* prescribes a weekly minimum number of 20 lessons up to the 2nd grade, gradually raising to 28 lessons in grades 8-10. Science in the common core takes up about 11% of the minimum recommended curriculum time during compulsory school. Over and above the common core there are science options in grades 8-9(10).

In the vocational schools science lessons are taught according to the various vocational lines. The exact account is complicated and will not be explored in this report.

In the general upper secondary school, the *Gymnasium*, there are 32 lessons per week. Science is taught at various levels: a common core, an intermediate level option and a high level option. The language line has a science curriculum (including mathematics) covering about 14% of the curriculum. Over and above

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3. More detailed information in: *The Danish Higher Preparatory Examination*, "General rules and subject content", Ministry of Education and Research, 1991 [7].

the compulsory science curriculum there are science options. The mathematics line has a science curriculum covering about 16% of the curriculum and a variety of science options. For the exact numbers, science disciplines and options see section 1.3.

1.2 Science options in schools

The curriculum guidelines for science in the *Folkeskole* as recommended by the Ministry of Education are reproduced in Table 2. Due to teachers' cross curricular teaching, the lessons (formally of 45 minutes each) can be organised fairly flexibly, allowing schools and teachers to construct lessons within the same subject for a longer period.

At primary level Nature/Technology includes the subjects biology, geography, physics and chemistry. Since the teaching of Nature/Technology was implemented in 1994 and no guidelines yet exist, it remains to be seen whether the teaching will be integrated or separate. However, the implications of the provisions of the science curriculum tend towards both a life-world thematic and an integrated approach.

From the 6th grade on, science is divided into separate disciplines. Science in the common core of the compulsory school, the *Folkeskole*:

- 1st-6th grade: Nature/Technology
- 7th-8th grade: Geography/Biology
- 7th-9th grade: Physics/Chemistry
- 10th grade: Physics/Chemistry

Science options:

- 8th-10th grade: technology, needle-, wood- and metalwork, workshops for engine knowledge and possibilities for other workshops.

The municipalities may direct that the pupils are offered other options in practical subjects, e.g. prevocational training in industries, practical environmental studies, etc.

Health and sex education has its own curriculum, and the same applies to traffic education. They are mandatory subjects but should be integrated in other subjects where and whenever appropriate.

The two lines of the general upper secondary school, *Gymnasium*, offer a variety of mainly discipline-centered science courses, although the science curricula of the separate sciences contain thematic integrated approaches and include mandatory subjects like the History and Philosophy of Science, the Scientific Picture of the Universe, Technology and Society, etc. in the physics curriculum (Appendix 2)

As mentioned above, courses in the *Gymnasium* are either mandatory or options at two levels.

a) The language line science courses:

1. Common core:

Science (Chemistry, Physics and Mathematics), Biology, Geography.

2. Intermediate level science options:

Geography, Biology, Chemistry, Technology, Physics, Computer Science, Design.

3. High level science options:

Biology

b) The mathematics line science courses:

1. Common core:

Biology, Physics, Chemistry, Geography

2. Intermediate level science options:

Biology, Geography, Chemistry, Technology, Computer Science, Design.

3. High level science options:

Biology, Physics, Chemistry.

Selected extracts from the curricula are given in Appendix 2.

The common core of the two-year general upper secondary school called the Higher Preparatory Examination contains two of the three subjects - Biology, Physics/Chemistry and Geography - in the first year and optional science in the second year. The options are Biology, Chemistry, Computer Science, Geography and Physics.

1.3 Realistic data on the above

Minimum science lessons in the primary and lower secondary schools, *Folkeskolen*, are shown in Table 2, and the science lessons in the general upper secondary school (*Gymnasium*) in Table 3. The data have to be compared with the information in section 1.2.

Table 2: Minimum Science lessons in the Primary and Lower Secondary Compulsory school [14]

Subject	**Grade**									**Sum**
	1	**2**	**3**	**4**	**5**	**6**	7	**8**	9	
Science	1	1	2	2	2	3				11
Biology							2	2		4
Geography							2	2		4
Physics/chemistry							2	2	2	6
Options								2	2	?
Minimum lessons	20	20	22	24	24	26	26	28	28	25/2

Table 4 shows both the ratio of pupils taking science courses in the *Gymnasium* and the gender ratio.

The science lessons of the Higher Preparatory Examination are biology (3 lessons), geography (3 lessons) and Physics/Chemistry (4 lessons) in the first year. In the second year it is possible to take three options of 4 lessons each [14]. The relevant ratios are shown in Table 5.

1.4 Recommended learning activities

Science teaching in Denmark has a long tradition of laboratory work, field studies in biology and geography, woodwork and other kinds of practical work. These activities are strongly recommended on all levels and mandatory for passing science at most lower and upper secondary courses. During the last years, practical work has shifted from very rigid teacher-organised activities to project-like activities controlled by the pupils. Experimental projects are mandatory in the upper secondary school.

Physics courses in the lower and upper secondary school in particular changed dramatically late in the 1980s from a very discipline-centered approach towards a thematic life-world approach including environmental subjects. The idea was to give a scientific view of the 'life world'. In 1988, the upper secondary physics courses were given a humanistic touch by the inclusion of subjects like the History and Philosophy of Science, the Scientific Picture of the Universe, Technology and Society. The thematic approach is recommended for these kinds of subjects.

Table 3: Science lessons in the General Upper Secondary school, *Gymnasium* [9]

Subject	Language line grade			Math line grade		
	10	11	12	10	11	12
Science	3	4				
Geography		3			3	
Biology	3			3		
Physics				3	3	
Chemistry				3		
Optional		5	5		5	5
Optional			5			5
Optional			5			5

Table 4: The ratio of pupils in the 12th grade *Gymnasium* taking science courses in 1993/94 and the respective girls/boys ratio. (*The ratio of pupils attending the mathematical line) [20]

Options	Courses		Ratio %	Ratio ™/¡
Intermediate level courses	Biology		6	1.7:1
	Chemistry		5	1.0:1
	Geography		6	0.78:1
	Physics		0	
	Computer science		4	0.23:1
	Design		2	3.5:1
	Technology		0.3	0.34:1
	Biology		11	2.0:1
High level courses	Mathematical line only	chemistry	16*	0.72:1
		physics	20*	0.24:1

Table 5: The ratio in percentages of all students attending science courses in the Higher Preparatory Examination courses and the female/male ratio.
The general female/male ratio of all students is 2.3/1 (1993/94) [20]

	Subjects	Ratio %	Ratio ™/¡
First year	Biology	88	2.7:1
Common core	Geography	65	2.3:1
(two of three subjects)	physics/chemistry	43	1.6:1
	Biology	15	4.1:1
Second year	Chemistry	8	1.8:1
Options	Computer science	4	1.1:1
	Geography	2	1.9:1
	Physics	7	0.7:1

1.5 Mandatory tests and examinations

Compared to most other countries Denmark has very few tests and examinations beyond continuous evaluation by the teacher. The teacher is the main key to standards.

The only the Science Examination in the *Folkeskole* is an optional oral examination in Physics/Chemistry for the Leaving Certificate and the Advanced Leaving Certificate. The examination is based on an experiment prepared by the pupil. *Folkeskolen's* Leaving Certificate in Physics/Chemistry is taken by about 80% of all pupils with equal number of girls and boys (1993). The Advanced Leaving Certificate in Physics/Chemistry is taken by 40% of all pupils in the 10th grade (55% of an age group) with a girl/boy ratio of 0.61/1 (1993) [22].

For the General Upper Secondary Leaving Certificate, national centrally-prepared examinations in the high level science courses are mandatory. The questions for these examinations are produced by a national committee of science teachers and graded by nationally appointed science teachers. Oral examinations with nationally appointed external examiners alternate between the subjects from year to year. Fifty percent of the student's total result consists of marks given by the teachers at the end of a course.[4]

1.6 New trends and reforms underway

Danish teachers have numerous teacher associations where each subject has its own teacher association with its own publications. Curricula, examinations, methods of teaching, teaching materials, etc. are continually debated. Within the *Folkeskole* a particular issue of debate is the consequences of the 1994 Act and its provisions. The implementation of differentiation within all subjects and of Nature/Technology at primary level without trained teachers and with far too low budgets for material and in-service training are vigorously criticised.

Within the *Gymnasium*, the issues of writing and differentiation in all subjects are being discussed; in particular the consequences of the ever increasing ratio of an age group attending the *Gymnasium* is the subject of debate. Targets of criticism are mainly the incoherence of the budgets and the demands for material and in-

4. For more detailed information consult: *Keeping up standards in Danish upper-secondary education*, The Danish Ministry of Education,. Department for General Upper Secondary Education, 1994 [11].

service training due to curriculum reforms. Extending the Higher Preparatory Examination courses from two to three years has also been considered.

2. How is science delivered?

2.1 Organisation and authority

The primary and lower secondary schools, the *Folkeskole*, are owned by the 275 municipalities who are responsible for organising education. The Act on the *Folkeskole* and the provisions of the act are "framework laws". The municipalities are responsible for organising education and for establishing the curriculum for their schools. The supervision of the municipalities is in the first instance left to the counties of which there are 14. Supreme authority rests with the Ministry of Education.

All public upper secondary schools are owned by the counties. There are 231 general upper secondary schools, *Gymnasier*, of which 22 are privately owned but publicly subsidised [24]. The curriculum for the *Gymnasium* is laid down by the Ministry of Education alone, which has the supreme authority in all educational matters.

2.2 Resources and funding

Teaching material is free for all pupils. There is no national or other centralised approval of books or other kinds of teaching materials. Every school supplies their pupils with teaching materials. The final authority in this field belongs with the school committee, which consists of elected representatives of the parents, teachers, staff and the headteacher. In the upper secondary schools, the authority belongs to the director and finally the Ministry of Education.

The publishing of books and teaching material is a matter of private enterprise and commercial competition. Every school has its own laboratories for the various sciences with equipment normally matching the teaching material used. However, following the implementation of Nature/Technology at primary level in 1994, teachers and schools have not as yet been allocated a reasonable budget for teaching materials by the authorities.

Schools have their own libraries and are provided with audiovisual aids. Most schools also have their own workshop, photocopy machines, etc. Science teachers often produce their own worksheets. Each county has one or more Educational Centres where schools and teachers can get information about books and teaching materials. Books can also be loaned for teaching purposes and teachers can produce their own teaching materials and audiovisual aids in a workshop.

2.3 Methods of teaching

Danish teachers are traditionally autonomous with respect to teaching methods and there is no state or other centralised approval of teaching materials. In Nature/Technology at primary level the aim is for child-centred, investigative, mainly practical, group work although the actual outcomes remain to be seen.

Teachers are encouraged to comply with the request to differentiate their teaching methods through dialogue with the individual pupil and groups of pupils. In addition they should share experiences within practical work and the life, world with their pupils, to encourage them and to establish self-confidence and active participation. The intentions are, moreover, towards cross curricular thematic approaches to life-world topics. Books published until now do not seem to entirely support these approaches. Varying from school to school, and from teacher to teacher, pupils are asked to do some homework.

In lower secondary science there is a strong tradition of a balanced method of lecture mode with demonstration experiments, especially in Physics/Chemistry, and laboratory work and fieldwork. Teachers often ask pupils to do homework, including reading, preparing laboratory work and writing reports. In the general upper secondary school, the concepts of science are usually delivered in lecture form by the teacher. The extent of lecturing will depend very much on the subject and the teacher. This systematic approach will then be supported through exercises, problems and experiments which are carried out in groups. High level courses in particular are influenced by the final written examinations. A fixed number of lessons is reserved for experimentation which is carried out in groups. Experimental projects and independent investigations are mandatory and encouraged. Homework, for studying theory, doing exercises and problems, and for writing reports is usual.

2.4 Sources of pedagogic innovation

There are several sources of pedagogical innovation and in-service training depending in part on the type of school. As mentioned in the introduction, teachers in the primary and lower secondary and teachers in the upper secondary are trained differently (see section 6.1). The sources of innovation and in-service training are also different.

The Royal Danish School of Educational Studies is in charge of in-service training and educational research and development. The school has 8 divisions throughout the country and runs courses and projects for qualifying teachers mainly in the primary and lower secondary schools. The Royal Danish School of Educational Studies is of considerable significance and the main source of innovation for teachers. The Ministry of Education finances innovation projects in schools especially in connection with curriculum reforms, etc. Innovation and in-service training in the upper secondary schools rely on grants from the Ministry of Education. These grants often finance courses arranged by teachers associations and projects established by groups of teachers. Courses are also carried out at the educational centres mentioned in section 2.2 and they can provide teachers with practical assistance for their innovation projects. Targets for innovation are the new subjects and topics in the curriculum, differentiation, and teaching students to exercise control of their own learning and writing.

3. Going beyond school

3.1 Use of out-of school resources

Visits to science museums, hands-on science centres, and planetariums are recommended, but depend on the budgets and priorities of the schools. Some of the science museums have special services for schools with free materials and free guidance. Since all schooling, including teaching materials, is free, the payment by parents for these activities is a controversial issue. Field work and visits to nature reserves are also valued. Some of the reserves have free material and specially trained guides.

3.2 Consideration of public science-based issues within lessons

The new curricula recommend topics from the life world and special attention is drawn to environmental topics and issues such as exploitation of natural resources, energy supply and technology, science and society. In the primary and lower secondary school, health and sex education must be integrated into other subjects where appropriate.

3.3 Science education and vocational training

A variety of vocational schools have general science courses as well as job-related science courses.

3.4 Science clubs and cultural associations

Denmark has a youth organisation in science (*Ungdommens Naturvidenskabelige Forening*) and the Danish Association for the Conservation of Nature has a youth organisation (*Natur og Ungdom*) with many different activities. Many other youth organisations in sports and the Scout movement are devoted to investigating nature and environmental issues.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Denmark does not usually participate in international surveys. However, for the first time, and on a minor scale, Denmark is participating in the test activities of the IEA - the Third International Mathematics and Science Survey (TIMSS). The results are not yet available.

4.2 Public or political concerns about educational standards

Political concerns in the 1980s about educational standards resulted in an investigation of each educational subject throughout the educational system from primary up to tertiary level. The Project Content and Quality in Danish Education (Danish abbreviation KUP)[5] resulted in numerous reports and recommendations. Educational research projects were also launched to investigate possibilities and foresee problems in connection with reforms. The main result for science teaching was the implementation of science in the language line of the general upper secondary schools in 1988 and of Nature/Technology at primary level in 1994.

Science standards do not seem to be of great interest to the general public in Denmark compared with reading, writing and arithmetic.

5. Pupil interest and motivations

5.1 Generally by age and gender

Surveys of pupil interests and motivation have not been carried out recently in Denmark. Some small surveys from the early 1980s showed no difference in motivation and interest compared with other countries.

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5. More detailed information in: *Content and Quality in Danish Education.*, Ministry of Education and Research, 1994 [5].

Recruitment for science courses has not changed dramatically.

5.2 By type of science or topic by age/gender

In the figures in Table 4, it is obvious that physics is favoured by boys and biology is favoured by girls. Research also confirms findings from several countries that the preferences for topics within sciences are different for boys and girls. Girls tend to be more interested in human and socially-related topics.

5.3 Options for choice within science

Beyond the formal options referred to in section 1.3 and 1.4, it should be noticed that many curricula are framework curricula which leave a great deal of choice to the school and the teacher - and to the pupils depending on the degree of free choice allowed by the teacher. Development within the schools tends to leave more decisions to the pupils as a result of the idea of increased responsibility and control of learning.

5.4 Pupils' perspectives on the value of science

There are no Danish surveys on values, etc.

6. Training, status and morale of scientific teachers

6.1 Initial training

Teachers are trained in separate institutions according to the level or type of schools in which they will be employed.

The 18 Colleges of Education offer general teacher training of 4 year duration for the primary and lower secondary compulsory school [26]. These teachers are allowed to teach across the curriculum for the whole 1-9 (10) year compulsory school. There are no reliable statistics showing the qualifications of science teachers in the compulsory schools. However, very few teachers have any training in science. Teachers at the primary level especially have no training for teaching Nature/Technology, a science subject which was recently implemented by the new curriculum (1994). Also the Colleges of Education have as yet no courses for teacher training at that level. In general teachers are not trained to teach integrated subjects.

Teachers for the general upper secondary schools have graduated from one of the five universities, usually with two subjects. Their university training of five years is not different from the training of researchers and does not usually include educational training. To be allowed to teach in the general upper secondary schools they have to be Masters of Science and during their first year of service, half of the time is devoted to practical teaching methodology and a short course of theoretical pedagogy administered by the Ministry of Education. Teachers in science also have to take a course in experimental work administered by the universities.

Teachers in vocational schools have different backgrounds (including vocational). A relevant period of specialised training and some vocational experience form the basis of practical and theoretical courses in educational theory and practice offered by the State Institute for the Educational Training of Vocational Teachers..

6.2 Decision-making authority for the above

The Ministry of Education has the final authority in all matters concerning teacher training.

6.3 Continuing training

The Royal Danish School of Educational Studies is a national institution for in-service teacher training. The school has eight divisions throughout the country and runs courses for qualifying teaching mainly in the primary and lower secondary schools. The Royal Danish School of Educational Studies is of considerable significance and the main source of continuous training for teachers. However, the responsibility and permission for in-service training courses, and the granting of leave to attend them, rests with the municipalities.

In-service training for teachers in the upper secondary schools depends on grants from the Ministry of Education. These grants often finance courses arranged by teacher associations established by groups of teachers. The responsibility and permission rests with the directors, the school committees and the counties. Innovation, developmental work and in-service training are also initiated and financed at local level. Schools usually have a small budget for local courses. In-service training of any kind does not contribute to the teacher's career or salary. In-service training within the vocational school is administered by the State Institute for the Educational Training of Vocational Teachers.

There is no regular sabbatical leave for teachers. However, the government has introduced a scheme for sabbatical, further education or parental leave, which every citizen can obtain on certain conditions, for a minimum 13 weeks and a maximum 52 weeks (one year) with job security and 70% of the unemployment benefit rate.

6.4 Number, teacher/pupil ratio, gender, age profile

The teacher/pupil ratio in the primary and lower secondary schools is about 1/10.4 and the number of pupils per class is on average 18.4 (1993) and cannot by law exceed 30 [22]. The number of teachers is equivalent to 50,462 full-time posts (1993) [22]. The average weekly teaching load is 25 hours. There is a complicated system of converting teaching hours to other duties.

Because there is cross curricular teaching in the *Folkeskolen*, it is difficult to give an account of the age and gender profile of science teachers. However, there is a dominance of female teachers within *Folkeskolen* especially at the primary level, and a strong dominance of male teachers in the sciences especially at the lower secondary level.

In the general upper secondary schools the teacher/student ratio is about 1/9.2 with an average of 24.5 students per class (1993). There are about 8,905 teachers (1993), working an average of 1,567 hours per year. There is also a system here for converting teaching hours to other duties [24]. The age profile of all teachers can be found in Table 6 and the number and gender distribution within the sciences appears in Table 7.

Table 6: Age distribution of teachers in the General Upper Secondary School (1993/94) [20]

Age group	Number	%
^{2} 24	20	.2
25-29	315	3.5
30-34	700	7.8
35-39	1279	14.3
40-44	2081	23.2
45-49	2369	26.4
50-54	1314	14.7
55-59	524	5.8
60-64	268	3.0
65-69	90	1.0
≥70	6	0.1
Total	**8966**	**100**

Table 7: Science subjects and gender of science teachers in general upper secondary school (1993/94)[20]

Subject	Female	Male	Total	% Female	% Male
Biology	233	374	607	38	62
Computer science	35	144	179	20	80
Physics	156	959	1115	14	86
Physics/chemistry	15	118	133	11	89
Geography	120	383	503	24	76
Chemistry	147	393	540	27	73
Natural science	107	629	736	15	85
Technology	19	53	72	26	74
All sciences	**832**	**3053**	**3885**	**21**	**79**
All subjects	**6264**	**9308**	**15572**	**40**	**60**

6.5 Drop-out rates, late entries, maternal leave

Cross curricular teaching in *Folkeskolen* makes it difficult to give an account of the drop-out rates and late entries of teachers within science specifically.

Employees in public institutions in Denmark have a general maternal leave allowance of 8 weeks before and 24 weeks after delivery with full salary and job security. The father can take 2 weeks in connection with the delivery and maternal leave after delivery can be shared, with the father taking up to 10 weeks leave with full salary.

6.6 Status and salary

Salaries for teachers have generally decreased. The lifetime earnings for a teacher in the primary and lower secondary school, *Folkeskolen*, decreased by 38% in the period 1970-1990, and is lower than bricklayer's labourer. While the lifetime earnings of nurses and policemen are below even this level [23].

Lifetime earnings of teachers in the general upper secondary schools have decreased by 41% in the same period. However, the lifetime earnings of teachers in the general upper secondary schools is 18% more than teachers in *Folkeskolen* and on a level with other university-trained persons in public service, although below the earnings of private employees [23]. Teachers' salaries depend on negotiations by the teachers' union with the government.

Teachers in compulsory schools and teachers in upper secondary schools are considered to have very different jobs. The first group of teachers are trained at colleges of education. They are cross-curricular teachers and have to deal with pupils of all abilities within the same classroom. The other group of teachers are trained at universities. They usually teach two subjects and deal with the brightest 30% of the population. However, this ever increasing ratio causes problems for many teachers.

The status of teachers within the compulsory system has decreased during the last few years. Evaluation reports and debates in the media have questioned teachers' competence, and a new act on the government of the schools has diminished teachers' influence on their own working situation. Complicated agreements about salaries and working hours have also jeopardised the usually high social morale of teachers with regard to extra time for excursions, contact with parents, leisure time activities, etc. Early pensioning and dropouts to other occupations are not unusual.

The implementation of Nature/Technology at primary level relies heavily on an extra effort by the teachers given that the budgets for materials and in-service training are very low. Teachers may very well suffer from a decline in motivation. The status of teachers within the upper secondary schools is considerably higher and more stable. However, their teaching qualifications have been questioned and an extension of their training in teaching methods and pedagogy is being considered

7. Equality of opportunity?

7.1 Different status of the schools

The educational policy of Denmark aims at equal opportunity for all citizens. Any citizen has free access to the educational system at any time. Drop-outs can be retrieved through the adult educational system.

A number of private schools (about 10% within the compulsory system) are subsidised by the government. Owing to some turbulence in the public school system, attendance at private schools has increased over the last few years from 6% in 1970, to 11.3% in 1993. Some private schools are founded by parents because of dissatisfaction with the teaching methods within the public schools, e.g. some parents seem to prefer more traditional ways of teaching. Others have different observances: political, religious, educational, etc. Their status is more dependent on conviction and does not lend itself to general comparison with the public schools.

7.2 Regional differences

The Danish school system and system of social welfare ensures equality in opportunity throughout the country. Although policies within the municipalities differ somewhat, and their budgets vary in consequence, the fact that the supreme authority rests with the Ministry of Education ensures a level of equality.

7.3 Immigration and migrant populations

In 1993 there were 27,410 pupils in the public compulsory school system, or 5.2% of all pupils, with a foreign mother tongue [22]. The number is increasing. However, the distribution of foreign speaking citizens is very unequal. In some classes, especially in some urban schools, they can be in the majority. Teachers, schools and parents recognise the problems, but there do not seem to be any easy solutions. The Danish authorities have no significant policy for dealing with these increasing problems beyond an intention to maintain equality.

7.4 Special education for handicapped children?

The policy of the country is to integrate all kinds of handicapped children in normal classes as far as possible; and they are provided with extra staff and supplementary education. Handicapped children (about 1% of an age group) who are not able to be integrated receive education provided by schools within the counties.

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Appendix 1

The Aims of the Folkeskole

1) The Folkeskole shall - in cooperation with the parents - further the pupils' acquisition of knowledge, skills, working methods and ways of expressing themselves and thus contribute to the all-round personal development of the individual pupil.

2) The Folkeskole shall endeavour to create such opportunities for experience, industry and absorption that the pupils develop awareness, imagination and an urge to learn, so that they acquire confidence in their own possibilities and a background for forming independent judgements and for taking personal action.

3) The Folkeskole shall familiarise the pupils with Danish culture and contribute to their understanding of other cultures and of man's interaction with nature. The school shall prepare the pupils for active participation, joint responsibility, rights and duties in a society based on freedom and democracy. The teaching of the school and its daily life must therefore build on intellectual freedom, equality and democracy.

The full text of the act in English is available [1] and the official English translations of the aims and contents of the subjects can be obtained from:

The Danish Ministry of Education
International Relations Division
Frederiksholms Kanal 25 D
DK-1220 Copenhagen, Denmark

Appendix 2

The General Upper Secondary School (Gymnasium)

The following is a selected extract from the Executive Order concerning the subjects, etc. in the Upper Secondary School (the Gymnasium).

The full text for each subject contains aims of the subject, syllabus with comments and examinations.

1) The full text of the subject biology, obligatory level.

2) The syllabus for the subject biology, high level

3) The aims and the syllabus for geography, mathematics/language line, obligatory level.

4) The aims and the syllabus for chemistry, mathematics line, obligatory level.

5) The aims and the syllabus for physics, mathematics line, obligatory level.

6) The aims and syllabus for science (mathematics-physics-chemistry), obligatory, language line.

1. BIOLOGY

Obligatory Level

Aims:

The aims of instruction:

1) The students should acquire an understanding of biological methods and modes of thinking and gain knowledge of selected biological areas.

2) The students should develop some skill in describing and analysing biological systems on the basis of experimental work.

3) The students should receive some training in formulating and solving biological problems by means of scientific methods.

4) The students should acquire a fundamental scientific basis for analysing and evaluating the possibilities of technological development and its consequences for nature, society and the individual.

5) The students should learn to apply their knowledge of biology and its methods to forming an opinion about individual and social problems related to biology.

Syllabus:

The instruction is organised around topics. 3-5 topics are selected from the areas listed below, either using the areas individually or in combinations of elements from two or more areas.

The subject is experimental. Qualitative and quantitative investigations and experiments are an integral part of the instruction. Through experimental work the students are introduced to laboratory work and laboratory safety.

In connection with the teaching, the students learn to present biological information and understanding.

The students should carry out experiments in 15-20 lessons.

The instruction comprises the following areas:

1. Introduction - biology as a subject and a science

The working methods, the subject areas and the application of biology as well as the world picture of modern biology must be studied as an introduction to the instruction and then expanded upon later in the course.

2. Human Biology

Through the instruction the interaction between the individual and the environment is studied in such a way that the human organism is considered in an overall perspective.

a. Physiology - Health and Disease

The instruction takes as its starting point issues relating to health and prophylaxis.

The instruction includes a survey of the organ systems and functions of the body and a study in depth of factors especially related to the absorption, transportation and transformation of matter and energy.

The structure and function of selected organ systems as well as the general structure and function of the cell must be included.

b. Reproduction

The instruction comprises human sexuality and the physiology of reproduction, including the structure and function of the sexual organs, hormonal regulation, pregnancy and birth. Furthermore, contraceptive methods, venereal diseases as well as examples of various aspects of human heredity and new biological techniques are studied.

Cell division and the structure and function of chromosomes are included in the instruction.

3. Ecology - Environmental studies

The instruction deals with man's utilisation of and influence on nature, including the concept of sustainable utilisation.

The instruction includes practical studies in connection with one or more ecosystems.

Primary production, secondary production, food chains and food webs, the adaptation of organisms to the environment as well as principles of the transportation of matter and the transformation of energy in the ecosystem are included in the instruction.

Examination:

There is an oral examination with time allotted for preparation, amounting to about 20 minutes, including time for giving instructions and handing out material. Including the time taken for deciding upon the final mark, three students are to be examined per hour. 120-150 pages of the syllabus studied intensively, with the integrated experimental work, is selected for use in the examination of ordinary students.

Independent students or students under special circumstances select approximately 180 pages of the syllabus studied intensively, along with the related experimental work, for use at their examinations. The experimental work may be done at a laboratory course, cf. Executive Order on Higher Preparatory Examination Courses.

Students may use books and other material listed on the form used to submit the syllabus read during the instruction and the syllabus selected for the examination.

The students' own notes and laboratory logs as well as approved pocket calculators and dictionaries of foreign words may also be used at the examination.

The candidate is required to answer one examination question, which normally must be accompanied by sub-questions about precise details and supplementary material, e.g. tables, diagrams or apparatus. The examination question must normally be accompanied by supplementary material that is unknown to the candidate as well as material that has been studied. The experimental work must be included in the examination questions to an appropriate extent.

One single mark is given, based on a general assessment.

2. BIOLOGY

Mathematics line

High level

Syllabus:

The instruction alternates between work with topics and other teaching units. The choice of topics must ensure coverage of the following areas:

1) Biology as a Science.

2) Biological Production and Biotechnology.

3) Health and Disease.

4) Nature and the Environment.

The subject is experimental qualitative and quantitative investigations and experiments are an integral part of the instruction. The theoretical and experimental work should be organised in such a way that the students will gradually learn to plan and carry out studies and experiments on their own.

In connection with the experimental work, the students should be trained in assessing possible risks and in taking the necessary safety precautions while working with equipment, chemicals and biological materials.

The students are trained in making critical appraisals of working methods and test results.

In connection with the instruction the students must learn to present biological information and understanding. This is done by oral presentation, by writing papers of a qualitative as well as a quantitative kind and by preparing reports. Other forms of presentation may also be included.

The students are to carry out experiments in about 60 lessons.

The syllabus comprises:

1. Genetics and Evolution

The instruction must ensure a broad introduction to genetic theory and method, including human genetics, population genetics, the theory of evolution, and the application of genetics in research and production.

The molecular and cellular basis of genetics is included in the instruction. Furthermore, cell differentiation and embryology, hereditary patterns, the interaction between heredity and the environment, mutations, natural selection, improvement and genetic engineering must be studied.

2. Physiology

Human physiology is developed, and examples of physiological factors in plants and animals are given.

In the instruction emphasis must be placed on the relationship of structure to function, the maintenance of balance and the interaction between the individual and the environment.

The molecular basis of physiological processes, as well as their basis in the biology of the cell and of tissues, is incorporated in the topics and other units studied.

When dealing with human physiology, problems related to health promotion, the causes of disease, prophylaxis and treatment as well as the application of medical technology are included.

The following processes are to be elaborated on and treated in the instruction: absorption and transportation of matter, transformation of matter and energy, excretion, movement as well as biological regulation in connection with hormones, the nervous system and the immune system.

3. Ecology

Ecological problems are developed within the following sub-areas: biological production, the utilisation of resources, environmental pollution, and nature management. Taken as a whole, the topics must ensure insight into ecological theories, methods and models. Furthermore, examples of the adaptation of plants and animals to the environment are included.

Gross and net production, cycles of elements and the transformation of energy, eco-toxicology, population biology, behavioural biology, as well as the development and sustaining capacity of eco-systems are elaborated and studied in the instruction.

4. Biochemistry and Biophysics

Biochemistry and biophysics form an integral part of the instruction within the topics and units selected.

The structure and function of carbohydrates, fats, proteins and nucleic acids are studied. Enzymology, molecular transport processes, chemosynthesis, photosynthesis, protein synthesis, intermediary metabolism as well as methods of biochemical analysis are also included.

5. Microbiology

Microbiology forms an integral part of the instruction in the topics and units selected. Micro-organisms as the causes of disease, the function of micro-organisms in the ecological systems, micro-biological laboratory methods as well as the application in research and production of micro-organisms are included.

6. Elective project work

For a period of about 30 lessons the students are to work on projects of their own choice. This work is usually carried out in groups.

3. GEOGRAPHY

Obligatory level

Aims:

The aims of the instruction:

1) The students should gain knowledge and understanding of the interaction between various natural and man-made factors that influence the material conditions of human life on earth.

2) The students should gain skill in the application of scientific methods and the methods of the social sciences, as well as the use of technical aids to observe, describe and analyse geographical phenomena.

3) The students should achieve an understanding of the effect of technological, economical, political and historical development on the interaction between nature and society - locally and globally.

4) The students should achieve an understanding of the connections between man's exploitation of the earth and its natural resources and the environmental consequences of this - locally and globally.

5) On the basis of knowledge and insight the students should develop an ability to form an opinion on Danish and international environmental and societal conditions in an independent and balanced way.

Syllabus:

The syllabus comprises the following subject areas:

1) Nature and the environment

2) Industry and population

3) Regional analysis

In the course of the time allotted for instruction 3-5 different topics must be chosen that are suitable for demonstrating essential aspects of the interaction between man and his surroundings - natural as well as man-made. If 4 or 5 topics are chosen, one of these may be freely chosen from the aims of the subject and take up to 20 per cent of the instruction time.

Topics must be chosen in such a way that the social as well as the natural aspects of the subject are carefully studied, and in such a way that the consequences of the interaction between society and nature occupy a central position. The choice of topics must ensure that the students gain insight into local, national and global conditions and that problems of industrialised countries as well as problems of developing countries, along with their mutual relations, must be included.

Part of the instruction must deal with conditions in Denmark.

The following are to be used in the instruction: maps, aerial photographs, satellite pictures, statistical material and measuring equipment.

1. Nature and environment

The instruction must ensure knowledge of the natural basis for man's activities and the environmental consequences of these.

The topics must be chosen so that the students gain basic knowledge of global climatic conditions and the water cycle. Depending on the topic, the following are studied: geomorphology, soil science, the geology of raw materials or the theory of plate tectonics - or combinations of these to an appropriate extent.

2. Industry and population

The instruction must ensure knowledge of the structure and spatial distribution of production.

In connection with production, population conditions and commercial structure must be studied, as well as the connection between them, and elements of the cultural landscape in cities or in the countryside must be studied.

In the analyses, the developmental aspect must be stressed. The choice of topic must ensure thorough knowledge of one industry in Denmark.

3. Regional analysis

Regional analysis consists of a comprehensive study of an area.

In this study, emphasis must be placed on the natural and societal basis for production and the conditions of life in the region as well as the position of the region in a global and in an international context.

4. CHEMISTRY

Mathematics line

Obligatory level

Aims:

The aims of the instruction:

1) The students should acquire a basic knowledge of the language of chemistry, its concepts and methods of calculation.

2) The students should become acquainted with experimental methods of work in chemistry and become aware of the elements of risk, safety precautions and environmental factors.

3) The students should achieve a certain ability to express themselves concerning chemical problems.

Syllabus:

The instruction comprises the following core topics:

1) the periodic system and the study of some relevant elements and their compounds;

2) the composition, structure and states of matter;

3) chemical calculations of quantity, energy changes, and basic types of reactions;

4) organic chemistry including the diversity of carbon compounds;

5) risks and safety precautions when handling chemical substances.

6) In addition some options must be included.

The options should take up at least 10 per cent of the time allotted to instruction and must include one connected teaching unit that forms a whole.

The instruction must include theoretical problems and calculations. Experiments by students and demonstration experiments must be carried out, and a record of laboratory work must be kept. Experiments by students take up 15-20 lessons.

5. PHYSICS

Mathematics line

Obligatory level

Aims:

The aims of the instruction:

1) The students should gain an understanding of the world around them and a knowledge of the scientific picture of the world.

2) The students should gain insight into the principles and methods of physics underlying the technology of our time.

3) The students should become familiar with the methods and the way of thinking in the science of physics.

4) The students should gain an understanding of central areas of classical and modern physics by working with physical theories and experiments.

5) The students should become able to apply physical principles and methods to describing selected areas of the physical world around us.

6) The students should become able to process and evaluate information about technological and scientific problems relevant to our culture and society.

7) The students should become able to express themselves orally and in writing on physical and technological topics.

Syllabus:

The syllabus must be organised so that it comprises a core syllabus, including the following dimensions:

1. The immediate surroundings

The students must acquire an understanding of the possibility of explaining phenomena in our immediate surroundings on the basis of physics.

2. The physical world picture

The students must gain an impression of physics as a coherent description of nature.

3. Physics in the light of history and philosophy

The students must acquire a knowledge of parts of the history of physics and gain an impression of physics as a mode of perception.

4. Technology

The students must acquire a knowledge of the concrete application of the results and methods of physics in technology.

5. Technology and society

The students must gain an insight into the close relationship between progress in physics and the development of society and technology.

The core syllabus is:

1. Energy

Various forms of energy and energy conversion. The conservation of energy. Energy sources, the storing of energy and energy quality.

2. Electrical circuits

Circuits with linear components. Examples of non-linear and active components.

3. Waves

Wave propagation, interference, reflection and refraction. Sound.
Electromagnetic waves.

4. Atomic and nuclear physics

The components of atoms and atomic nuclei. The emission and absorption of radiation. Radioactive decay. Ionising radiation.

5. Mechanics

Linear motion of constant velocity and constant acceleration. Simple harmonic motion. Newton's laws. Work and energy.

The instruction must be organised so that all the dimensions are included. Principal consideration must be given to the following dimensions: 'The immediate surroundings', 'The physical world picture' and 'Technology'. For each of these dimensions at least one teaching unit must be planned, the principal aim of which is to illustrate the dimension in question.

The experimental work performed by the students themselves must amount to about 40 lessons. One half of the time is to be spent on student experiments, about which the students write individual reports. The other half of the time is devoted to experimental projects. This project work is done in small groups, each with its own assignment, and a group report is to be submitted on each project.

The treatment of numerical examples and problems must be included in the work, both in the lessons and as part of the students' independent work in the subject.

6. SCIENCE

(Mathematics-physics-chemistry)

Aims:

The aims of the instruction:

1) The students should gain knowledge of and skills in some central areas of mathematics and the natural sciences.

2) The students should gain knowledge of methods and modes of thinking in mathematics and the natural sciences.

3) The students should be enabled to evaluate and form an opinion on problems that they encounter in other subjects and in everyday life that involve mathematics and the natural sciences.

Syllabus:

The syllabus includes mandatory core material and material that may be freely chosen. The core material and the material for free choice are studied in teaching units of varying length that are organised around topics. Part of the material may, however, be studied in ordinary teaching units. The students must be able to make both qualitative and quantitative evaluations in the areas studied and must be able to solve simple numerical problems.

The instruction must include a significant experimental element, partly consisting of experiments carried out by students, on which they are to produce reports or records, and partly consisting of demonstration experiments.

The mandatory core material comprises the following, in alphabetical order:

1. Atoms

The components and structure of the atoms as well as the periodic system. Nuclear processes and radioactivity. Examples of electromagnetic radiation.

2. Energy

Examples of energy forms and energy conversion.

Energy supplies.

3. Cosmology

The solar system, stars and galaxies.

Description of the evolution of the universe.

Historical examples of world pictures.

4. The environment

Safety in technological processes.

Environmental topics of current interest.

5. Reactions

Examples of precipitation reactions, redox reactions, and acid-base reactions.

6. Probability and statistics

Probability space.

Examples of probability distribution.

Dealing with data, statistical descriptors.

7. Numbers

Elementary calculation.

Calculating percentages.

Using technical aids for calculating.

8. Growth

Linear and exponential growth.

Examples of other growth models.

The material for free choice takes up about 1/3 of the instruction time.

Report from Germany

Kurt Riquarts

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

a) Primary education

In Primary School (grades 1 to 4) a five or six day school week is divided up into 20 or 25 class periods (45 minutes each). Lessons usually only take place in the morning. Science-based topics cover about one period per week (see Appendix 3).

b) Secondary education

At Secondary Level I (grades 5 to 10) a six or five day school week is divided up into 30 to 35 class periods (45 minutes each), mainly in the morning, except in comprehensive schools. The average time devoted to science in these six years is 20 periods per week (from a total of 180) (see Appendix 4).

1.2 Which sciences are to be taught

In primary school there is a subject called *Sachunterricht* (which could be translated as 'teaching about things' or 'teaching about real objects') which covers 3 or 4 periods per week on average - usually one third of it is devoted to science-related topics.

At secondary level I the subjects taught are biology, chemistry, physics and, to some extent in some *Länder* (states) - technical science. In the comprehensive systems for grades 5 to 8 there is a coordinated science approach.

The extent to which science is taught varies according to the different type of school as well as to the *Länder*; increasing differentiation of teaching in terms of subject specialisation is another characteristic for the secondary education course.

The main differences between the *Länder* are:

1) The grade in which science education starts:

Biology starts in grade 5, physics in grades 5 to 8, chemistry in grades 5 to 9.

2) Introduction in science education:

The introduction phase for each of the three subjects lasts up to one year; the earlier natural science teaching is begun, the more likely it is there will be an introduction.

3) Total amount of science education at secondary level I:

The overall time devoted to science during grades 5 to 10 ranges from 14 to 30 periods per week, which means 2 to 6 periods per week per year. In those states with few compulsory science lessons usually half of the time is devoted to biology; when more time is available for science, it is for the benefit of physics and - to a lesser extent - chemistry.

4) Science syllabus:

Each state has its own official curriculum or syllabus which is also different for each type of school (16 states times 4 types of schools on secondary level I equals 64 syllabi for biology, 64 for physics, etc.) The main differences are not to be found in the topics to be taught, but rather in the delegation of the contents to varying class levels and in the varying didactical conceptions. The contents for one type of school are given as an example of the differences (see Appendix 5). For other types of schools, see Riquarts 1995.

At secondary level II (grades 11 to 13) science is compulsory on a basic level for at least two years. But the students still have a choice of the subject - biology, chemistry, physics. On average, biology is chosen twice as much as physics and chemistry. At secondary level II the students have to choose two specialised two-year courses. Within all the Länder an average of 40% of the students take biology, 16% physics, 13% chemistry. Optional courses may be chosen, e.g. astronomy, technology, statistics, data processing.

The focal points for biology courses at the upper secondary level are:

- cell biology
- genetics

- metabolic and developmental physiology
- processing information and behaviour
- ecology and environmental protection
- evolution theory.

The focal points for chemistry courses at the upper secondary level are:

- fundamental concepts of organic chemistry
- chemical reactions (e.g. acidic, basic and redox reactions)
- electrochemistry
- nuclear chemistry.

The focal points for physics course topics at the upper secondary level are:

- fundamental concepts of mechanics (e.g. impulse, force, energy)
- waves
- fields
- electricity
- nuclear physics.

The topics treated in the basic courses are usually the same as in the advanced ones. The main difference lies in the time available and the level of the material to be covered (see Riquarts 1995).

1.3 Realistic data on the above

As the school supervisors watch over the aspects listed under 1.2 (time schedule, curricula), it may be assumed that the lessons are taught to the extent mentioned and covering the topics listed. All state syllabi indicate that the time allocated to the core curriculum should not exceed two thirds or three quarters of the time available; the remaining time should be spent on additional or cross curriculum topics. This does not seem realistic; classes not taught due to a lack of teachers or teachers' attempts to teach everything in the curriculum perfectly lead to insufficient time for additional activities.

1.4 Recommended learning activities

The syllabi in Germany are content based. The learning activities mentioned are usually part of the preamble to the curricula. They are, thus, at the individual school's or teacher's discretion. Laboratory work in physics and chemistry usually has a preferred position; about one quarter of the teaching time is spent in the laboratory trying to achieve scientific understanding by involving the students in problem-solving activities which help them develop conceptual knowledge, establish relations between these concepts and use them to explain and predict natural phenomena.

Field studies and topics such as the history of science and science in industry tend to be more marginal. Controversy in science history tends to be limited to the upper secondary level.

1.5 Mandatory tests and examinations

At the national level there are no mandatory tests and examinations. The responsibility lies with the individual school, but strictly bound to the syllabi of the particular state for the type of school in question as well as for a single subject.

Six of the sixteen states have a centralised examination only for the *Abitur* (school leaving examination for university entry).

In order for one state's *Abitur* to be recognised by all of the states, the KMK (Standing Conference of the Ministers of Education) has agreed on binding standards which set down which contents are to be tested at which level for the *Abitur* examinations.

1.6 New trends and reforms underway

In a federal state, reforms cannot take place at the national level. In the *Länder* there are permanent reforms of the syllabi for the various ongoing subjects. As the study by Hopmann (1988) shows, the average life expectancy for a syllabus is seven years, i.e. after completing implementation of a syllabus the next revision commission is called into action.

There have been no major changes with regard to the contents lists, i.e. in the strict sense of scientific contents (exception: addition of biotechnology in the biology curriculum, secondary level II), but it should be noted that the opening up of physics education to technical and technological aspects and especially for moderate STS perspectives has increased.

There is a lot going on in the area of research and development, and it is affecting teacher training.

The computer is, of course, becoming more and more important. So many new programs have been developed including those from companies which supply teaching materials. But the research boom has lost some of its impetus as not all of the expectations have been fulfilled.

In general : It has been recognised that a pupil's perspective is necessary and that the pupils' interests, learning abilities and needs must be taken seriously, i.e. their ideas. Concerns include STS, project teaching (project days, weeks) and open teaching, and the right to choose some elective courses at secondary level I.

2. How is science delivered?

2.1 Organisation and authority

The Federal Republic of Germany comprises 16 *Länder* (states), which have exclusive jurisdiction in the educational sphere. Authoritative control includes regulation of the curriculum, time schedules, professional requirements, teachers, school buildings, equipment and recruitment of teachers. Only about 4-5% of children attend private schools, which are financially supported and supervised by state authorities (see Appendix 13).

Owing to the fact that the authority for the school system lies with the *Länder*, one finds a few key differences between the educational structure of the *Länder* (e.g. compulsory schooling: 9 or 10 years; comprehensive schools yes or no; free learning aids) and many differences in detail (e.g. expression of subjects; time schedules; variety of optional subjects and courses).

The Federal Minister of Education and Science has a concurrent right of legislation for the non-school vocational sector, as well as a right to outline legislation on general principles for the university system and joint legislative functions for educational planning, the promotion of scientific institutions and research projects of national significance.

This right of the federal authority is regulated in an administrative agreement on the establishment of a *Bund-Länder* (Federal and State) *Commission for Educational Planning and Promotion of Research* (BLK). The Commission is a standing forum for all research issues affecting both the federal authorities and the *Länder*, including in particular preparation of joint long-term outlines for synchronised development of the education system as a whole (*Bildungsgesamtplan*: general education plan) and assessment of its realisation costs. Furthermore, the Commission decides which educational research and innovation processes should be implemented, laying down both the extent of such experiments and the order in which they should be conducted. A number of educational pilot projects have been financed by federal and *Länder* authorities.

The *Länder* coordinate their educational policy through the institution of the *Standing Conference of Länder Ministers of Education* (KMK). Resolutions and recommendations only become legally binding when they are promulgated in the form of state laws, decrees or regulations by *Länder* authorities. The KMK also deals with all curricular problems and innovations requiring coordination, such as recognition of examinations, schooling of foreign pupils or environmental education (for details see Appendix 1).

The states organise the supervision of the school system in the following way:

- Ministry of Education
- regional school board
- county school administration.

The intermediate level (b) is omitted in the nine smaller states.

Compulsory schooling commences at the age of 6 and finishes at 18. Nine (or ten) of these years have to be spent in full-time schooling; the following years either in full-time schooling or part-time vocational schools, e.g. in connection with an apprenticeship (for the structure see Appendix 2).

Pre-school:
The kindergarten for three to six year-olds is not directly linked to the education system and attendance is voluntary.

Primary:
The primary school (*Grundschule*) is the lowest level of the educational system attended by all pupils. It comprises grades 1 to 4 (6 to 10 year-olds).

Secondary level I:
(10 to 16 year-olds) offers differentiated teaching in accordance with young people's ability, talent and inclination and includes:

- the *Hauptschule* (grades 5 - 9/10)
- the *Realschule* (grades 5 or 7/10)
- the *Gymnasium* (grades 5 - 10) 10)

and, as a school experiment in all *Länder* and a normal form of school in some *Länder*, the Integrated and the Cooperative Comprehensive school.

In 1993, the distribution of the 14/15 year-olds (grade 8) is as follows (see Appendices 6 and 7):

Hauptschule	28.1%
Realschule	28.6%
Gymnasium	30.3%
Comprehensive Schools (including Waldorf schools)	9.2%
Special Schools	3.8%

According to the special task of the types of school one finds many differences in the time-schedule and even in the subjects.

Secondary level II:
(16 to 19 year-olds) offers a three year course, which leads to university entrance qualification (*Abitur*). Since the mid 1970s the course is no longer organised in terms of types of *Gymnasium* (classical, modern languages, mathematics and science), but is replaced by a system of basic and specialised courses as well as compulsory and optional ones.

During the last two years of schooling (grades 12 and 13) students must take a total of 28 courses, 22 at the basic level and 6 at the advanced level. All subjects are grouped into three fields of knowledge:

- language, literature and the arts
- social sciences

- mathematics and science.

There are quite a number of limitations in the students' choice of subjects to ensure that all students reach proficiency in a broad range of subjects.

The final examination (*Abitur*) must be taken in 4 subjects: one each of the three mentioned fields of knowledge, and in two advanced levels.

Secondary level II also encompasses full-time or part-time vocational education. The West German 'dual system' of vocational education involves cooperative apprenticeships at two learning sites: the school and the workplace. Enterprise-based vocational training then has two sponsors: the *Länder* governments establishing and financing vocational schools, together with enterprises themselves financing and providing apprenticeships. Correspondingly, responsibility in enterprise-based vocational education is also split. The authority shared between the *Länder* Ministers of Education, the Federal Minister of Education and Science, the Federal Institute for Vocational Training and representatives of industry, commerce, the skilled trades and trade unions.

Handicapped children attend various forms of Special schools.

Normally a school day begins at 8 a.m. and ends at 1 p.m. There are a small number of all-day schools with two sessions a day. The number of weekly periods (of 45 minutes each) depends on the student's age, beginning with 20 per week and increasing to 36. The school year lasts approximately 38 weeks, commencing after summer vacation.

2.2 Resources and funding

The schools are financed in three ways:

1) The personnel costs (teachers) are paid by the states. The teachers (who are usually state civil servants) are assigned to the schools according to the number of pupils enrolled. The amount paid by the 16 states was DM 45,542 million in 1991; about 36% of their budgets.

2) The non-personnel costs (such as building maintenance, equipment, laboratories, libraries, etc.) are paid by the county, whereby the state contributes to new construction and larger investments (e.g. computers). The amount paid by the counties in 1991 was DM 12,092 million; about 15% of their budgets.

3) In some states parents have to pay for textbooks and learning materials. In the states governed by Social Democrats the costs for textbooks are mainly covered by the county.

In 1991 the expenditure for primary and secondary education was 3.8% of the GDP (OECD 1993; BMBW 1994).

Authors/publishers can develop textbooks based on the required state curricula. These textbooks are inspected to see whether they comply with the legally proscribed subject-oriented curricula. For this reason, textbooks in Germany have to be 100% dependent upon the syllabus in order to be licensed. Either the teacher or the subject department head selects the textbook to be used from that particular state's list of approved textbooks.

2.3 Methods of teaching

The decision about teaching is the teacher's responsibility. According to the contents in the syllabus, the teacher decides which teaching method he/she feels is appropriate.

There are no data available showing which teaching method predominates.

As pupils are usually in school only in the morning, there is an increasing amount of homework to be done by the pupils - from a few minutes in primary school to four to five hours for secondary level II.

2.4 Sources of pedagogic innovation

According to the federal set-up in Germany, there are various agencies responsible for innovation:

1) Federal level: The BLK (see section 2.1), comprised of the federal government and the 16 states, promotes (and finances) educational research and innovation processes via pilot projects. The main foci in the sciences within the last years have been 'girls and science' and integrated science approaches.

2) On the state level, the system of innovation is completed by institutes of educational research, in-service teacher training and school administration. These institutions - close to the state ministries of education - give a form of research support to administrative and in-service activities as well as planning and processing curriculum development and implementation of new syllabi,

concerned lately with, for example, the introduction of computer literacy, biotechnology or projects with an integrated science approach (see Bünder/Lauterbach 1994)

3) Educational research is pursued at universities and colleges of education. Additional research institutes alongside the universities deal with basic and applied research. Their work is characterised by an interdisciplinary approach, problem orientation and policy improvement focus. The institutes are publicly maintained, with four of them (e.g. the IPN at the University of Kiel) funded jointly by the Federal and *Länder* authorities.

4) On the local (school) level, the teachers simply decide whether any of these offers suit their specific requirements, in line with their independence (see section 2.3).

3. Going beyond school

According to the system described, the use of resources beyond the fixed context-based syllabus depends on the individual teacher. In the following, only the possibilities, not the use, can be described.

The time available for out-of-school activities is at least two days per school year. Teachers usually use these days for excursions, e.g. visiting local industries, science museums, nature reserves. Most schools devote a week to a project. Projects focus increasingly on topics from environmental studies or STS based issues (see section 3.2).

3.1 Use of out-of school resources

There are a large number of science museums and natural resources; a recent list, prepared for school use, sets the number at 120 (see Diekmann 1989), not counting numerous locally used parks and initiatives. The most well known is the Deutsche Museum in Munich, with an annual budget of DM 25 million, a 700,000 volume library and about 1.6 million visitors each year. About half of these visitors are students on class trips with their teachers.

The publicly funded media section broadcasts an educational radio and television programme which in the past was mainly intended for immediate use in the classroom. Due to competition from private broadcasting companies and especially because of advancements in technology, there is a clear trend towards programmes suitable for students but broadcast at non-school hours.

Schools can borrow such programmes free of charge from local media centres along with 16mm films and slide series. The most important producer of such material, which usually includes a booklet with additional material, is the *Institut für Film und Bild in Wissenschaft und Unterricht* (FWU - Institute for Film and Picture in Science and Teaching), which is jointly funded by the states and the federal government. The FWU lists about 5,000 media entries of which 1,500 are 16mm films, 1000 are slide shows, 1,000 are video cassettes and 300 are computer software. About 300 new listings are added annually. One quarter of the material has been produced for use in science classes (FWU 1993).

3.2 Consideration of public science-based issues within lessons

The topics with a social-political reference taught in class are mainly tied in with current events. During the 70s they were mainly questions about energy, in particular atomic energy, which were discussed in physics classes. During the 80s some of the same questions were discussed from an environmental perspective, thus moving them from physics lessons to biology lessons. Focal points were also questions about biological equilibrium, water and soil pollution, acid rain and the deforestation of the tropical rain forests. In the 90s, the trend is towards questions about the effects of science on society; one of the key words is 'sustainable development', e.g. an attempt to place an individual phenomena in context and do without subject-specific content in order to see the scientific relationship as a whole ('get the big picture'). The preferred teaching method for this is the project week.

3.3 Science education and vocational training

Vocational schooling/training operates in a dual system involving on-the-job training and part-time attendance at a vocational school. Responsibility for supervising the former lies with the federal government and for the latter with the *Länder*. This apprenticeship system is financed by the *Länder* (by financing the vocational schools) and by the enterprises (offering youngsters jobs and paying them an apprentice salary).

At the moment schooling is one day per week, gradually extended to two days within the coming years. The subjects are (a) core ones, e.g. German, mathematics and social sciences, and (b) specialised classes for specific jobs.

After completion of compulsory schooling, about 30% of the age group go on to secondary level II in school, and about 60% start their vocational training in the dual system described above. Appendix 8 gives an overview of the ten apprenticeships most frequently chosen by boys and girls. The figures clearly show the gender differences: the male apprentices prefer applied science jobs, whereas the female apprentices tend to prefer clerical professions such as consulting room assistants and 'caring' professions such as doctor's assistants.

3.4 Science clubs and cultural associations

Natural science associations have a tradition in Germany reaching back over 100 years. They have a total of four to five million members, 20 to 30% of whom are young people, depending on the goals of the particular association. The organisations include:

- general science societies at the local level, usually with 20 to 150 young people;
- societies - often at regional level - with specific science interests, e.g. a nature reserve in the mud flats of the North Sea;
- associations operating at national level with a network of local branches, e.g. Federal Association for Health Education.

The activities of the 100 or so youth associations in the *Deutscher Bundesjugendring* (German Federal Youth Ring) are geared almost exclusively to formal groups. This national network encompasses some four million young people between the ages of 10 and 25 (not including the one million members of the *Sportjugend*, the youth sports association).

The association with the largest membership is the *Deutscher Naturschutz-Ring* (German Nature Protection Ring) with 93 societies and 3.3 million members, followed by the Youth Section of the *Deutscher Bund für Vogelschutz* (German Bird Protection Federation: approximately 30,000 members) and the *Deutsche Waldjugend* (German Forest Youth, about 5,000 members). These societies tend not to have a political approach, although in recent years the nature observation and investigative activities, which were previously the primary purpose of the societies, have been increasingly complemented by involvement in environmental protection issues.

Since the late 1960s, conservationist issues have increasingly given rise to *Bürgerinitiatives* (Citizens' Initiatives). They generally emerge as single purpose movements with interests, often determined by regional factors, ranging from traffic, energy supply and town planning problems to issues of nature protection. The estimated number of such initiatives varies between 4,000 and 10,000, as many movements of this type disband after completion of a specific task. Some 300,000 members, mainly young people, have joined the *Bundesverband Bürgerinitiativen Umweltschutz* (BBU - Federal Association of Citizens' Initiatives for Environmental Protection) which aims to formulate and implement a general environmental programme.

Practically all of the institutions mentioned thus far deal with the problems of new technologies and offer courses such as: An Introduction to Data Processing; Working With the Microcomputer; Effects of New Technologies. Although such topics feature increasingly in school curricula, the demand in the out-of-school sector is still very high. As girls have shown decidedly less interest in the new technologies than boys, the federal government, a computer manufacturer and a periodical have started a campaign entitled 'Computer Courses for Girls'.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Germany took part in the first IEA science study. Although the outcome was not that bad, the criticism was made that the study did not give a real picture of the student's achievements because of the loss of context and the US biased approach. The outcome did not have an influence on how science education should be run in the country. Germany was also involved in the Third IEA Study (TIMSS), the results of which were available in1995.

4.2 Public or political concerns about educational standards

The discussion about educational standards in Germany is a tradition that goes back some 150 years (standards are always said to be declining - see Hentig 1993). The polarisation always takes place between the general education aimed for and what society wants on the one hand, and specialised education that can be used in the workplace on the other.

This concerns the area of education that follows compulsory education (after 9 to 10 years): vocational education with its general educational work (an area generally considered exemplary) and the scholastic - on a comparable academic level - vocational education at secondary level II.

The expected improvements following the reform of secondary level II in 1972 (aimed at increasing specialisation in the last three years of school in function of studies) have not materialised. Owing to the German system of non-specialisation of the school leaving certificate leading to university studies (to wit, all subjects carry equal weight, therefore any subject can be studied at the university), pupils tend to take the 'easier' subjects to attain good final marks, without taking into consideration what they plan to study: a faulty development in the system.

4.3 Suggested reforms

The development of the full-time school system at secondary level II has failed to strengthen compulsory education - at least that is the opinion of the informed public. Most of the *Länder* have already altered - or will do so in the near future - the regulations at secondary level II with regard to the said course. As far as science is concerned, two of the three science subjects will be compulsory in grades 11 and 12, and at least one of them has to be taken in grade 13. Furthermore, the optional sphere is reduced to a set of possible subject combinations with the expected result that more pupils will have to take science lessons.

5. Pupil interest and motivations

The reform of the educational system which took place at the end of the 1960s was supposed to abolish all hindrances to equal opportunity within the system. The aim of the educational reform was to guarantee fundamental equal rights to education and unlimited equality for girls and boys. Coeducation was the basic educational principle which was to guarantee the equal treatment of all students regardless of sex.

Furthermore, the German system of a core curriculum does not include the choice of courses, except for a few additional options in some types of schools (see section 5.3 and Appendix 9).

5.1 Generally by age and gender

Empirical findings (see Hoffmann 1992) verified the following facts: that girls, in comparison with boys:

- are clearly less interested in physics, chemistry and computer science lessons;

- less often choose options (at secondary level I) and achievement courses (at secondary level II) in physics and computer science as well as in mathematics and chemistry;
- more often drop information technology after the introductory course in the upper secondary level of the *Gymnasium*;
- very seldom choose physics, technology and engineering sciences or mathematics and chemistry as the subjects to study, or choose a profession from one of these fields.

The numerous empirical findings which are available at present as well as our own separate results show:

1) That the pattern for girls' reduced interest in scientific and technical education is set in the area of pre-school and outside school.

By the end of the 5th grade, well before the majority of classes begin to study physics, girls generally show markedly less interest than boys in most of the areas of physics.

Girls get distinctly less support and encouragement from their parents to work in the areas of physics and technology or to embark on a scientific career. Sons, on the other hand, are encouraged in their leanings towards science and technology, daughters in their socially integrated activities.

2) That in pre-school and out-of-school areas, trends appear which are then reinforced by school and by lessons in physics, chemistry and technology. The syllabi as well as the modes of behaviour of both male and female teachers are influenced in the first instance by the interests, knowledge and abilities of the boys. The attitudes and expectations of male and female teachers are, like those of parents, greatly influenced by traditional stereotyping of gender roles. This results in a marked reduction of self image and a one-dimensional view of life on the part of both girls (who will be primarily family-oriented) and boys (where career development will be given priority).

5.2 By type of science or topic by age/gender

The results show that a reduction in prejudices towards girls in the area of scientific-technical education and professional orientation will not occur without corrective measures. It is not a question of convincing girls/women to take scientific-technical courses, but rather of making sure that all levels of qualification are open to them. The aim of education is to develop individual (girls and boys) abilities. A sufficiently high level of education allows girls to choose a profession according to their abilities and interests.

One of the attempts to cope with the failure of equal opportunities within the given coeducational system is a BLK intervention project (see Hoffmann et al. 1995). It focuses on the initial courses in physics and chemistry in grammar school and addresses the following concerns:

How can physics and chemistry lessons in *Gymnasium* be structured in such a way as to lessen the disadvantage sustained by girls in the area of scientific education and to keep the doors open to highly qualified jobs in science and technology?

1) Are girls' interest and participation in physics and chemistry lessons improved by lessons which relate to their life experience, abilities and interests and by the introduction of specific teaching methods and forms?

2) Can the loss of interest which has been observed in boys in both physics and chemistry also be reduced by the introduction of this type of altered lesson format?

3) Can such a change in the lesson format lead to a broadening of girls' self-conceptions?

4) Will these changes greatly encourage girls to take an interest in the natural sciences, apart from their participation in compulsory lessons, and take this into account in their choice of career (achievement courses and university studies)?

5.3 Options for choice within science

The foundation of German schooling is the core curriculum: at secondary level I (10 to 16 year-olds) there are no options of choice between the sciences (see the fixed time schedules for the various types of schools of the 16 states in Appendix 4). There are also a few additional courses to be chosen by the pupils from the whole range of subjects, an average of 4 lessons per week. This free time in the schedule usually comes about (beginning in 7th grade) with the second foreign language (which is required for the *Abitur* and is thus important for admission to university). Pupils who do not take the second language have to choose other courses; these other courses usually include a science subject (see Appendix 9).

At secondary level II (grades 11 to 13) the students have to take at least two of the three sciences for one year (grade 11), and one of these two for the next two years (grades 12 and 13) on a basic level. On average, students choose biology twice as often as physics and chemistry. In addition to the basic-level subjects, students have to take two courses in specialised subjects. From the whole range, 40% of students take biology, 10% physics and 13% chemistry.

5.4 Pupils' perspectives on the value of science

Traditionally, scientists have had a high image; they are regarded as experts in their field, and are seen as people who have an understanding of complex matters and know the answers to technological applications. Now expert knowledge is increasingly regarded as limited knowledge, taking no account of social issues or the implications of scientific development. Publicly these 'green issues' are dealt with by various 'Citizens' Initiatives' (see section 3.4).

The question of the value of science is tied to interest in science (see section 5) and the interest of the societal and career usefulness of the science subjects. Latest surveys show (see Hoffman/Lehrke 1986; Hoffmann et al. 1995) that although the intensity of the pupils' experience of natural phenomena appears to be reduced in the course of time, questions about the usefulness of the sciences, especially physics, show a contrary trend. Although interest in this area is reduced, its importance is increasingly emphasised. Gender specific differences are clear; only the boys see this importance in connection with a later profession.

6. Training, status and morale of scientific teachers

6.1 Initial training

Teachers for all kinds of schools - with the exception of those at pre-schools/kindergartens, and the technical instructors at general and vocational schools - are trained at universities and institutions of higher education. Admission to training depends on possession of the *Abitur*. Two training phases can be distinguished.

1) Academic studies - i.e. scholarly training in educational and social studies, the subject(s) to be taught, and teaching methods. This concludes with Part I of the degree examinations.

2) The introduction to school practice (on-the-job training) takes between one and three years depending on the job involved. This phase comprises practical

involvement in schools and complementary training at seminars. This concludes with Part II of the degree examination.

There have been attempts to merge the two phases of training but these were not successful.

At present, teachers in the Federal Republic of Germany are usually trained for specific kinds of schools - i.e. for primary schools, *Hauptschule*, *Realschule*, *Gymnasium*, vocational schools, etc. In most *Länder*, teacher training for primary schools and *Hauptschule* is completely integrated in universities. In some *Länder* this takes place in Colleges of Education, as was generally the case before the 1970s. Teachers at primary schools/*Hauptschulen* must complete at least six semesters (eight in Bremen) at an institute of higher education followed by preparatory service of between one and three years. Their studies usually involve one or two subject specialisations along with the general training. Training for teachers at *Realschulen* extends over the same period at college or university (with two main subjects) followed by eighteen months of preparatory service. Teacher training for the *Gymnasium* takes at least eight semesters in two subjects. The degree courses are discipline-oriented and prospective teachers are not taught separately from other students. Interdisciplinary and vocational courses at universities are rare.

The second, on-the-job, phase of training usually takes 18 months.

The technical teaching staff at vocational schools have completed training in the relevant skill, further training at a higher technical institution, and basic training in education at special courses. Teachers of general subjects and specialised theory at vocational schools have to complete eight semesters at an institute of higher education and usually also a year of relevant practical training. The probationary teaching period usually lasts 18 months. Teachers at Special schools are trained in therapy at university institutes or colleges of education. This normally takes eight semesters followed by probationary training of at least 18 months. In most *Länder* only people who have completed their training for positions in primary schools, *Hauptschulen*, *Realschulen*, or *Gymnasium* can receive training for appointments at Special schools.

6.2 Decision-making authority for the above

The responsibility for academic studies lies with the universities. The examination is a state one, but jointly prepared by a state representative (usually from the Ministry of Education) and the student's academic teachers.

The responsibility for the second phase of training (on-the-job training) lies with the local state which supervises the practical training in school and complementary training at seminars.

6.3 Continuing training

In all *Länder* there is ample opportunity for teachers to attend 'in-service training'. This is intended to keep teachers up-to-date on the development of the subjects they teach, as well as on the broader field of psychology and sociology in education and teaching methods. Courses are organised regionally or at state level, often during school hours, and teachers are excused from their school duties to attend. A start was made in recent years on correspondence courses for teachers.

The greatest number of courses in further education for teachers are offered by the state institutes for continuing and further education that were created in the 1970s (Bünder, Riquarts 1994); these institutes have full-time employees as well as part-time teachers for special courses. The focal points of further education in science are (a) procuring scientific knowledge and (b) enabling an exchange of experience, whereby the goal with the highest priority is - as studies have shown - 'procuring knowledge' for teaching science oriented towards the usual paradigm of the subject.

Other courses are offered by the Association of Science Teachers (MNU) as well as the universities.

As all teachers are civil servants, they are placed within a state according to need, although secondment is usually only done within a county.

Teachers do not receive sabbatical leave.

6.4 Number, teacher/pupil ratio, gender, age profile

The total number of full-time teachers rose from 210,000 in 1960, to 493,000 in 1990; the greatest increase was in the 1970s and 1980s although there was no comparable increase in students. At the same time the ratio of male to female teachers shifted in favour of male teachers (from 42% to 62%). This did not occur at the same rate in the various types of schools: there was a clear increase in female teachers at elementary schools to about 67%, whereas at the *Gymnasium* there was a slight increase to about 37% (see Appendix 10).

The considerable increase in the percentage of female teachers in 1992 (to 72% and 42% respectively) is due to the inclusion of the new federal states. Because of decreasing numbers of pupils in the late 1980s and reduced availability of financial resources, hardly any new teachers have been recruited in recent years (see Appendix 11).

From the 1960s up to 1990, the number of pupils per teacher consistently improved. It varies according to type of compulsory education. The numbers for 1992 were: special schools 6.1; primary schools 20.0; *Hauptschule* 14.6; *Realschule* 16.5; *Gymnasium* 16.2 (see Appendix 12 - variations in the numbers result from schools that have pupils at different levels and/or from different types of schools).

This positive development came about through increased teacher employment in the 1960s and decreased enrollment later. The teacher/pupil ratio has become slightly less favourable since 1990 owing to an increase in enrollment without any substantial increase in teacher employment.

6.5 Drop-out rates, late entries, maternal leave

Teachers are civil servants; no one wants to retire, and there is no drop-out. Late entries are - after the age of 45 - impossible. Leaves can be obtained for a certain period, be it for employment in another state or state-like institution, or for raising children; this leave is always given with the guarantee that at the end of it a position will be open (usually in the same county).

6.6 Status and salary

Teachers' salaries follow the civil service system: teachers at elementary schools are at the level of those who complete specialised colleges, all other salaries are comparable to those of university graduates, i.e. judges and doctors in the health system. The difference in salary between a 'normal' teacher and a principal are in percentage terms marginal. Of more importance is the automatic salary increase for civil servants: every two years they are awarded a raise just for being in the system.

The reputation of teachers is on the one hand high owing to university studies. On the other hand, it is declining owing to a perception of limited work achievement (3 months' vacation plus a half-day school system).

7. Equality of opportunity?

7.1 Different status of the schools

Although in the Federal Republic of Germany the state does not have a monopoly on education (see GG Art 7, Abs. 4), only about 6% of school-age children attend a private school. These must be accredited by the state and are supervised by the state. The state, however, is also required to subsidise them.

The private schools can be divided according to pedagogical or confessional aspects into four groups: (1) Catholic schools, (2) Protestant schools, (3) Waldorf schools, (4) *Landerziehungsheime* (Hermann Lietz) - see Appendix 13.

Private schools are usually founded for pedagogical or religious reasons. Although one of the arguments against them is that they are mainly for privileged groups, this is not true for the Federal Republic of Germany. Students finishing private schools in Germany do not have an advantage over those from public schools.

For educational policy, it is important to note that there has been a shift in the stream of pupils in public schools at secondary level I (10 to 16 year olds). In 1952 just under 80% of the 13 and 14 year olds went to a *Hauptschule*, 11% to a *Gymnasium* and 7% to a *Realschule*. As a result of educational expansion in the 1970s (striving for a higher qualified school leaving certificate), the *Hauptschule* lost its position as 'main school'. At the same time the *Gymnasium* and the *Realschule* were able to triple their numbers, and the comprehensive schools gained in strength (see Appendix 9).

7.2 Regional differences

According to the school financing system (see section 2.2) there are no major regional differences in teacher availability (of course, younger teachers would like to stay in 'their' university city and not be assigned to a rural area), however, the rural counties are richer than the urban ones. This means that the physical provisions (buildings, equipment) are usually better than in highly populated urban areas. The common financing model between state and county ensures that no larger regional differences arise. In addition, the big cities in Germany do not have a huge population (except Berlin, Hamburg and Munich), so that the phenomena seen in other inner cities are not as evident.

Nevertheless, there is a problem mainly in some *Hauptschulen* as a result of the increased number of non-German pupils (whose parents work in Germany) as well as children from families seeking asylum, who sometimes attend a school for only a short time either because asylum has been denied or because a return to their homeland has become possible.

7.3 Immigration and migrant populations

From 1960 to 1992 the number of non-German pupils has increased from 27,800 to 837,100 (see Appendix 14). The majority are from Turkey (43.0%) and from Yugoslavia (11.8 %) (see Appendix 15).

The greatest problems for schools are caused by those pupils who already attended school in their homeland and then abruptly - without the necessary language skills - have to continue their schooling in Germany (usually Turkish children), and by Moslem students whose religious beliefs prohibit their participation in all of the lessons (for lack of parental consent).

The greatest increase in the number of non-German pupils was in the 1970s. The fact that the teacher/pupil ratio was becoming increasingly favourable enabled schools to provide sufficient extra lessons, especially in German.

The improved teacher/pupil ratio was used in ever smaller classes for pedagogical innovation, especially changes in teaching methods (problem solving, group discussion, exploring science, project work), in increased experimental work in science teaching and more optional courses and activities.

Another group profited from the improved teacher/pupil ratio: immigrant children. During the 1980s the number of immigrants of German heritage from East European countries, whose children's German was not very good, hugely increased.

The integration of these children was relatively easy, as this group was highly motivated and made good use of the extra intensive courses in order to be integrated in the normal classes as quickly as possible.

7.4 Special education for handicapped children?

About 4% of the pupils attend various forms of special schools (for handicapped children). Very differentiated offers are made in this area depending on the type of disability: there are programmes for children with learning disabilities, for the blind, for the deaf, for the physically handicapped, for the mentally handicapped, for those with behavioral disorders, etc.

The largest sector (75%) is that of special schools for children with learning disabilities, children who were 'flops' at the compulsory schools. These schools concentrate on treating disabilities that occur due to poor environmental stimuli, emotional neglect or even social waywardness in the child's surroundings.

Other special schools (for the physically and mentally handicapped) have special equipment to help compensate for the disabilities.

The status of the pupils at special schools is controversial: on the one hand, it is advantageous for the children not to have to compete with children at 'normal' schools, but on the other hand, they are stigmatised by the form of school they attend, causing integration problems in the workplace.

Currently only about 12 to 15% of the pupils at special schools succeed in returning to normal schools. New procedures are being developed to avoid transfers to special schools and to integrate handicapped children - except those with extreme physical handicaps - into the normal school system.

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Abbreviations

States

BW	Baden-Würtemberg
BY	Bavaria
BE	Berlin
HB	Bremen
HH	Hamburg
HE	Hessen
NI	Lower Saxony
NW	Northrhine-Westphalia
RP	Rhineland Palatinate
SL	Saarland
SH	Schleswig-Holstein
BB	Brandenburg
MV	Mecklenburg-Vorpommern
SN	Saxony
SA	Saxon-Anhalt
Th	Thueringen

Subjects

B	Biology
C	Chemistry
M	Mathematics
P	Physics
S	Primary Science

School Types

HS Hauptschule

RS Realschule

GY Gymnasium

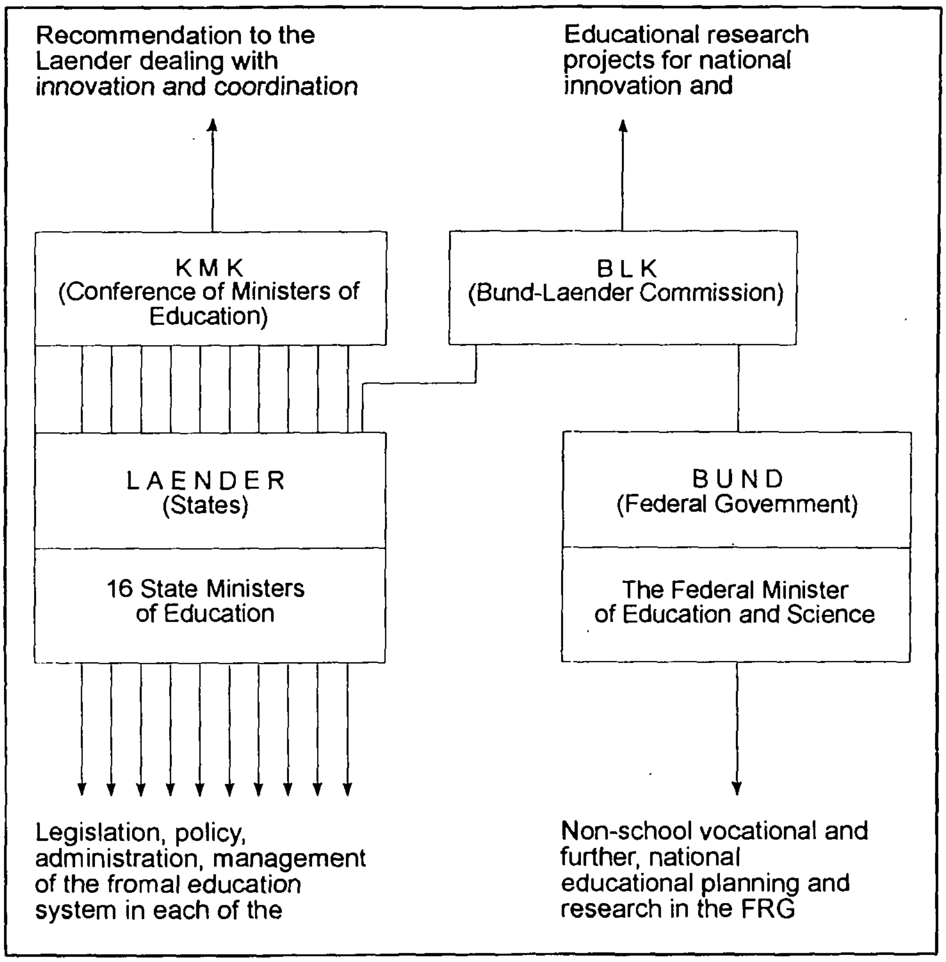
GS Gesamtschule

Institutions

BBU	Bundesverband Bürgerinitiation Umweltschutz (Federal Association of Citizens' Initiatives for Environmental Protection)
BLK	Bund-Länder-Kommission (Federal-State-Commission for Educational Planning and Promotion of Research)
BMBW	Bundesministerium für Bildung und Wissenschaft (Federal Ministry of Education and Science)
KMK	Kultusministerkonferenz (Standing Conference of Länder Ministers of Education)
FWU	Institut für Film und Bild in Wissenschaft und Unterricht (Institute für Educational Media)

Appendix 1:

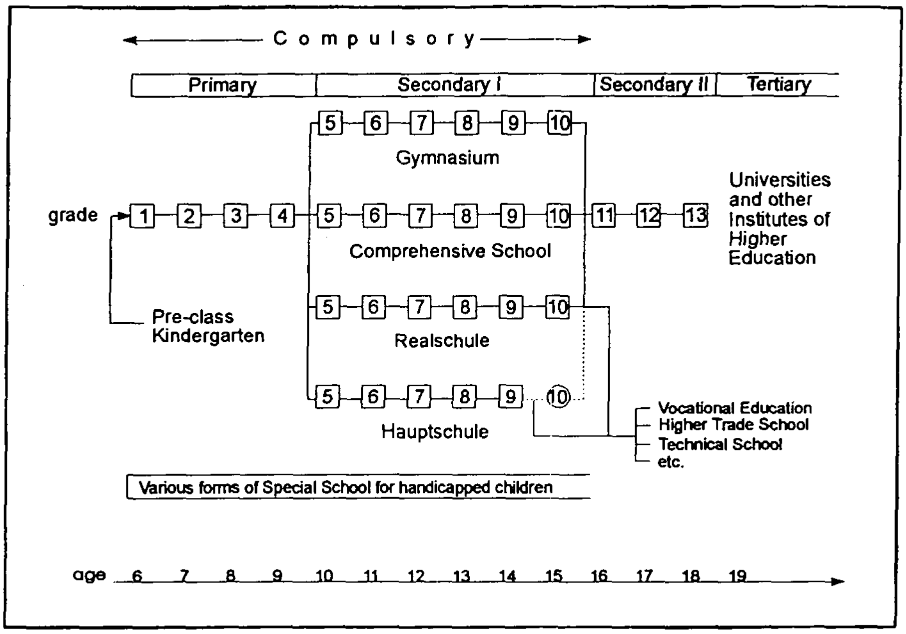
Responsibility of Federal and States Governments in the Education System of the Federal Republic of Germany



Source: Riquarts, K.: Framework for Science Education in Germany. Kiel: IPN, 1995. (in press)

Appendix 2:

Structure of the School System in the Federal Republic of Germany[1]



1 The figure shows the main system. There are three major differences:

(1) In some states, grade 10 of Hauptschule is compulsory

(2) In two states, grades 5 and 6 belong to Primary

(3) In four states (of former East Germany) Secondary II has grades 11 and 12 only.

Source: Riquarts, K.: Framework for Science Education in Germany. Kiel: IPN, 1995. (in press)

Appendix 3:

Schedules: Compulsory Periods per Week in Mathematics and Primary Science (grades 1 - 4)

Year	**1**		**2**		**3**		**4**			
Subject	**M**	**S**	**M**	**S**	**M**	**S**	**M**	**S**	**Mathematics**	**Local studies and learning about living things and real objects**
State valid beginning										
BW 1984/85	4	3	5	3	5	3	5	3	19	12
BY 1983/84	[1]	1	1	1	5	4	5	4	10	8
BE[2] 1991/92	1	1	5	3	5	3	5	5-6	15	11-12
HB 1990/91	5	2	5	3	5	3	5	4	20	12
HH 1986/87	1	1	4	3	4	5	4	6	12	14
HE 1989/90	5	2	5	2	5	4	5	4	20	12
NI 1981/82	5	2	5	3	5	4	5	4	20	13
NW 1990/91	4	[3]	4	3	4	3	4	4	16	7
RP 1988/89	1	1	5	2	5	4	5	4	15	10
SL 1990/91	4	3	4	3	5	4	5	4	18	14
SH 1980/81	5	1	5	3	5	4	5	5	20	13
BB2 1994/95	4	3	4	3	4	3	4	4	16	7
MV 1991/92	5	1	5	3	5	4	5	4	20	12
SN 1992/93	4	3	5	4	5	3	5	4	19	14
SA 1995/96	5	2	5	3	5	3	5	4	20	12
TH 1990/91	5	3	5	3	5	3	5	3	20	12

Source: Riquarts, K.: Framework for Science Education in Germany. Kiel: IPN, 1995. (in press)

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1. There is only a total number of periods for the following subjects: German, Mathematics, Primary Science, Music, Sport and Art (Bavaria and Berlin: 17 periods; Hamburg: 14 periods).

2. In Berlin and Brandenburg primary school includes grades 5 and 6; each have 5 math periods.

3. There is only a total number of periods for the following subjects: Language, Art and Primary Science.

Appendix 4:

Schedules: Compulsory Periods per Week in Science at Secondary Level (grades 5-10)

- The Former West German States

state	year / subject / school type	5 B	5 C	5 P	6 B	6 C	6 P	7 B	7 C	7 P	8 B	8 C	8 P
BW	HS	2		-	2		-	2		1	2		1
	RS	2	-	-	2	-	-	1	-	-	1	2	2
	GY	2	-	-	2	-	-	2	-	-	1	-	2
	GS										special regulations		
BY	HS	2	-	-	1	2		1	2		1	2	
	RS							2	-	-	2	-	2-3
	GY	2	-	-	2	-	-	2-3	-	-	1-2	-	0-2
	GS	2	1		2	1		1,5	-	1	1,5	-	1-2
BE	HS	2	-	-	1	-	-	2	-	-	-	1	2
	RS							2	-	-	-	1	2
	GY				(primary			2	-	2	-	1	2
	GS				School)			2	-	-	-	1	2
HB	HS	<—	3	—>	<—	3	—>	<—	3	—>	<—	3	—>
	RS	<—	3	—>	<—	3	—>	2	-	1	-	1	2
	GY	<—	3	—>	<—	3	—>	2	-	1	-	1	2
	GS	<—	3	—>	<—	3	—>	<—	4	—>	<—	4	—>
HH	HS	2	-	-	2	-	1	2	1	1	2	1	1
	RS	2	-	-	2	-	2	2	1	1	2	1	1
	GY	2	-	-	2	-	2	2	-	-	2	-	2
	GS	-	-	2	2	-	-	-	2	-	2	-	2
HE	HS	2	-	-	2	-	-	1	-	2	1	1	1
	RS	2	-	-	2	-	-	1	-	2	1	1	1
	GY	2	-	-	2	-	-	1	-	2	1	1	1
	GS	2	-	-	2	-	-	1	-	2	1	1	1
NI	HS	2	1		2	1		<—	3	—>	<—	4	—>
	RS	2	1		2	1		2	-	2	2	1	1
	GY	2	1		2	1		1-2	-	1	1	2	2
	GS	<—	3	—>	<—	4	—>	<—	4	—>	<—	4	—>
NW	HS	<—	4-5	—>	<—	3-4	—>	<—	2-4	—>	<—	3-4	—>
	RS	<—	3-4	—>	<—	3-4	—>	<—	3-5	—>	<—	3-5	—>
	GY	2	-	-	2	-	2	1	2	-	2	-	2
	GS	<—	2-3	—>	<—	3-5	—>	<—	2-3	—>	<—	4-5	—>
RP	HS	2	1		2	1		2	2		1	2	
	RS	2	1		2	1		2	-	2	-	2	-
	GY	2	1		2	1		2	-	-	1-2	1	2
	GS	<—	2	—>	<—	2	—>	1	1	1	1	1	1
SL	HS	2	-	-	2	-	-	2	2		-	2	
	RS	2	-	-	2	-	-	2	-	-	-	2	2
	GY	2	-	-	3	-	-	-	-	2	2	2	2
	GS	2	-	-	2	-	-	-	1	2	2	1	-
SH	HS	2	-	-	2	-	-	2	2		1	2	
	RS	2	-	-	2	-	-	-	-	2	2	1	2
	GY	2	-	-	2	-	-	-	-	2	2	-	2
	GS	<—	4	—>	<—	4	—>	<—	4	—>	<—	4	—>

state	year / subject / school type	9 B	9 C	9 P	10 B	10 C	10 P	Σ 5-9 natural sciences	(10)
BW	HS	2		1	2		3	13	(+5) from
	RS	1	1,5	1,5	1	1	2	18	voluntary
	GY	-	2	1	2	2	1-2	18-19	grade
	GS		special regulations						
BY	HS	1	2					14	
	RS	-	2	2-3	1	2	2-3	15-18	(+4) from grade
	GY	1-2	0-3	1-2	2-3	0-3	2-3	13-27	5+6
	GS	1-2	-	1-3	-	-	2-3	15-20	
BE	HS	1	1	2	1	1	2	13	
	RS	2	2	2	2	2	2	17	
	GY	2	2	2	2	2	2	19	
	GS	2	2	2	2	2	2	17	
HB	HS	<—	3	—>	<—	3	—>	15	(+3) from
	RS	2	2	-	2	2	2	22	voluntary
	GY	2	2	-	2	2	2	22	grade
	GS	<—	3	—>	<—	3	—>	20	
HH	HS	2	1	1		(4)		17	(+4) from
	RS	2	1	1	2	1	1	22	voluntary
	GY	-	3	2	2	2	2	23	grade
	GS	2	2	2	2	2	2	22	
HE	HS	1	2	1	1	2	2	19	
	RS	1	2	1	1	2	2	19	
	GY	1	2	1	1	2	2	19	
	GS	1	2	1	1	2	2	19	
NI	HS	<—	3	—>	(1)	(1)	(1)	16	(+3) from
	RS	1	1	2	1	2	1	21	voluntary
	GY	1	1-2	2	1	1	2	21-23	grade
	GS	<—	3	—>	<—	3	—>	21	
NW	HS	<—	3-4	—>	<—	2-4	—>	17-25	
	RS	<—	3-4	—>	<—	3-4	—>	18-26	
	GY	2	2	2	-	2	2	23	
	GS	<—	4-5	—>	<—	4-5	—>	19-26	
RP	HS	2	2		<—	(4)	—>	17	(+4) from
	RS	2	1	1	1	2	2	19-21	voluntary
	GY	-	2	2	1-2	2	1-2	20-24	grade
	GS	1	2	1	1	2	2	16-20	
SL	HS	2	2	2	(2)	(4)		16	(+6) from
	RS	2	2	2	1	1	3	21	voluntary
	GY	2	1-3	1-3	-	2-3	2-4	21-28	grade
	GS	2	1	1	-	3	3	20	
SH	HS	1	2					14	
	RS	2	2	2	1	1	2	21	
	GY	2	2	2	2	2	2	22	
	GS	<—	4	—>	<—	4	—>	24	

Sciences at Secondary Level (grades 5-10)
- The Former East German States

Year		5			6			7			8		
Subject		**B**	**C**	**P**	**B**	**C**	**P**	**B**	**C**	**P**	**B**	**C**	**P**
State	**School type**												
BB	HS												
	RS	←	4	→	←	4	→	2	-	-	-	2	2
	GY	(primary school)						2	1	1	1	1	2
	GS							2	-	-	-	2	2
MV	HS	2	-	-	2	-	-	1	-	2	1	2	1
	RS	2	-	-	2	-	-	2	-	2	1	1	1
	GY	2	-	-	2	-	-	1	-	2	2	2	2
	GS	2	-	-	2	-	-	2	-	2	2	2	2
SN	HS	2	-	-	2	-	2	2	-	2	1	2	2
	RS	2	-	-	2	-	2	2	-	2	1	2	2
	GY	2	-	-	2	-	2	2	-	2	1	1-2	1-2
	GS		-	-		-			-				
SA	HS	2	-	-	1	-	2	1	1	1	1	1	1
	RS	2	-	-	1	-	2	1	1	2	2	2	1
	GY	2	-	-	2	-	2	1	1	2	1	2	1
	GS		-	-		-							
TH	HS	2	-	-	2	-	-	1	2	2	2	2	2
	RS	2	-	-	2	-	-	1	2	2	2	2	2
	GY	2	-	-	2	-	-	2	-	2	2	2	2
	GS		-	-		-	-						

Year		9			10			Σ 5-9 (10)			Σ 5-9 (10)	
Subject		**B**	**C**	**P**	**B**	**C**	**P**	**B**	**C**	**P**	**Natural science**	
State	**School type**											
BB	HS											
	RS	2	2	1	1	1	2	5	5	5	15	
	GY	1	2	1	1	1	2	5	5	6	16	
	GS	2	2	1	1	1	2	5	5	5	15	
MV	HS	2	2	2	1	1	2	9	5	7	17	(+4) from
	RS	2	2	2	1	2	1	10	5	6	21	voluntary
	GY	1	2	2	2	2	1	10	6	7	23	grade 10
	GS	1	2	2	1	2	1	10	6	7	23	
SN	HS	1	1	1				8	4	8	20	(+1)
	RS	1	2	2	2	2	1	10	6	9	25	Astronomy
	GY	1	2	1	1	1	1	9	4-5	7-8	20-22	
	GS											
SA	HS	2	2	2				7	4	6	17	
	RS	1	2	2	2	1	2	9	6	9	22	
	GY	1	2	2	1	1	1	8	6	8	22	
	GS											
TH	HS	2	2	2	2	2	2	11	8	8	21	(+6) from
	RS	2	2	2	2	2	2	11	8	8	27	voluntary
	GY	1-2	1-3	1-2	1-2	1-2	1-2	10-12	4-7	6-8	20-27	grade 10
	GS											

Source: Riquarts, K.: Framework for Science Education in Germany. Kiel: IPN, 1995. (in press)

Appendix 5:

Science Content, Secondary Level I

	Subject area	BW	BA	BE	BR	HA	HE	NS	NW	RP	SA	SH	BB	MV	SN	SA	TH
M 1	*Energy*	8	9/10	8/9	5	6/8	9/10	9/10	9/10	8	9	8/10	7/9	8	7	8/9	7/10
M 2	Work	8	9	8	8	8	9/10	8	9/10	8	9	8	7/9	8	7	7/9	7/10
M 3	Efficiency	8	9	8	8	8	9/10	-	9/10	8	10	8	7/9	8	7	7	7
M 4	Mechanical vibrations and waves	-	-	10	-	-	-	-	-	10	-	-	9/10	10	9		
M 5	Simple movements		8	-	10	-	9/10	10	8	-	7	7	7/9	7/9	6	6/9	9
M 6	Power, weight power	8	8	8	7/8	8	9/10	8	8	6	7/8	7/8	7/9	7/8	6/7	7/9	7/10
M 7	Simple mechanical machines		8/9	8	8	8	9/10	8	9	9	8	8	7/9	8	7/10	7	7/9
M 8	Pressure, friction	10	8	8	7	10	9/10	9	8	9	7	8	9	7^{X}	8	7	8
O 1	Diffusion of light, shadows, reflections	9	9	8	6	8	6	7	5/8	7	8	7	10	7	6	6	7
O 2	Refraction of light, lenses	9	9	8	7	8	7	8	8	7	8	9	10	7	6	9/10	7
O 3	Simple optical equipment	9	9	8	7	$9/10^{X}$	7	8	5/8	7	8	9	10	X	6	9/10	7
O 4	Light spectrum	9	9	8	7	$9/10^{X}$	7	8	8	7	8	9	10	X	10	10	7
O 5	Wave optics	-	-	10	-	-	-	-	-	-	-	-	10		10	10	
W 1	*Temperature and* thermal expansion	8	9	7	5/8	6/9	7	5/6	9	5	8	7	8	7/8	6	6/8	8
W 2	Heat transfer	8	9	8	6	6	7	5/6	9	10	9^{X}	7	8	7	8	6/8	
W 3	Thermal energy and heat engines	8	9	8	6/10	9	9	10	9	10	9	10	8	8	8	8	8
W 4	Particle models	-	9	7	8	-	7	$5/6^{X}$	9	10	9	8		7/8	8	8	
W 5	Gas laws	-	9	-	-	10	-	-	9	9	9	-	8		8		
A 1	Molecular construction, atomic models, elementary particles	10	10	10	10	10	-	-	10^{X}	-	-	10	10	10	10	9	
A 2	Radioactive radiation	10	10	10	10	10	-	10	10^{X}	-	-	10	10	10	10	9	
A 3	Nuclear energy, nuclear power plants	10	10	10	10	10	$9/10^{X}$	10	10^{X}	-	-	10	10		10	9	
E 1	Simple electrical circuit	9	8	5/6	5	6	7	5/6	5	5	7	8	8/9	8	7	6	8
E 2	Electricity	9	8	9	8	8	7	7	10	8	7	8/9	8/9	8	7	7	8
E 3	Electric tension	9	8	9	8	9	8	8	10	8	7	9	8/9	8	7	7	8
E 4	Electric resistance	9	8	9	8	9	8	8	10	9	7	9	8/9	8	8	8	8
E 5	Induction, generator	10	10	9	10	$9/10^{X}$	8	9	10^{X}	9	10	9	8/9	9/10	9	9	9
E 6	Transformer	10	10	9	10	$9/10^{X}$	8	9	10^{X}	9	10	9	9	10	9	9	9
E 7	Conductor through electrically fed magnetic field	10	10	9	10	8	7	7	10	9	10	8	8/9	9	9	8/9	9
E 8	Parallel and series circuits	10	10	9	-	$9/10^{X}$	8	8	10	9	10	9	8/9	9	7	7	7
E 9	Electrical power and efficiency	9	9	9	8	9	9/10	10	10	8	10	10	8/9	9	7	7	8
E 10	*Elements of* communications engineering	-	10	9	10^{X}	-	-	-	-	-	-	10^{X}					
E 11	Electromotors	10	10	9	10	8	-	9	10^{X}	9	10	8	9	9	9	7/9	9
E 12	Static electricity	9	8	9	8	9	8	-	10	8	10	9	9	9			
E 13	Magnetism	9	8/10	9	10	8	6	5/6	10	6	7	7	7/8	9	9	6/8	9
E 14	Semiconductors	10	10	9	10	10^{X}	8	-	10^{X}	10	10^{X}	9	10		9		9
E 15	Electron tubes	9	10	-	-	-	8	-	-	10	-	-	10		9		9
E 16	*Electromagnetic* vibrations and waves	-	-	-	-	-	-	-	-	10	-	10^{X}	10		10		
S 1	Acoustics	8	-	10	8	6	-	-	-	10	9^{X}	7	10	X	10	6	
S 2	About water	-	-	-	-	6	-	5/6	(8)	5	8/9	-			6	6	
S 3	Converting energy	8	9	8/9	5/10	8/9	9/10	10	9	8	9	10	7	10	7	7	
S 4	Elements of data processing	-	-	-	10^{X}	-	9/10	-	-	-	-	10^{X}		-			

M = Mechanics O = Optics W = Thermodynamics A = Atoms E = Electricity
S = Miscellaneous X = Elective

Chemistry - Gymnasium

Subject area	BW	BA	BE	BR	HA	HE	NS	NW	RP	SA	SH	BB	MV	SN	SA	TH
1 Concepts																
1.1 Concerning *homogeneous and* heterogeneous materials	9	9	8	5/8	8	8	8	7	5/7	8	9	8	8	8	7	8
1.2 Concerning simple *division procedures*	9	9	8	5	8	8	8	7	5/7	8	9		8		7	8
1.3 Concerning the structure of atoms, molecules and aggregates	9/10	9/10	8/9	8/9	9/10	8/9	8/9	9/10	7-10	8-10	9/10	8	8	8	7/8	8
1.4 Concerning the regularity of atomic characteristics (periodic table)	10	10	9	8//9	9	9	9	9/10	7/8	9/10	9	8	8/9	8/9	7-9	8
1.5 Concerning the regularity of reactions	9/10	9/10	8/9	8/10	8/10	8-10	9/100	9/10	7/9	8-10	9/10	8	8/9	8	7/8	8
1.6 Concerning the energy involved in reactions	9	9	8	8	8	8	8	7/9/10	6/7	8-10	9/10	8	8/9		8/9	8
1.7 Concerning the characteristics of electro-chemical processes	10	9/10	9	9	10	9/10	9	9/10	8/9	9/710	9		8	8/9		
2 Basic laws																
2.1	9	9	8	8	9	9	8	9/10	9	8	9	8	8/9	8	8/9	8
2.2 Gas laws	9	9	-	–	–	–	8	9/10	–	8	10					8
2.3	9	9	9	8	9	9	8	9/10	8/9	8-10	9	8	8/9	8	9	8
2.4 Law of mass effect	-	-	-	-	10	-	-	-	-	–	-			8		10
3 Symbols																
3.1 Element and connection symbols	9	9	8	8	7	9	8	7/9	7/8	8	9	8	8/10	8	7/8	8
3.2 Structure symbols	10	10	8	9	-	9	9/10	9/10	9	-	-	8	8/10		9	9
3.3 Reaction symbols	9	9	8	8	9	9	8	9	8	8	9	8	8		8/9	8
4 Anorganic groups of material																
4.1 Metals in general	9	9	9	5/9	8	8	9	7/9/	7/8	8	9	8	8	8	7/8	9
4.1.1 Light metals (otherwise *see 4.7*)	9	9	9	9	9	8	9	7/9/10	9	9/10	9			8		9
4.1.2 Heavy metals	9	9	9	9	8	8	9	7/9/10	9	9/10	9			9		
4.2 Non-metals (1) oxygen, hydrogen	9	9	8	8	8	8	8	7/9/10	6/7	8	9	8	8	8	7/8	8
4.3 Non-metals (2) sulphur, nitrogen, halogens or with acids	10	10	8/9	8/10	9	8	9	9/10	8/9	9/10	9		9	8	7-9	8-10
4.4 Non-metals (3) carbon (phosphor, silicium) or with acids	-	10	9/10	9	10	8	10	9/10	8/9	8-10	10	8	9/10	8	9	9
4.5 Acids (1) hydracids and their salts	10	9	8	8	9	9	9	9/10	8	9/10	10	8	8/9	9	8	9
4.6 Acids (2) oxygen acids and their salts	10	10	8/9	8	9	9	9	9/10	8	9/10	10	8	9	9	8/9	9
4.7 Hydroxides	9	9	8	8	9	8	9	9/10	8	9/10	10	8	9	9	8	9
4.8 Salts (when not already covered in 4.5 and 4.6)	10	9	9	8	9	9	9	9/10	8/9	9/10	9					
5 Organic groups of matter	-	10	10	9	10	10	10	10	9/10	-	-	9	10	9	9/10	9
6 Topics																
6.1 Analytical procedures	9	10	-	-	-	9	-	9/10	-	-	10	8	8/9	9	8/9	
6.2 Building and raw materials	-	10	9/10	-	-	-	10	o	9/10	-	10	8	8	10	8-10	
6.3 Production procedures	10	9/10	9/10	8-10	10	9	10	9/10	9	9/10	10	8	8/9	10	8-10	9/10
6.4 Environment	9/10	10	9/10	9	9	8-10	oo	7/9/10	9	o	10	8	9	9	9	
6.5 Nutrition, Foodstuffs and production	-	-	10	9/10	-	9/10	10	10X	10	–	10			10	9	
6.6 Washing, cleansing	-	-	10	10	-	-	-	o	10	–	-			9		
6.7 Energy supply	-	-	8/10	9/10	-	10	-	o	10	-	-		10	9	9	9
6.8 Questions of safety, of fire fighting	9/10	9/10	8	o	-	8	-	7/9/10	5/6/8/10	–	-	8	8	8	7/9	
6.9 Philosophical aspects	-	-	-	o	-	-	-	-	-	-	-					

X = elective o = formulated as a general goal

Biology - Gymnasium

Subject area	BW	BA	BE	BR	HA	HE	NS	NW	RP	SA	SH	BB	MV	SN	SA	TH
Parts of a blooming plant	5	5-7	5/6	7	5/6	6	5-8	5-7	5-7	6	5		5/6	5	5/6	6
Distribution of seeds and fruit	6	6	5/6	6	5/6	-	5/6	5/6	6	-	6		5/6	5	5/&	5
Structure of a blooming plant	5	5	5/6	7	-	6	5-8	5-7	-	-	5/6		5/6	5	5	
Structure of cultured, cultivated and household plants	-	7	5/6	-	5/6	-	5/6	(5/6/7/ 9)	-	6/8	5/6		5/6	8	5/6	6
Plain seeds	7	8	-	-	7/8	-	-	7	7	8	8		9	8	6	
Fungi	8	8	9	-	7/8	-	-	(9)	7	9	8		9	8		7/(
Moss	8	8	9	-	7/8	-	-	(9)	7	8	8		9	8		7/8
Ferns	8	-	9	-	7/8	-	-	(9)	7	8	8		9	8		7/8
Photosynthesis, Respiration	7/8	7	9	6/9	7/8	6	7/8	9	6	-	8	9	9	8	7/8	8
Sexual reproduction (pollination, fertilization, germinating, development)	5	5/6/8	5/6	7	5/6	6	5/6	5/6	5/6	6	5/8		6		5/8	6
Asexual reproduction	-	-	5/6	-	5/6	-	5/6	(5/6/9)	5	6	5/8		6		5/8	6
Autotrophic/heterotrophic life	8	6	9	9	7/8	-	7/8	9	-	-	-	9	9			8
Vertebrates: hibernation	6	5	-	7	-	-	5/6	5/6	6	6	6					
Mammals: structure and life habits (often functional aspects)	5	5/6	5/6/7	5	5/6	-	7/8	5/6	-	-	5/6/8/ 9			5	5	
Vertebrates: domestication and breeding	5/6	-	5/6	-	-	-	5/6	5/6	5	-	5				10	
Structure, life habits and importance of domesticated and wild animals	5	-	5/6/7	5	-	-	-	5/6	5	6	5					
Birds: structure and life habits (often functional aspects)	5/6	5/6	5/6/7	9	5/6	-	5-8	5/6	6	6	5/6		5	5	5	
Reptiles: structure and life habits (often functional aspects)	6	-	7	7	5/6	-	7/8	7	6	6	6			6		
Amphibions: structure and life habits (often functional aspects)	6	-	7	7	5/6	-	5-8	7	6	6	6		5	6	5	
Fish: structure and life habits (often functional aspects)	6	6	7	7	5/6	-	5-8	7	6	6	6		5	6	5	
Insects	7	7	9	7	-	6	7/8	8(9)	7/8	-	8/9		6	7		
Other articulates	7	7	9	-	7/8	-	-	8/9	8	8	8		6	7		
Mollusks	7	-	9	-	-	-	-	8/9	7	8/9	8					
"Worms"	7	-	9	-	-	-	-	8/9	7	9	8		6	7		
Coelenterata	7	-	-	-	-	-	-	8/9	-	9	8					
Single cells	7	-	9	5/9	-	-	7/8	8/9	-	9	8	7		7		7
Bacteria, viruses	7	-	9	-	7/8	-	7/8	9	7	9	8	7		7	6	7
Early bloomers	6	-	5/6	-	-	-	-	(5/6/9)	5	6	5/6					
Biological balance	-	5	9	6/9	-	6	5/8	9	6-8	8	5/6/9	9	9	6/9	6/9	8
matter cycle	-	-	9	6/9	-	6	5-8	9	-	-	9	9	9	6/9	6/9	8
Ecological system forest (in addition to ecological aspects, emphasis on economic *biology and* environmental protection)	8	8	9	-	-	6	7/8	9	7	8	9	9	6/9	6	6/9	8
Various ecological systems (e.g. fields, inland waters)	-	-	5/6/9	-	-	-	-	9	6/7	-	9	9	9	9	9	
Parasites, symbiosis	8	8	9	9	7/8	-	7/8	(8/9)	7	-	8	9	9	9	9	7
Innate and learned behavior in animals	6	7	10	5/10	-.	5/9	7/8	(5)	8	-	9		5	10		7/9/10
Human behavior	6	-	5/6	-	-	9	9/10	(8)	-	-	5/6/9		5	10		9/10
Preying behavior	5	5	-	-	-	6	-	(8)	5/6	-	5		5	10		7/10
Proof for evolution	-	9	-	-	-	7	9/10	(10)	9/10	6	-	9/10	10	10	10	10
Evolution factors	-	-	-	-	-	-	-	-	-	-	-	9/10	10	10	10	10
Human evolution	10	-	-	-	-	7	9/10	(10)	9/10	-	-	9/10	10	10	10	10
Cells and the microscope	5	-	5/6/9	5	7/8	5	5-8	9	-	-	8	7	6	7	6	7
Structure and function of plant, animal and human cells	-	7	9	-	5/6	-	7/8	9	7/9/10	9	8	7	6/9	7	6	7
Reproduction and development of birds, amphibions, fish	-	-	7	-	-	5	-	(7)	-	-	-			5/6		
Fundamentals of heredity (hereditary laws, Mendel, mitosis, meisis)	10	10	-	10	9/10	5/9	9/10	9/10	9/10	-	-	9/10	10	10	10	10
Hereditary diseases, family services	10	-	-	-	-	9	9/10	9/10	-	-	-	9/10	10	10	10	10
Environmental factors	6	10	9	10	9/10	9	9/10	9/10	9/10	-	-	9/10	10	10	10	10
System: blooming plants	5/6	-	5/6	7	-	5/6	5/6/7/ 8	5/6	-	6	5/9		9	5		
System: vertebrates	5/6	6	5-7	-	-	-	5-8	5/6/8	-	-	9		5/6	6	5	

Subject area	BW	BA	BE	BR	HA	HE	NS	NW	RP	SA	SH	BB	MV	SN	SA	TH
Movement, support and mobility system	10	5/10	5/6	5	5/6	5	5/6	5/6/8/ 9/10	5/8	9	5		5/8	5	5	
Food, nutrition, digestion, digestive organs	5/10	6/10	5/6/10	6/9	5/6/9/ 10	5	9/10	5/6 (8-10)	5/8	-	5/10	7	8	6/7	6/7	5/6/8
Excrement, excrement organs	-	10	10	-	5/6/9/ 10	-	9/10	9/10	-	-	-	7	8	7	7/8	8/9
Respiration, respiratory organs	6/10	6/10	7	6/10	5/6/9/ 10	5	9/10	5/6/8/ 9/10	5/8	-	6/10	7	8	6	7	5/6/8/ 9
Blood, blood circulation, circulatory organs	5/10	6/10	7/10	9	5/6/9/ 10	5	9/10	5/6/8- 10	6/8	-	6/10	7	8	7	8	9
Sensual physiology	5/10	5/6/9	10	10	5/6/9/ 10	7	7/8	5/6/8/ 9/10	8	-	-	7	8	8	10	
Brain, nervous system	10	9	10	10	9/10	10	7/8	5/6/8/ 9/10	9/10	-	10	7	8	8	5	8
Nerves and hormones control and regulation)	10	9	10	10	9/10	10	9/10	9/10	9/10	-	10	7	8	8	10	8
Genital organs, reproduction, development	10	5/10	5/6/10	5	5/6/9/ 10	5	5-8	5/6/9/ 10	5/8	-	5/6/10	9	5/8	5/9	5/8/10	6/9
Contraception, birth control	10	10	7/10	10	9/10	5/9/10	9/10	9/10		-	10	9	5/8	9	8	9
Types of sexual behavior	-	-	10		5/6/9/ 10	9	-	9/10	9/10	-	10	9	5/8	9	8	9
venereal diseases	-	-	7/10	-	9/10	-	9/10	9/10	7/9/10	-	10	9	5	9	8	9
Infectious diseases	10	10	10	-	-	5	9/10	5/6/9/ 10	7	-	10				6	8/9
Injuries to the motoric system	-	5	5/6	6	-	5	5/6	5/6/8/ 9/10	-	-	5		8		5	
Respiratory and circulatory organs: diseases and health maintainance	10	10	7	9	-	5	9/10	(5/6/8/ 9/10)	8	-	6/10	7	8	6		
How to handle medication, drugs and intoxicants	7/10	6/9	5/6/7/ 10	-	5/6	10	5-10	(5/6/8/ 9/10)	6/8	-	10	7	8	6/8	6	6/9
Hygiene, personal hygiene	-	5	5/6/10	5	5/6	5	9/10	(5/6/8/ 9/10)	-	-	5	7	5	6	5	5
Healthy living	10	10	5/6/7/ 10	-	5/6	5/10	9/10	5/6/8/ 9/10	-	-	5	7	5	5	5	9
Problems due to overpopulation	-	-	10	-	9/10	10	-	(5/6/8/ 9/10)	9/10	-	-					10
Breeding plants and animals	6	7	-	-	-	6/9	9/10	(5/6/8/ 9/10)	7	6	5				10	
Interferring on nature and the consequences	6	-	5/6/9	-	7/8	10	-	(5/6/8/ 9/10	-	6	9	9	9	6/9	5/9	10
Protected species, nature and landscape conservation	5	6	5/6/9	-	-	-	5/6/9/ 10	(5/6/8/ 9/10)	-	6/8	9	9	9	6/9	9	10

Source: Riquarts, K.: Framework for Science Education in Germany. Kiel: IPN, 1995. (in press)

Appendix 6:

Pupils in the State School System (Without Vocational schools) per thousand

Year	Total	Primary[1] (grades 1-4)	Secondary level I (grades 5-10)						Secondary level II (grades 11-13)
			Hauptschule[2]	Sonderschule	Realschule	Comprehensive[3]	Gymnasium	others[4]	
1970	8982.6	3977.2	2374.9	322.0	885.8	9.2	1062.1	8.8	337.3
1975	10070.4	3929.5	2510.4	393.8	1174.1	158.7	1394.5	11.5	499.5
1980	9124.2	2785.9	2271.6	354.3	1351.1	202.0	1495.5	8.9	668.0
1985	7158.8	2271.6	1572.4	271.4	1049.0	195.2	1110.2	9.8	691.2
1990	6811.6	2561.3	1272.6	251.9	864.6	267.8	1053.0	11.6	555.5
1991	8571.1	3437.0	1446.2	344.0	1039.1	405.7	1315.2	16.3	619.3
	of which are new states:[5]								
	1653.5	847.9	164.3	85.5	162.1	114.6	227.3	0.6	75.5
1992	9364.8	3470.0	1839.1	360.2	1056.8	456.7	1484.6	13.5	634.1
	of which are new states:[5]								
	2031.7	771.9	508.8[6]	87.1	145.0	116.5	340.0	1.3	83.1
1993	9474.9	3524.3	1835.3[6]	372.3	1106.2	431.3	1530.5	12.4	662.6

1) Primary:including Waldorf schools and comprehensive schools.

2) Hauptschule: including the orientation level (grades 5 and 6) which is - in some states - independent of the school track.

3) Gesamtschule: including Waldorf schools (private schools, but offering a comprehensive education on the basis of the Waldorf pedagogy).

4) Others: evening schools for students who already work, but want to make up for missing school leaving certificate.

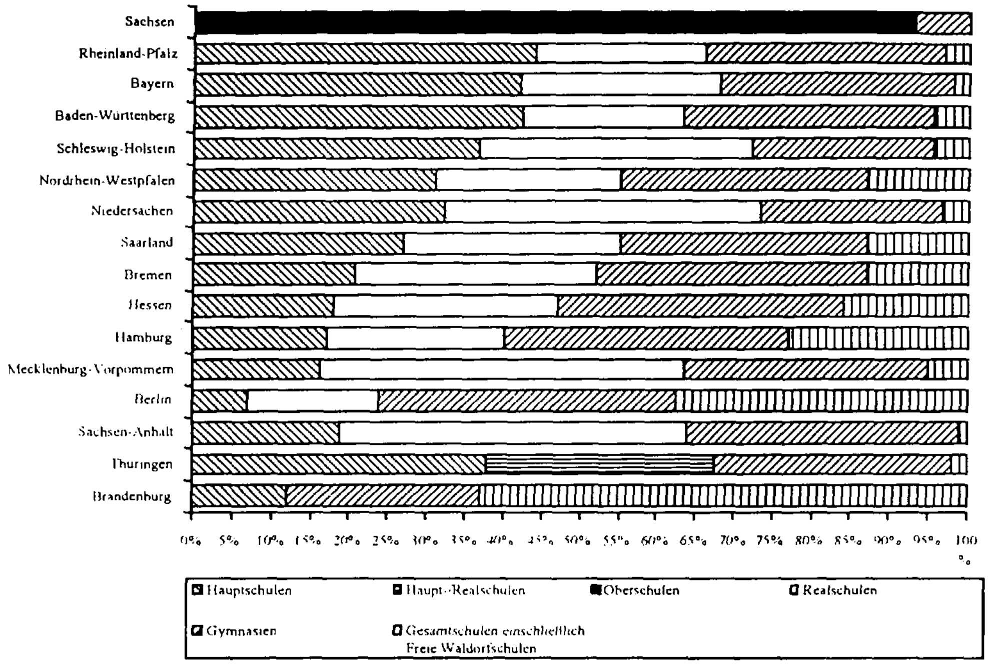
5) New States: former East Germany excluding East-Berlin (those numbers are included in the former West-Berlin).

6) Hauptschule (from 1992 on): this includes the 355,900 students from the integrated Hauptschulen and Realschulen created in the new states.

Source: Bildung im Zahlenspiegel 1993; Grund- und Strukturdaten 1994/95 and earlier editions.

Appendix 7:

Distribution of Pupils (grade 7) at the Various Types of School (in percentages)



Sachsen: still unchange polytechnical secondary schools.

Hamburg, Sachsen-Anhalt: course division for Haupt and Real students in joint schools which are called "secondary schools" in Sachsen-Anhalt.

Source: Arbeitsgruppe Bildungsbericht (1994) p. 436. Statistisches Bundeamt, Fachserie 11, Reihe 1, Allgemeinbildende Schulen 1991.

Appendix 8:

Male apprentices in the 10 most popular professions in 1991 - FRG, i.e. the "old" states -:

Profession	**Male**	**Apprentices**	**1991**	**1985**	**1976**
	Absolute	Percentage[1]		Rating	
Auto mechanic	63,106	7.6	1	1	1
Electrician	43,094	5.2	2	2	2
Industrial mechanic - machine and systems technican[2]	30,309	3.7	3	3	3
Wholesale and export merchant	28,623	3.5	4	8	6
Industrial mechanic - production technican[3]	28,181	3.4	5	11	15
Joiner	26,943	3.3	6	5	5
Bank clerk	26,676	3.2	7	10	14
Industrial merchant	25,109	3.0	8	12	9
Retail merchant	24,506	3.0	9	19	17
Plumber	22,158	2.7	10	6	7
Total	318,705	38.6	x	x	x
Total number of apprentices[4]	826,613	100.0			

1. the percentage of all male or female apprentices
2. in the past: machine fitter
3. in the past: factory mechanic
4. without the former GDR

Female apprentices in the 10 most popular professions in 1991 - FRG, i.e. the "old" states -:

Profession	**Female**	**Apprentices**	**1991**	**1985**	**1976**
	Absolute	Percentage[1]		Rating	
Bank clerk	51,223	8.5	1	4	4
Consulting room assistant	46,082	7.6	2	6	3
Retail merchant	41,352	6.9	3	9	9
Hairdresser	41,053	6.8	4	1	2
Industrial merchant	37,527	6.2	5	5	5
Dental assistant	32,069	5.3	6	6	3
Salesclerk for food	30,432	5.0	7	5	5
Industrial merchant	25,109	3.9	8	12	9
Wholesale and export merchant	20,473	3.4	9	11	10
Tax and accounting clerk	19,283	3.2	10	12	11
Total	343,003	56.8	x	x	x
Total number of apprentices[4]	603,598	100.0			

Source: Bildung im Zahlenspiegel 1993 and earlier editions

Appendix 9:

Required Elective Course Schedule - 'Old' Federal States

School type		**Hauptschule**				**Realschule**				**Gymnasium**				**Gesamtschule**			
Year		7	8	9	10	7	8	9	10	7	8	9	10	7	8	9	10
State																	
BW	**E**	-	-	-		3	3	3	3	-	-	-	-	8	8	8	8
	E					3[1]	3[1]	3[1]	3[1]					-	4	4	3
BY	**E**	4	6	6		2	4	5	5	-	-	-		4	7	8	9
	E	-	-	-	-		3[2]	3[2]	3[2]					-/1/-	-/1/-	-/2/1	2/3/1
BE	**E**	-	-	-	-	4	4	4	4	-	-	3	3	4	4	6	6
	E					4[3]	4[3]	4[3]	4[3]	-	-	3	3	4	4	6[4]	6[4]
HB	**E**	2	2	2	2	4	4	4	4	-	-	-	-	4	4	8	8
	E	-	2	2	2	4	4	4	4	-	-	-	-	4	4	8	8
HH	**E**	-	4	4	2	-	4/5	4/5	4/5	-	-	5	6	6(7)[5]	6(7)[5]	6(7)[5]	6(7)[5]
	E	-	-	-	-	-	-	-	-	-	-	-	-	3[6]	3[6]	3[6]	3[6]
HE	**E**	1	2	3	4	-	4	4	4	-	-	x[8]	x[8]	6	6	9	9
	E	1	2	3	1	5[7]	4[7]	4[7]	4[7]	-	-	1	2	4	4	7	7
NI	**E**	2	2	6	6	1	1	4	4	-	-	-	-	4	4	8	8
	E	-	-	2	2	-	-	4	4					4	4	4	8
NW	**E**	2	2	3	3	3	3	4	4	-	-	4	4	4	4	6	6
	E	2	2	3	3	-	-	4	4	-	-	4[9]	4[9]	4	4	6	6
RP	**E**	2	2	2	2	4	4	4	4	-	-	-	-	5	5	6	7
	E	-	-	-	-	2	2	4	4					4	4	4	4
SL	**E**	-	-	-	-	5	5	5	5	-	-	-	-	4	4	8	8
	E	-	-	-	-	-	-	5	5					4[10]	4[10]	4	4
SH	**E**	2	2	2		-	-	6	6	-	-	-	-	4	4	6	6
	E	-	-	-		-	-	4[11]	4[11]					4[12]	4[12]	6[12]	6[12]

Remarks:

α total number of periods in required electives

β possible number of periods for science (either total or in biology / chemistry / physics) or see separate note

1 Choice between - Nature and Technology, Home Economics and working with textiles, French

2 Beginning with grade 8 there are three tracks (groups of required electives): (1) math and science, (2) business, (3) the arts, home economics or social sciences. When track (1) is chosen the pupils have an extra physics period.

3 When choosing the math and science track grades 9 and 10 have, in addition to the two periods in physics, chemistry or biology, 2 further lessons in math.

4 Choice of 2 three hour courses (biology, chemistry, physics) possible.

5 Two subjects are chosen which are 3 hour courses with the exception of a second foreign language (four hour).

6 Nature and Technology or the Sciences

7 If not a foreign language, then preferably vocational education.

8 The third foreign language can be a three to four hour course with the exception of Ancient Greek which can be up to six hours.

9 1 four hour course or 2 two hour courses are possible.

10 2 or 4 hour courses possible.

11 2 or 4 lhour courses in all sciences possible.

12 Choice among second foreign language, business economics and technology.

Required Elective Course Schedule - 'New' Federal States

School type		Hauptschule				Realschule				Gymnasium				Gesamtschule			
Year		7	8	9	10	7	8	9	10	7	8	9	10	7	8	9	10
State						3	3	4	4	-	-	3	3	4	3	7	7
BB	**E**					3	3	4	4	-	-	3[a]	2[a]	4[b]	3[b]	5[b]	5[b]
	E	3	3	3	3	4	4	4	4	-	-	2	2	4	4	6	6
MV	**E**	3[c]	3[c]	3[c]	3[c]	4[d]	4[d]	4[d]	4[d]			2[e]	2[e]	4[f]	4[f]	4[f]	4[f]
	E	4	4	4		4	4	4	4	4	4	4	4				
SN	**E**	4[g]	4[g]	3[g]		4[c]	4[c]	4[c]	4[c]	4[h]	4[h]	4[h]	4[h]				
	E	1	1	1		4	4	3	3	-	-	-	-				
SA	**E**	1	1	1		1	1	1	1								
	E	3	4	5		3	3	3	3	-	-	-	-				
TH	**E**	3[i]	4[i]	5[i]		3[j]	3[j]	3[j]	3[j]								
	E																

Remarks:

α Total number of periods in required electives

β Possible number of periods for science (either total or in

a In principle every subject area is possible; a third foreign language or

b Second foreign language, science or vocational education

c Four areas including technology/economics are possible

d Six areas including science and technology are possible

e Science or technology possible

f Not science, but technology possible

g Two areas including technology/economics are possible

h Only at Gymnasiums with a science profile

i Planned: economics/technology

j Four areas including science are possible

Source: Riquarts, K.: Framework for Science Education in Germany. Kiel: IPN, 1995. (in press)

Appendix 10:

Number of Teachers, Gender Distribution (compulsory Schools) - in thousands -

Full-time teacher							
		number of female teachers		number of female teachers in percentage at two types of schools		**Part-time teachers**
Year	**Total number**		in %	Grund-/ Hauptschule	Gymnasium	
1960	210.0	89.1	42.2	45.5	31.6	43.8
1965	243.9	115.4	47.3	52.2	30.4	56.7
1970	314.2	162.6	51.8	58.8	32.0	87.9
1975	426.9	237.9	55.7	63.0	36.4	105.7
1980	498.0	275.3	55.3	63.9	36.4	67.7
1985	497.6	270.9	54.4	64.4	36.3	48.1
1990	493.0	277.2	56.2	66.8	36.8	43.2
1992[2]	655.5	408.0	62.3	72.3	42.6	43.3

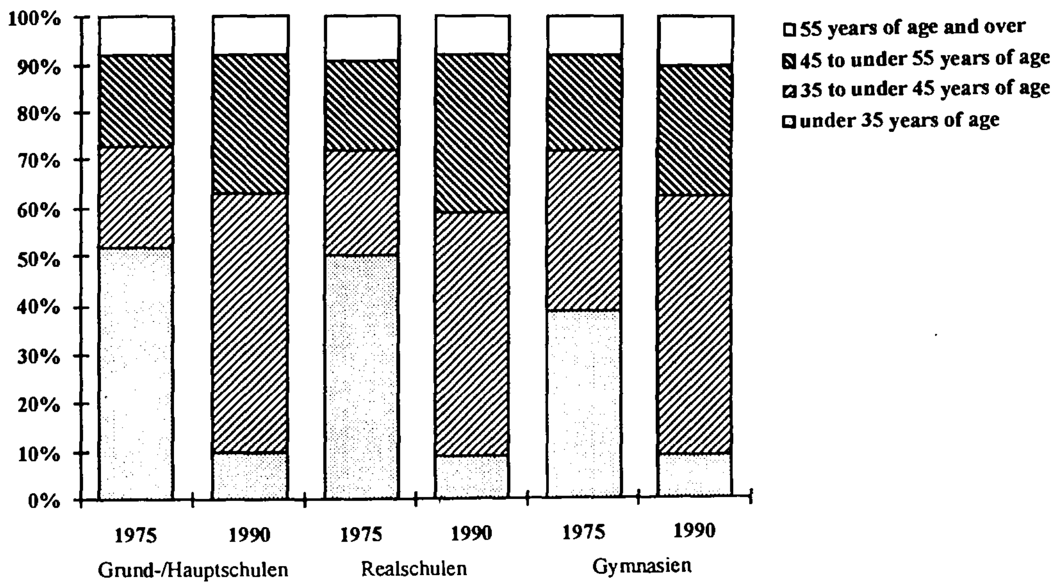
1. These teachers - who usually teach 4 to 6 periods a week - are employed for subjects like Religion and Music (in compulsory schools) and for subjects with a professional orientation (in vocational schools).

2. from 1992 on: including former East Germany

Source: Bildung im Zahlenspiegel, Statistisches Bundesamt 1993.

Appendix 11:

Age Profile of Teachers



Source: Arbeitsgruppe Bildungsbericht (1994) p. 695.

Appendix 12:

Number of Students per Teacher at Compulsory Schools

Year	Primary	Haupt-schule	Sonder-schule	Real-schule	Compre-hensive[1]	Gymnasium grades 5-10	Gymnasium grades 11-13
1960	35.7		20.1	23.0	-	17.4	
1965	33.1		17.7	23.5	-	17.9	
1970	31.6		15.3	23.1	-	18.8	
1975	27.4		11.8	22.7	14.7	18.4	
1980	21.7		8.6	21.5	13.5	17.4	
1985	20.2	15.0	6.8	17.7	13.1	17.0	11.3
1990	20.5	14.3	6.3	16.2	12.5	15.3	10.6
1991	20.2	14.4	6.2	16.3	12.4	15.7	10.2
1992[2]	20.0	14.6	6.1	16.5	13.3	16.2	10.5
in new states	19.4	10.3	6.2	13.4	22.5[3]	17.9	12.4

Source: Arbeitsgruppe Bildungsbericht (1994); Grund- und Strukturdaten 1993/94

1 Comprehensive school including Waldorf schools

2 1992: including the former East Germany

3 Comprehensive school: only grades 5-10

Appendix 13:

Private Schooling: Number of Schools and Students

	Institution	Schools (absolute)	Students(absolute)	Percentage
(1)	parochial schools	1856	377.596	77.5
	-Catholic	(1134)	(286.396)	(58.7)
	-Protestant	(742)	(91.200)	(18.7)
(2)	Waldorf Schools	163	50.850	10.4
(3)	Others		55.200	11.3
(4)	Landerziehungs-heime	17	3.850	0.8
	Total		**487.496**	**100.0**

Source: Handbuch freie Schulen. 1993

Appendix 14:

Non-German Students Attending Compulsory Schools (in thousands)

Year[1]	Total
1960	27.8
1965	37.3
1970	161.9
1975	393.0
1980	645.9
1985	668.5
1990	779.6
1991	801.6
1992	837.1
1993	867.6

Source: Grund- und Strukturdaten 1994/95

1 from 1991: including the new states

Appendix 15:

Country of Origin of Non-German Students (1992)

Country	Number	%
(a) Europe	689,634	82.3
EU Countries by country	145,020	17.3
Belgium	1,461	0.2
Denmark	910,000	0.1
France	3,623	0.4
Greece	37,407	4.5
Great Britain	5,672	0.7
Ireland	256,000	0.03
Italy	69,185	8.3
Luxembourg	147,000	0.01
Netherlands	3,207	0.4
Portugal	10,939	1.3
Spain	12,222	1.4
Other European Countries by country	544,614	65.0
Yugoslavia	98,979	11.8
Austria	6,847	0.8
Switzerland	939,000	0.1
Turkey	359,669	43.0
(b) Africa	33,357	4.0
(c) America	9,236	1.1
(d) Asia	64,379	7.7
(e) Australia and	435,000	0.1
(f) Unclear	40,098	4.8
Total	**837,139**	**100**

Source: Grund- und Strukturdaten 1993/94

Report from Greece

Vasilis Kouladis

Introduction

Education was, and still is, valued very highly in Greek society. This is not a new phenomenon. From the first years of Independence and the creation of the Greek State (1828) a special effort was made for the establishment and gradual expansion of the schooling network. The need for personnel trained in particular skills related to the character of the Greek economy (of which one of the main and most durable traits is the reliance on the service sector) laid the groundwork for the development of the schooling system and the prevailing ideology concerning the value of education[1].

This framework as well as the pre-occupation of the society with classicism helps to explain the special status of languages and mathematics in the Greek curricula[2]. The subjects related to science traditionally were not high in the curricular hierarchy. On the other hand, the upgrading of these subjects was always (up until recently) at the forefront of the demands for a radical curricular reform. These demands were connected with the social strata and political parties which had put emphasis on industrial development.[3]

An interpretation of the present position of the science subjects (which is discussed in section 1), the way science is delivered in schools (see section 2), as well as the dynamics of change (see section 8) should therefore take into account the following points:

a) the gradual development of a consensus among the forces which shape the curricula;

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1. K. Tsoukalas, *Dependence and reproduction*, "The social role of educational mechanisms in Greece (1830-1922)", Athens Themelio, 1977.

2. For instance Ch. Noutsos , *Secondary Curricula and Social control*, Athens Themelio, 1979.

3. Ibid and K. Tsoukalas, 1977.

b) the conventional, subject-centred and teacher-dominated way of teaching;

c) the compromises which constitute the basis for the development of curricular consensus (for instance the science school subjects were upgraded, mainly via their inclusion in the university examination syllabi, but science is taught in a way which is no different from the teaching of other subjects);

d) the institutional inertia which prevents the rapid implementation of radical changes.

1. Science in the National Curriculum

Science is taught in Primary (*Demotiko*, 6 years) and Secondary (*Gymnasio*, 3 years and *Lykeo*, 3 years) schools. Table 1 shows the subjects which are taught at each grade and the corresponding age groups[4].

Table 1: School subjects

Age group	Grade	No. of subjects	Subjects	Remarks
10-11	D5	2	GS (integrated), Geo	compulsory for all students in all schools
11-12	D6	2	GS (integrated), Geo	compulsory for all students in all schools

Note: There is no subject called 'science' or anything similar in the four first grades of the primary school. Elements of science are taught, however, particularly in the teaching of the subject 'Getting to know our Environment'. This subject is taught for 4 periods per week.

4. Some of the data on which Tables 1 and 2 as well as the diagram 1 (Appendix 1) concerning the structure of the Greek formal education system are taken from: G. Kontogiannopoulou-Polydorides, Th. Mylonas, J. Solomon and D. Vergidis, "System in Education" in: *International Encyclopedia in_Education*, T. Neville Postlethwaite (ed.), Oxford, Pergamon Press, 1994. To all these colleagues and to Ph. Vlachos I express my gratitude.

My thanks are also due to my colleagues K. Ravanis and G. Bagakis of the University of Patras, V. Chatzinikita of the University of the Aegean and V. Tselfes of the Aristotle University of Thessaloniki for their valuable comments on this report.

Age group	Grade	No. of subjects	Subjects	Remarks
12-13	G1	2	Bo/Zo, Geo	compulsory for all students in all schools
13-14	G2	4	Ph, Ch, Bio, Geo	compulsory for all students in all schools
14-15	G3	4	Ph, Ch, Bio, Geo	compulsory for all students in all schools
15-16	L1	4	Ph, Ch, Tech, Earth	All students in 95% of schools
16-17	L2	5	Ph, Ch, Bio, Tech, Earth All students in 95% of schools	
L3	4	Ph, Ch, Bio, Tech	40% of students in 70% of schools	

Note: 70% of the upper secondary schools are 'general-academic'. The other 25% are technical *Lykea* while 5% of them are 'multilateral'. In the technical *Lykea*, Physics and Chemistry are taught in the last grade, but less time is assigned to their teaching. Technological subjects constitute a major component in the curricula of the last year (60% of the total time).

Abbreviations:

Ph	=	Physics	**Ch**	=	Chemistry
Bio	=	Biology	**Bo/Zo**	=	Botany and Zoology
GS	=	General Science	**Tech**	=	Technology;
Geo	=	Geography	**Earth**	=	Earth Sciences.

1.1 Recommended number and duration of lessons

The officially prescribed numbers of subjects for each grade are shown above in Table 1. All schools follow the same centrally-constructed curricula.

It should be noted that:

1) each lesson (period) lasts for 45 minutes; and

2) the school year is divided in two 17-week semesters.

In Table 2 below, the number of lessons (periods) per week and per subject is listed for every subject.

Table 2: Number of lessons

	GS	Geo	Total
D5	3	1	4 out of 26
D6	3	1	4 out of 26

	Ph	Ch	Bio	Geo	Bo/Zo	Total
G1				3	3	6 out of 25/27
G2	2	1	2	2		7 out of 28
G3	2	2	1	2		7 out of 30
	Ph	**Ch**	**Bio**	**Tech**	**Earth**	
L1	3	2		2	1	8 out of 29
L2	3	2	2	>2	1	>10 out of 29
L3	5*	3*	4*	>2*		it varies

*The data given in this entry concern the students who intend to study science, maths, engineering or medicine.

1.2 Which sciences are to be taught

Integrated science is taught only in primary schools. This is a rather recent development. The major reform of the primary schools curricula, which included the introduction of integrated science as opposed to separate subjects, dates from 1983. It is, however, more accurate to say that the primary science curriculum is a combination of different 'chapters' rather than an attempt to produce an integrated curriculum.

From the first year of secondary schooling the distinctions between subjects - even between subjects related to the physical sciences - are sharp and their teaching is formal.

The inclusion of technological issues is discussed in section 1.4.

1.3 Realistic data on the above

The educational system of Greece is very centralised. The Ministry of Education through the district directors of education makes sure that the schools follow the centrally prescribed curricula. Thus, the entries (subjects and number/duration of lessons) in Tables 1 and 2 are indeed a realistic depiction of the situation.

In addition to the above, all schools have to teach the same topics for each subject. In Appendix 2, the list of topics to be taught (syllabi) are given for the following grades: sixth grade of primary school (*Demotiko*), the second grade of lower secondary school (*Gymnasio*) and the second grade of lower secondary school (*Lykeo*).

Furthermore, it should be noted that the same textbooks, teachers guide-books and worksheets/notebooks are used for the teaching of science by all schools.

Schools usually fail to cover all the topics which are included in the curriculum list. It is estimated that 65-70% of the whole list is covered for Physics, 60-65% for Chemistry, 45-50% for Biology and Geography is a reliable general trend for all grades with the exception of the last grade of *Lykeo* (L3). In this grade all schools cover the list. The reason for this exception is the fact that the university entrance examinations (national examinations) are based on the topics and subject matter of the last grade. It should be stressed, however, that apart from the special effort made to achieve further uniformity for this grade, the amount of content is more realistic.

For the type of science (e.g. integrated or separate subjects, etc.) and the inclusion of technology-related issues, see sections 1.2 and 1.4.

1.4 Recommended learning activities

Teaching of science in Greek schools both at the primary and secondary level is generally formal and textbook-based, with a heavy homework load for the pupils. The majority of subjects are compulsory for all students. The practice of streaming and/or setting is absolutely prohibited.

The national curriculum recommends learning activities and gives detailed guidelines for their implementation. In primary school and the first stage of secondary school, pupils rarely do experiments by themselves. All the experimental activity, which does not take more than 20% of the available time, is conducted by teachers (i.e. demonstrations). Research has shown that primary teachers, probably because of lack of training, are very hesitant in conducting demonstrations. In the upper secondary schools (*Lykea*), students do a lot of computational exercises with no experimental work at all. It should be noted, however, that in the technical *Lykea* there are technological subjects which involve laboratory work, e.g. analytical chemistry, electronics, etc.

The same pattern can be seen in field studies. As one goes from the primary to upper secondary school, the time devoted to field studies is increasingly less. It should also be said that fieldwork, roughly 5% of the total teaching time in primary and lower secondary schools, is conducted mainly in geography, botany and geology.

Issues related to scientific applications in industry appear usually by the end of each chapter, mainly in a descriptive form. Pupils have chances to visit one or two local industries.

Issues concerning the history of science and related controversies do not appear in science textbooks and are therefore not taught, apart from the occasional mentioning of biographical notes concerning great scientists.

There is however one exception. The physics textbook and relevant curriculum of the second grade in the multilateral *Lykea* introduces each new chapter with an historical account that attempts to put the development in the relevant field into a socio-historical context.

1.5 Mandatory tests and examinations

There is only one national examination which is not mandatory for all pupils: the entrance examination for university and for the technological institutions (which are similar to the British Polytechnics before the last reform).

Otherwise, assessment is school-based. A summary of assessment, in the form of tests, takes place in grade 5 and 6 (age 11-12) of primary and grade 7-12 (age 13-18) of secondary. Its main purpose is to consider whether or not a student can continue his studies after completing a school year. 100% of the students in grades 5-11 and about 80% of the students in grade 12 should take the tests. Almost all item types are short response or essay tests. Normative assessment in the form of discussion, short tests, etc. can be used for diagnosing students' difficulties and to influence everyday instruction.[5]

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5. The description of the school-based assessment reflects the situation at the time this report was written. As stated in sections 5.2 and 5.3 there are frequent changes in the way pupils and students are examined.

The university entrance examination is administered centrally for all universities. A prerequisite for sitting for this exam is a certificate from upper secondary school, i.e. *Lykeo*. Formally, there is no distinction between the certificates of general-academic *Lykeo* and technical *Lykeo* in terms of this exam. In practice, 90% of the candidates who enter the university have certificates from general academic *Lykea*. Roughly 80% of the students who acquire a certificate from an upper secondary school sit for the university entrance examinations.

As shown in Diagram 1 (Appendix 1), 40% of the age group succeed in entering tertiary educational institutions (22% into universities, 18% into technological institutions). There is a clear tendency for those graduates of the technical *Lykea* who continue their studies to go to the technological institutions. It should be stressed that this examination is an event which gains prominence every year, and is one of the few examinations that public opinion considers as meritocratic. Research has shown that the students from middle-class family backgrounds are favoured - i.e. succeed in the departments heavily in demand - in this examination system.

1.6 New trends and reforms underway

New major trends and reforms are not anticipated. The last major educational reform took place in 1983. Lesser changes include the gradual expansion of the 'multilateral' (or, 'multi-branched') *Lykea*.

There are also frequent minor adjustments of the university entrance examinations. The main features of these examinations have remained constant over the past three decades, namely: central control; *numerus clausus*; no participation of schools; and student preparation in private 'cramming' schools.

The critique of the national curriculum and its evaluation are focused on the inadequacy of secondary schools to prepare students for either university studies or for jobs. Debates concerning necessary reforms include issues like the increase in the pace of introduction of 'multilateral *Lykea*', the introduction of post-secondary vocational schools, and the inclusion of new technologies (i.e. computing) in the school curricula.

As far as the monitoring and evaluation of existing curricula are concerned, changes in the roles of the Directors of Education and district Counsellors of Education (see section 3.1) who have to monitor curricula implementation are frequent. These changes are minor, however, and they do not alter the main characteristics of the evaluation system which are: centralisation, the absence of national standardised tests for schools, and the absence of direct parental influence.

2. How is science delivered?

2.1 Organisation and authority

The central government (Ministry of Education) is responsible for the training of teachers, designing the curricula, employing and paying the teachers, constructing new schools and monitoring the teaching. There are several central agencies attached to, and dependent on, the Ministry of Education, which design and implement relevant policies, e.g. Agency for School Buildings, Agency for School Textbooks, etc. In addition to these agencies which do not interfere with schools directly, there are: the district Director of Education (administration, personnel) and the district Counsellors (their official role is to guide teachers and enforce the curricula guidelines). Secondary schools have specialised coordinators for science, while primary school coordinators do not hold a degree in science.

The director of the school deals with the day-to-day administration. For serious matters, he must call and consult the general assembly of teachers. Alternatively, the general assembly can be called if 30% of the teachers request it. The general assembly can override any decision of the director. Parents have no say in the way school is administered, apart of course from their intervention in the broadest political sense, i.e. general-national elections, political parties. Local authorities play an increasing role in financing the schools, except the staff.

The authority of the teacher, which is traditionally high, particularly in small communities, still holds.

2.2 Resources and funding

Every year all students receive free of charge the whole range of textbooks, worksheets and all relevant teaching materials. Roughly speaking, every student receives 10-15 books every year, which amounts to an expenditure of 40-70 US$. This expenditure is the responsibility of the Ministry of Education. The salaries of the staff are also paid by the Ministry of Education.

Expenditure for laboratory furnishing, apparatus, and libraries lies with each individual school. The money comes from the local authorities, which keep a separate account for financing the schools. Since resources are scarce, schools rely on local authorities only for the every day running of the school, i.e. heating, cleaning. On the other hand, for the creation and/or expansion of labs schools rely on either the help of central agencies, parental support, or even sponsoring from the private sector (firms, individuals).

2.3 Methods of teaching

The lecture mode is the prevailing method of teaching science in Greek schools at all levels. Pupil-led investigations are notably absent, while demonstration experiments do not amount to more than 20% of the total teaching time, as has already been stated in section 2.4. Pupils are encouraged to work individually rather than in groups, and this in spite of the fact that one of the stated aims of the science curricula is to promote group work. The homework load is very heavy, with Greek language, maths and science being the subjects which require most of the homework. It is estimated that primary pupils have to work 3-4 hours per day to do their homework. The workload gradually increases, so that at the end students preparing for the university spend about 6-8 hours on homework.

To this homework load, one should add the daily attendance of private cramming schools. Pupils of primary and lower secondary level go to these private schools in the afternoons to learn foreign languages, while upper secondary students attend 'cramming' schools for the university entrance examinations.

It is estimated that at least 90% of pupils in primary and lower secondary level, and 80% in upper secondary (general-academic state *Lykea*) attend these private schools.

2.4 Sources of pedagogic innovation

The major sources of pedagogic innovation are:

1) the education departments of the universities;

2) the Ministry of Education Agency responsible for the development of curricula (Pedagogic Institute);

3) groups of practicing teachers.

By law, the link between research and the introduction of innovation is the responsibility of the Pedagogic Institute. The Pedagogic Institute is a governmental agency which is supervised and financed by the Ministry of

Education. However, it should be noted that in practice the function of the Pedagogic Institute is bureaucratic and confined to implementing Ministry decisions rather than designing educational policy.

University departments propose teaching innovations but these, given the very centralised character of the Greek educational system, are permitted to be tried out only on a small scale. This is to say that there are no established links for disseminating the results of this research to science teachers. The only route that can be used for the dissemination of relevant research are the centres for in-service teacher training. There are 20 in-service teachers training centres. In some of them, members of university departments do some teaching, so they have the opportunity to discuss with practising teachers their research. Teams of teachers with innovative ideas usually contact university departments for support and in most instances their work is incorporated into university research programmes.

3. Going beyond school

3.1 Use of out-of school resources

The use of out-of school resources is still based mainly on occasional visits to museums and local industrial firms. There are no places in which students can perform experiments, etc. and the use of media in schools is rather limited. Indeed, the use of television is scarce and officially there is no time assigned for such activity.

Some countryside schools have their own gardens which pupils can use for educational purposes.

3.2 Consideration of public science-based issues within lessons

Public science-based issues have entered the classroom mainly in reference to issues concerning pollution. It should be noted, however, that the discussion of such issues is mainly descriptive in character, avoiding scientific controversy. This point is of considerable importance, because the media report extensively on the sometimes heated debates on pollution and earthquakes.

3.3 Science education and vocational training

The status of school subjects related to science, especially to physics and chemistry, is considered high by both teachers and parents. One reason for this stratification is the fact that physics and chemistry are subjects tested for university entrance for most of the highly-held departments, e.g. medicine, computing, etc.

In the technical *Lykea* curricula, part of the time spent in the general-academic *Lykea* on traditional subjects has been reallocated to more technological subjects, such as electronics, etc. within the technical *Lykea*.

Further vocational training also tends to be school-based. Indeed, post-secondary institutions for vocational training (in conjunction with practice-periods spent in industrial firms) are increasingly popular.

3.4 Science clubs and cultural associations

Science clubs are not usual in Greece. The Association of Physicists and the Association of Chemists initiate events in schools from time to time. The curricula of the 'People's Universities' (informal institutions financed jointly by the Ministry of Education and the Local Authorities) do not usually contain science-related subjects.

All in all, outside of school there is little science education activity.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Greece participates in TIMSS. Popular reactions and critiques are mainly expressed during the university examination period; and they are heated but not well-informed. The general public is convinced that the actual preparation of students in the things that are important in their view (foreign languages and university entrance examinations) takes place in the private cramming schools and not in the secondary schools. This critique achieves national prominence and there is almost no defence on the part of, or on behalf of, the state schools. The thrust of the public demands, however, is not 'payment by results' or similar approaches, but a general and in some instances not well-articulated request for better education, more money for education, evaluation of curricula (with no teachers' assessment and no national standardised tests), and an upgrading of state secondary schools.

4.2 Public or political concerns about educational standards

Success in the various examinations rather than in educational standards are a major public and political concern. Changes in government are followed by 'reforms' in education. These reforms are usually minor changes in the examination system. Exceptions related to content, however, rather than the process of science teaching are:

a) the introduction of environmental studies in primary and lower secondary schools;

b) the introduction of information technology mainly in the secondary schools.

The two more recent radical changes in the Greek educational system (including the type of science to be taught in schools) took place in 1963 (i.e. democratisation of secondary and tertiary levels, free textbooks for all) and 1983 (emphasis in curricular changes).

The suggested reforms, which are echoed in the media, have been mentioned in section 4.1. In addition to these demands there are suggestions, mainly from the education departments of the universities, relating to particular problems like the use of computers as teaching tools, changes in the material to be taught (less), increase in courses in environmental education, curricula for immigrants, and more flexibility in curricula design and implementation.

5. Pupil interest and motivations

5.1 Generally by age and gender

In terms of student interest and motivation by age and gender, there has not been any research. It has generally been assumed that boys are more interested in science than girls. However, there are two things one must to take into account in evaluating this general assumption:

1) All subjects are compulsory for all pupils in most of the cases (see Table 1).

2) There is no streaming or setting in Greek schools.

3) The results in the university entrance examination indicate that the success of girls does not differ substantially from that of boys as far as public examinations are concerned. In Table 3 below, the percentages of girls and boys who succeed

in the university entrance examinations (for science-related departments) are given[6].

Table 3

	Female	**Male**
Physics	33%	67%
Chemistry	55%	45%
Biology	53%	47%
Geology	43%	57%
Medicine	52%	48%

Nevertheless, the stereotypical pattern is discernible.

5.2 By type of science or topic by age/gender

Since no research is available and no choice is permitted, it is difficult to draw conclusions about pupil interest and motivation by type of science or topic by age/gender.

It should be mentioned, however, that physics and chemistry are considered more important subjects than biology - at least by teachers and parents.

5.3 Options for choice within science

For primary and lower secondary school there is no choice whatsoever for students. Even in the first two grades of the upper secondary school, choice is limited and depends mainly on the type of *Lykeo* students attend. In the final grade (17-18 years old) choice is given and subjects related to science are opted for by those students who intend to continue their studies in fields which require science.

5.4 Pupils' perspectives on the value of science

The image of science and scientists is very positive. Science is conceived as helping to solve pollution and health problems, etc., rather than creating them. Student interest in undertaking a career in science is rather limited because of the problems related to unemployment and salaries. Science, however, is highly

6. The data were taken from "Eleftorotypia", 5 March 1995.

valued, as it is considered essential for pursuing a career, e.g. in medicine or engineering.

6. Training, status and morale of scientific teachers

6.1 Initial training

To work in a school, both secondary and primary school teachers should hold a university degree. Secondary school teachers study in the relevant university departments, e.g. department of physics for physicists, etc. with little, if any, study in education. When in school, they teach subjects of their specialisation and are usually asked to teach subjects close to their specialisation; for instance a physicist is usually asked to teach chemistry and/or biology, but never subjects which are considered remote for his/her studies.

Primary school teachers have to hold degrees from the departments of education. This development is recent - the first departments of education in the universities (4-year courses) were established in the mid 1980s. Thus, the majority of practising primary school teachers have certificates from Teachers Training Colleges (2-year courses). There is an ongoing attempt by the universities to re-train those primary school teachers who do not hold a university degree (nearly one thousand primary school teachers are being re-trained every year).

6.2 Decision-making authority for the above

Decisions for the content of degrees are made by the relevant departments, i.e. the general assembly of all department staff. Student representatives participate fully in this assembly. The Ministry of Education does not have a direct say in degree requirements, which are identical to the requirements of other university departments.

6.3 Continuing training

There are two major ways for teachers to continue their training:

At the in-service training centres in which both primary and secondary school teachers get refresher courses on teaching methods which last 4 months. There are 17 such in-service training centres throughout the country, training more than one thousand teachers each per year. These centres train both primary and secondary school teachers. The decision-making authority for these centres is the

Ministry of Education. Currently the system of in-service training centres is under reform.[7]

By law, all teachers accepted for a Ph.D. degree are entitled to a sabbatical leave with the full payment of their salary.

6.4 Number, teacher/pupil ratio, gender, age profile

The number of primary teachers is about 45,000, while secondary school teachers total roughly 50,000 (see Table 4 and 5 as well as Charts 3 and 4 of Appendix 4). It should be noted that 1% of primary school teachers have a science degree in addition to their certificate in education. There are 5,500 secondary school teachers who have a degree in subjects related to science (see Table 3 and Charts 1 and 2 of Appendix 3), e.g. physics, chemistry and/or biology (7,000 including Bo/Zo, Earth and Geology teachers).

The pupil/teacher ratio for science is not different from the ratio in any other subject, since all subjects are compulsory. This ratio varies between 14/1 to 20/1. It should be taken into account that village schools have fewer pupils and therefore their ratio is even better. For city primary and lower secondary schools the ratio is 22/1 to 24/1, while for upper secondary schools the ratio is 18/1 to 20/1. Tables 8, 9 and 10 (Appendix 6) show pupil/teacher ratio development between the years 1983 and 1990 for Primary (*Demotiko*), Lower Secondary (*Gymnasio*) and Upper Secondary (*Lykeo*) schools respectively. In Table 7 (Appendix 6) the numbers of students are given for primary and secondary (lower and higher) level.

The majority of primary school teachers are female (55%). In secondary school, female teachers outnumber the males, especially in languages. The percentage of male science teachers is higher than that of females - especially in physics and *Lykea* (the situation is reverse in Biology and *Gymnasia*). Table 6 and Charts 5 and 6 (Appendix 5) portray the composition of the body of secondary science teachers in detail.

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7. The main idea is to structure the training in flexible modules, e.g. science education, computing and physics, etc. These modules will be chosen by teachers according to their self-perceived needs. There are 4 such experimental centres in operation in the academic year 1994-1995.

Both primary and secondary school teachers receive their pension after 35 years of work. They enter the educational service rather late, at the age of 30 (employment in the educational service is regulated by a list in which all graduates willing to work as teachers are enrolled). Given that two or three decades ago fewer teachers were appointed than nowadays, there are today more young teachers in service.

6.5 Drop-out rates, late entries, maternal leave

The drop-out rate of primary school teachers is low (less than 5%)[8], given that the chances for re-employment with such a degree are slim. It is difficult to define the drop-out rate for secondary school teachers, as only those graduates who wish to become teachers are enrolled in the lists of the Ministry of Education. During the long interval between the time they enrol in the list and the time they take up a post, teachers usually work in private cramming posts.

Women are entitled to 6 months of maternity leave with full payment, and their job is secured. Either parent has the right to an additional year of leave - if they so wish - without pay, and again their job is secured.

6.6 Status and salary

There is no substantial difference in salary between secondary and primary school teachers. The average salary of a teacher is 2,500,000 drachmas (US$ 10,500) net per year. This salary is equal to those of other civil servants, but below those of professionals in the traditional high-status sectors, i.e. law, medicine, engineering. By comparison, a doctor in the National Health Service gets DR 5,600.000 (US$ 23,500) net per year, which is the same as the average salary for a university teacher.

Teachers are highly regarded in villages and small towns, while their traditional esteem in cities is weakening.

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8. This is an estimation based on data available from the Dept. of Education/University of Patras only.

7. Equality of opportunity?

7.1 Different status of the schools

The overwhelming majority of schools in Greece (95%) are state schools, as opposed to religious schools. The private sector in education amounts to less than 5% of the total student population. There are two kinds of private schools:

1) foreign schools, where a foreign language is the main means of teaching; and

2) private schools, where all subjects are taught in Greek.

Annual tuition fees are rather high; in average, they correspond to 1/5 of the salary of a school teacher and, therefore, only middle-class children attend this sort of schools.

These schools are better equipped than state schools and they place special emphasis on foreign languages and sports.

In the public sector there are special schools (usually one in every main city) in which teaching is considered to be better than the usual state schools. Pupils for these special schools are selected by drawing lots. The university entrance examinations' success rate does not indicate differences between public and private schools. A possible explanation for this is that students from private schools go abroad for studies.

7.2 Regional differences

Research has shown that very small village schools are disadvantaged compared to other schools. For this reason, schools in very small villages (less than 10 pupils) are closing down and pupils are conveyed every day to schools in bigger villages nearby. The costs for this transportation is covered by the local authorities. There are no significant problems associated with inner-city schools. On the contrary, schools situated in the centre of big cities are well-off, as their catchment area consists of middle-class citizenry.

7.3 Immigration and migrant populations

There are two types of immigrants in Greece:

1) Immigrants of Greek origin, usually from the countries of the former Soviet Union. (Up to now one hundred thousand have already returned to Greece - the arrival of another four hundred thousand is expected by the end of this decade.)[9] Special schools have been established for these immigrants, using teaching materials especially developed for this purpose and employing teachers from the immigrant population. The aim of these schools is to help immigrant children with the Greek language. When children are considered fluent in Greek, they are transferred to the usual state schools.

2) Economic immigrants. This is a recent phenomenon. These immigrants usually do not come with their children and no special measures have been taken to help these children.

7.4 Special education for handicapped children?

The policy is to integrate handicapped children into the usual schools whenever this is possible. If educational service psychologists are convinced that this integration is not possible, children are sent to special needs schools.

No science curricula or special teaching materials have been developed for handicapped children.

8. Dynamics of change

To illustrate the dynamics of change in science teaching in Greece the following elements should be taken into account:

a) As stated in sections 5.2 and 5.3, the enactment of laws introducing rather minor changes in the educational system (concerning mainly the university entrance examinations) is frequent in Greece.

b) The major reforms of the educational system (namely those of 1964 and 1982), even when they referred to science teaching, never affected in any substantial manner the way science was taught, despite changes in the organisation of the

9 P Linardos-Rylmon, *Immigrants employment and labour market in Greece*, Athens Institute of Labour, General Confederation of Trade Unions, 1993.

content. Of the latter, the most prominent are the introduction of subjects related to environmental education and the 'integration' of primary school science.

c) The teaching of science is subject-centred, with emphasis on pencil and paper problem solving skills and an absence of practical work: all in all, a traditional mode of delivering lessons.

d) One of the in-built and very durable characteristics of modern Greek society is the willingness and ability to absorb new technology into the services sector, and at a level which is well above the technical capacity or production of the country.

e) Science teachers are particularly keen on computing.

f) This willingness and ability to absorb new technology coexists with a very traditional approach to teaching, as well as resistance to real fundamental change in the school.

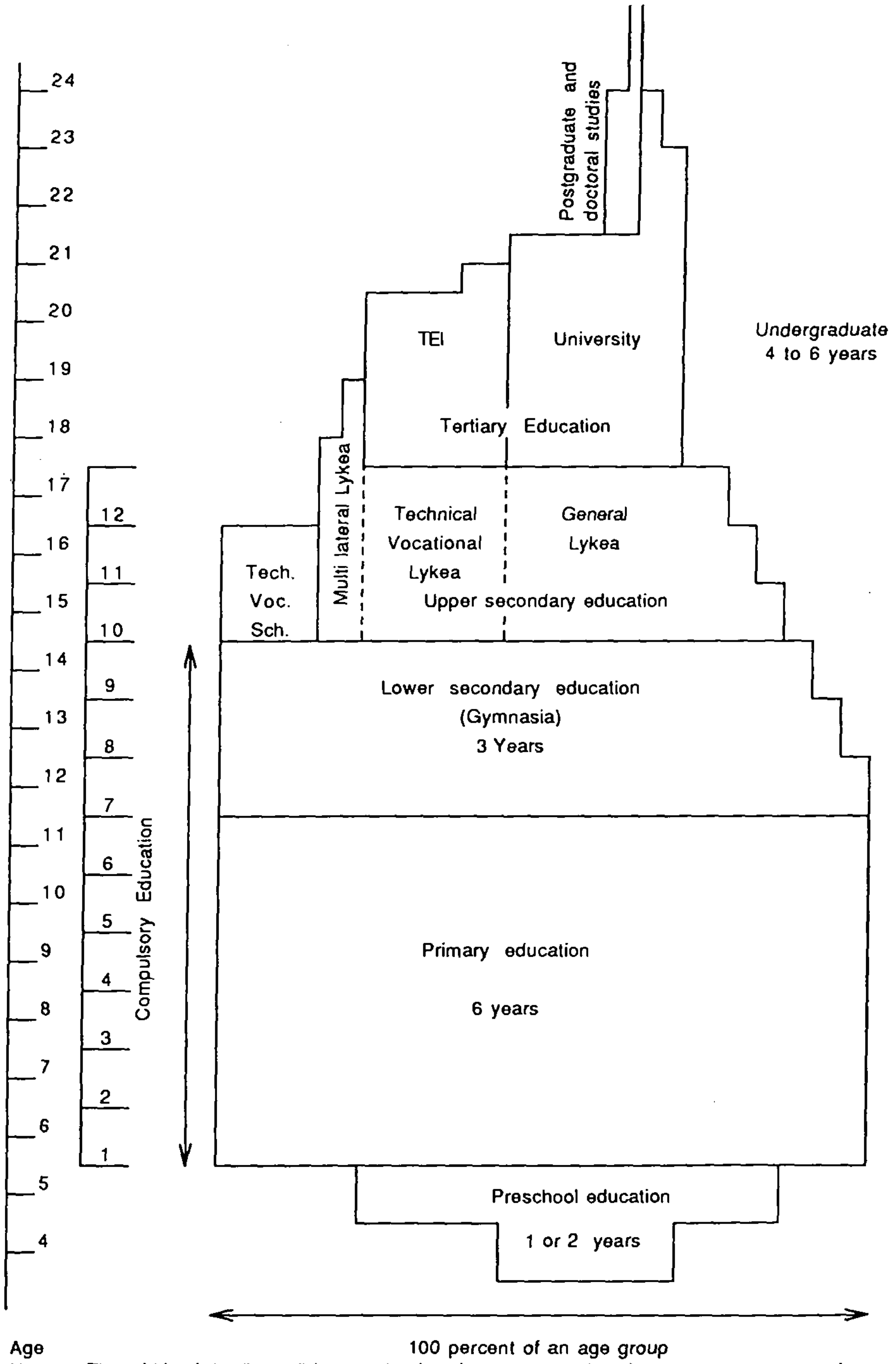
On the basis of these points the following prediction seems not unreasonable: new technologies will be introduced for the teaching of science[10] in the near future[11], but owing to institutional inertia their impact on the way science is delivered in schools will be slow to appear.

10. The infrastructure seems not to present special problems for such a development. For instance, over 75% of the Gymnasia have already at least 30 computers in network.

11. Indeed while writing this report the Ministry of Education advertised projects for software development suitable for teaching in secondary schools with emphasis on the subjects related to science.

Appendix 1

Structure of the Formal Education System, Greece 1991-1992



Note : The width of the "steps" in preschool and secondary education represent rough estimates arrived at from the Ministry of Education available data.

Appendix 2

Syllabus: 6th grade of Primary (*Demotiko*) School.

A1 Structure of matter.

1. The atoms of some elements.

2. Some atoms are radio-active.

A2 Nuclear energy.

1. Atomic fission.

2. Can we control nuclear energy?

3. The uses of nuclear energy.

B1 Ways of transmitting heat: Heat changes the condition of bodies.

1. Heat is transmitted by conduction.

2. The flow of heat.

3. Heat is transmitted by radiation.

4. Melting.

5. Liquids evaporate.

6. Boiling - Liquefaction.

7. Changes of the thermal energy. Applications.

B2 Phenomena of the atmosphere.

1. Winds. Sea currents.

2. Hydrometer.

3. Weather forecast.

4. Is the atmosphere electrically charged?

B3 The solar energy in relation to plants and animals.

1. Plants with and without flowers.

2. Sea weeds and lichens.

3. Fish.
4. Animals living in and outside the water.
5. Reptiles.
6. Birds.

C1 Movements of the solid crust of the earth.

1. Earthquakes.
2. Kinds of earthquakes; anti-earthquake protection.

C2 Deposits - Production of thermal energy.

1. Oil.
2. Products of crude oil.
3. Mineral carbons.
4. Coal gas - Carbon compounds.
5. Iron ores.
6. Sulphur and its compounds.

D1 Energy transmission by waves.

1. Creation and propagation of waves.
2. Transmission of mechanical energy by waves.

D2 Sound.

1. Production of sound.
2. Propagation and velocity of sound.
3. Reflection of sound. Echo and Resonance.
4. Characteristic attributes of sound.
5. The phonetic organs of the human body.
6. The auditory organs of the human body.
7. Musical instruments. Sound engineering - Reproduction of sound.

E1 Electromagnets and induction circuit.

1. Electromagnets.
2. Electric bell - telegraph - telephone.
3. From magnetism to electrism.
4. Power plant - Electrogenerators.

E2 Electromagnetic waves.

1. Transmission of electromagnetic energy.
2. Wireless communication media.
3. Television.
4. Radar - Radiotelescope - Other communication media.

E3 Reflection and refraction of light.

1. Reflection of light.
2. Mirrors, types of mirrors.
3. Refraction of light.
4. Lenses.
5. Applications of lenses.
6. The organ of vision (eye).

F1 Insects.

1. Energy of the animals.
2. Attributes of the insects.
3. An adorable insect.

F2 Vegetarian and carnivorous animals - Cetacean.

1. Attributes of vegetarian and carnivorous animals.
2. Large vegetarian animals.
3. Large carnivorous animals.

4. Large mammals of the sea.

G1 Biosocial and ecosystems.

1. Bio-communities.
2. Factors affecting the live organism.
3. Nutritional connections of the organism.
4. The forest.
5. Meadow - Desert.
6. Lake - River - Swamp.
7. The sea.

G2 Interference of the human being with the ecosystems - Protection of the environment.

1. Mono-cultivations and cattle.
2. Disturbance of the natural ecosystems.
3. Nature is in danger.

Syllabus: 2nd grade of Lower Secondary (*Gymnasio*) School.

Subject: PHYSICS

Introduction

1. Physical phenomena - physical measurements.

2. Derivative measurements - Systems of units.

1. The mechanic of solids.

1.1. Linear uniform motion - average speed.

1.2. Velocity as a vector measurement - Laws of linear uniform motion.

1.3. Force - Weight - Special weight.

1.4. Data of elasticity - dynamometers.

1.5. Forces.

1.6. Moment of a force - Pair of forces.

1.7. Parallel forces - Centre of gravity.

1.8. Friction.

1.9. Work of force - power.

1.10. Energy.

1.11. Types of balances.

1.12. Simple machines - Lever.

1.13. Pulley - Ramp - Winch.

2. The mechanic of fluids.

2.1. Pressure - Hydrostatics pressure.

2.2. Manometer - Basic Law of the hydrostatics.

2.3. Transmission of pressures at liquids - Applications.

2.4. Communicating vessels - Forces at the vessel walls.

2.5. Principle of Archimedes - Applications.

2.6. Estimate of density and special weight - Balloons.

2.7. Atmospheric pressure.

2.8. Barometers - Transmissions at the atmospheric pressures.

2.9. Properties of gases - Boyle-Mariotte Law.

2.10. Flow - Supply - Oil conductor.

2.11. Aeroplanes.

2.12. Molecular forces - Surface tension.

3. Heat

3.1. Temperature- Kinetic theory - Heat.

3.2. Thermometer - Celsius scale.

3.3. Body expansion - Linear expansion.

3.4. Liquid expansion - Irregularity of water expansion.

3.5. Modes of heat transmission.

3.6. Calorimeter.

3.7. Calorimeter - Heating power of fuels.

3.8. Melting - Freezing.

3.9. Gasification - Saturated steam.

3.10. Exhaust - Special heat of gasification.

3.11. Boiling.

3.12. Distillation - Sublimation.

3.13. Moisture.

3.14. Heat conduction and radiation.

3.15. Winds.

3.16. Steam engine - steam turbine - gas turbine.

3.17. Internal fuel engines - refrigerators.

4. Optics.

4.1. Light as a form of energy - Light production.

4.2. Light propagation.

4.3. Light reflection - Plane mirror - Idols.

4.4. Spherical mirror.

4.5. Light refraction.

4.6. Light analysis - Colours of bodies.

4.7. Idols of converging lenses.

4.8. Diverging lenses - Types of lenses.

4.9. Principle of the microscope operation, the telescope and the camera.

<u>Subject: CHEMISTRY</u>

Introduction.

1.1. Chemistry as experimental science of applications.

1.2. Elementary methods of chemical analysis.

1.3. Scientific research - Chemical Industry.

1. Chemistry and Nature.

1.1. Soil - Mixtures.

1.2. Atmospheric air.

1.3. Water - Pure substances - Natural standards.

1.4. Analysis and compositions of the water - Composite and simple bodies.

2. Microstructure of the Matter - Chemical Compounds - Symbolism.

2.1. Molecules and atoms.

2.2. Atomic and molecular weight - Avogadro number - Gram molecule - Gram molecular volume.

2.3. Periodical system of elements.

2.4. Transformation of chemical elements - Valency.

2.5. Chemical types - writing and terminology of inorganic chemical compounds.

2.6. Chemical reactions - Chemical equation - Chemical calculations.

2.7. Categories of chemical reactions.

3. Oxygen and Hydrogen.

3.1. Oxygen.

3.2. Hydrogen.

4. Three important groups of the Periodical system.

4.1. Alkali.

4.2. Halogen.

4.3. Carbon.

4.4. Silicon.

5. Acids - Bases - Salts

5.1. Acids - Hydrochlorine (HCl) and Sulphuric acid.

5.2. Bases - caustic sodium (NaOH).

5.3. Neutralisation - Salts.

5.4. The salts of calcium (Ca).

6. Mineralogy.

6.1. Rocks - Minerals - Ores - most important minerals and ores of Greece.

6.2. Elementary knowledge of mineral analysis.

<u>Subject: HUMAN BIOLOGY</u>

Introduction.

1. Cell differentiation - tissues.

1.1. Epithelium tissue.

1.2. Structural tissue.

1.3. Muscular tissue.

1.4. Nerve tissue.

2. General morphology and physiology of the organic systems of the human being - Bone system.

2.1. Texture of the bones during and after the embryonic age.

2.1.1. Bone creation.

2.1.2. Chemical composition of the bones.

2.1.3. Structure and increase of the bones.

2.1.4. Bone connection.

2.2. Parts of the skeleton.

2.2.1. The skeleton of the head.

2.2.2. The skeleton of the body.

2.2.3. The skeleton of the hands and legs.

3. Hygiene of the skeleton.

3.1. Disfigurement of the skeleton due to mechanical reasons.

3.2. Skeleton accidents.

4. Muscular system.

4.1. Kinds of muscles.

4.2. Texture of muscles.

4.2.1. Vascular fibres.

4.2.2. Smooth muscular fibres.

4.2.3. Cardiac muscular fibres.

4.3. Properties of the muscles.

5. Hygiene of the muscular system.

5.1. Muscular practices.

5.2. Conditions facilitating the muscular effort.

12. Hygiene of the respiratory system.

13. Nervous system.

13.1. Brain spinal nervous system.

13.2. Spinal cord.

13.3. Vegetable nervous system.

14. Hygiene of the nervous system - Reasons of nervous tiredness.

14.1. Sleep.

14.2. Implications of food, medicine, smoke on the nervous system.

15. Sense Organs.

15.1. The eye and vision.

15.1.1. Hygiene of eyes.

15.2. The ear and hearing.

15.2.1. Hygiene of ears.

15.3. Smell - Taste.

15.3.1. Hygiene of smell.

16. Cover system - Functioning of the skin.

17. Genetic system.

17.1. Chromosome map anomalies.

17.2. Premarital health certificate.

18. The physiology of the embryo.

18.1. Development - morphology and size of the embryo.

18.2. How the embryo feeds on.

19. Glands.

19.1. Endocrine glands.

20. Microbiology - Parasitology data - Viruses.

20.1. Diseases due to viruses.

20.2. Diseases due to bacteria.

20.3. Diseases due to protozoa and worms.

20.4. Parasiticide: Action and results.

20.5. Drugs and organic anomalies.

20.6. Vaccines - Serums.

20.7. Antibiotics.

20.8. Cancer.

21. The development of the human being and his/her relationship to the environment.

22. Social and cultural development of the human being.

23. Adaptability - Human races.

Syllabus: 2nd grade of Upper Secondary (*Lykeo*) School.

Subject: PHYSICS

1. Work-Energy.

1.1 Relation of work and energy. The meaning of work.

1.2 Work done by a constant force.

1.3 Work done by a variable force.

1.4 Energy and springs.

1.5 Work by force of constant measure: The case of force vertical to the movement of the body.

1.6 Theorem of change of kinetic energy.

1.7 Work done in taking a body along a closed route.

2. Momentum - Impulse.

2.1 Momentum: General introduction.

2.2 Force and the change of impulse.

2.3 Law of impulse - momentum.

2.4 Conservation of momentum.

2.5 Projectiles - projection forces.

2.6 Conservation of momentum and energy in mechanical systems.

2.7 Disintegration of radioactive nuclei.

2.8 Impulse: General introduction.

2.9 Elastic collision.

2.10 Plastic collision.

2.11 The discovery of neutrons.

3. Force fields.

3.1 The law of universal gravitation - The law of Coulomb.

3.2 Gravitational and electric forces.

3.3 From force to the notion of force field.

3.4 Elements of field of forces.

3.5 Definition of intensity.

3.6 Field lines.

3.7 The notion of potential.

3.8 Potential difference.

3.9 Potential.

3.10 Magnetic field.

4. Motion in fields of forces.

4.1 Projectile motion in vacuum.

4.2 Examples of projectile motion in vacuum.

4.3 Projectile motion in the air.

4.4 Escape velocity.

4.5 Satellites.

4.6 Motion with initial angular velocity.

4.7 Motion with initial velocity vertical to the field lines.

4.8 Force on a moving charge.

4.9 Motion of a charged particle in a uniform magnetic field.

4.10 Cyclotron.

4.11 Mass spectrometer/spectrograph.

4.12 Magnetic lenses.

5. D.C. Circuits

5.1 First rule of Kirchhoff.

5.2 Second rule of Kirchhoff.

5.3 Measurement of resistance.

5.4 Wheatstone bridge.

5.5 Cord bridge.

5.6 Measurement of the thermal coefficient of resistance.

5.7 Potentiometer.

5.8 Measurement of the electromotive force of an electrical element.

5.9 Measurement of the internal resistance of an electric element.

5.10 R-C-L circuits: General introduction.

5.11 The R-C series direct current circuit.

5.12 The R-L series direct current circuit.

5.13/5.14 Rectification - Smoothing of a.c.

6. Electromagnetic Induction.

6.1 Faraday's experiments and the law of electromagnetic induction.

6.2 The phenomenon of induction on a moving linear current-carrying conductor.

6.3 The phenomenon of induction on a moving current-carrying loop.

6.4 The phenomenon of induction on a motionless current-carrying loop and the time-changing electrical field.

6.5 Betatron.

6.6 Measurement of magnetic induction.

6.7 Lenz's law and the principle of energy conservation.

7. Alternating currents.

7.1 Production of alternating potential difference.

7.2 Alternating current.

7.3 Root mean square current - Root mean square potential difference.

7.4 Relation between root mean square current and amplitude.

7.5 Graphic representation of a sinusoidally varying current by rotating vector.

7.6 Impedance.

7.7 Circuit of alternating current with resistor.

7.8 Circuit of alternating current with coil.

7.9 Circuit of alternating current with capacitor.

7.10 Measurement of capacitance - Wheatstone bridge.

7.11 The R-L-C series circuit.

7.12 Resonance in R-L-C series circuit.

7.13 Experimental demonstration of resonance.

7.14 The R-C series circuit.

7.15 The R-L series circuit.

9.12 Entropy.

9.13 Energy crisis, Thermal pollution.

10. Laws of Gases.

10.1 Macroscopic - Microscopic description.

10.2 Laws of Gases.

10.3 State equation of ideal gases.

10.4 The model of the ideal gas.

10.5 Brown's motion.

10.6 Properties of ideal gases.

10.7 Pressure - Temperature of ideal gases according to the kinetic theory.

10.8 Distribution of Maxwell-Boltzmann.

10.9 The theorem of equipartition of energy.

10.10 Specific heat of gases.

11. Oscillations.

11.1 Periodic motions.

11.2 Force in the simple harmonic motion.

11.3 Energy in the simple harmonic motion.

11.4 Damped oscillations.

11.5 Exponential decrease.

11.6 Forced oscillations.

11.7 Resonance of oscillations.

11.8 Study of mechanical constructions.

11.9 Oscillation as a research method for the structure of matter.

11.10 The effects of oscillations on the human body.

11.11 Synthesis of oscillations: General introduction.

14.4 Compton phenomenon.

14.5 The atomic model of Bohr.

14.6 Interpretation of the emission spectrum of hydrogen according to Bohr's model.

14.7 Interaction between radiation and matter.

14.8 Free and forced emission of electromagnetic radiation Laser.

14.9 Material waves.

14.10 Correspondence principle.

Appendix 3

Table 3: Science Teachers in Secondary Schools

Lower Secondary Schools (Gymanasia)

	Phys.	Chem	Biol.	Geol.	Bo/Zo	Total
1983	1159	241	307	173	1205	3085
1986	1443	364	349	295	1171	3622
1989	1782	495	373	326	1093	4069
1990	1888	504	398	346	1056	4192

Upper Secondary Schools (Academic Lykea)

	Phys.	Chem	Biol.	Geol.	Bo/Zo	Total
1983	1666	346	92	35	329	2468
1986	1793	425	131	64	369	2782
1989	1803	497	170	76	356	2902
1990	1823	538	182	86	333	2962

Chart 1: Specialisations of Gymnasia Science Teachers

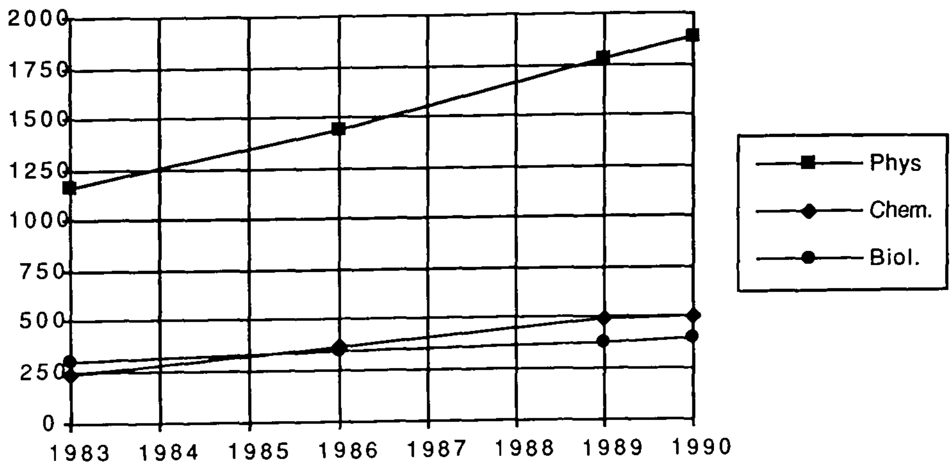
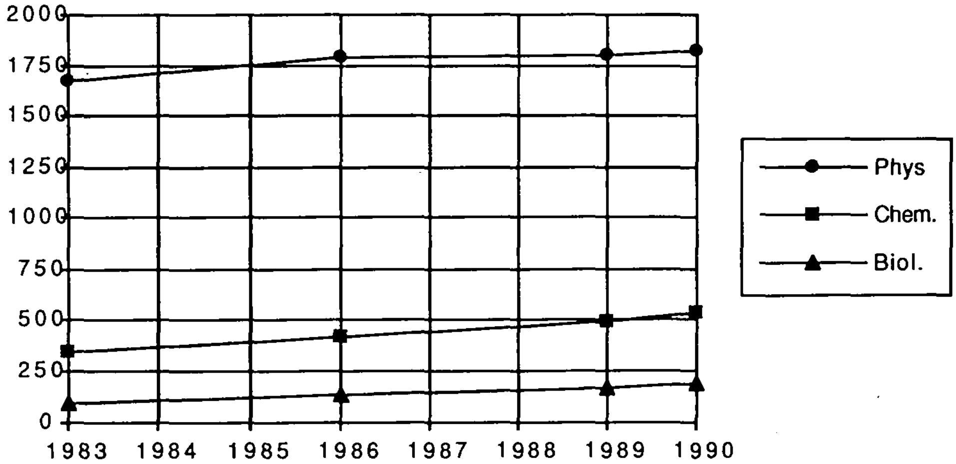


Chart 2: Specialisations of Lykea Science Teachers



Appendix 4

Table 4: Number of Primary Teachers

Year	Men	Women	Total
1983	19077	17748	36825
1986	19256	18690	37946
1989	20681	21804	42485
1990	20837	22762	43599

Chart 3: Number of Primary Teachers

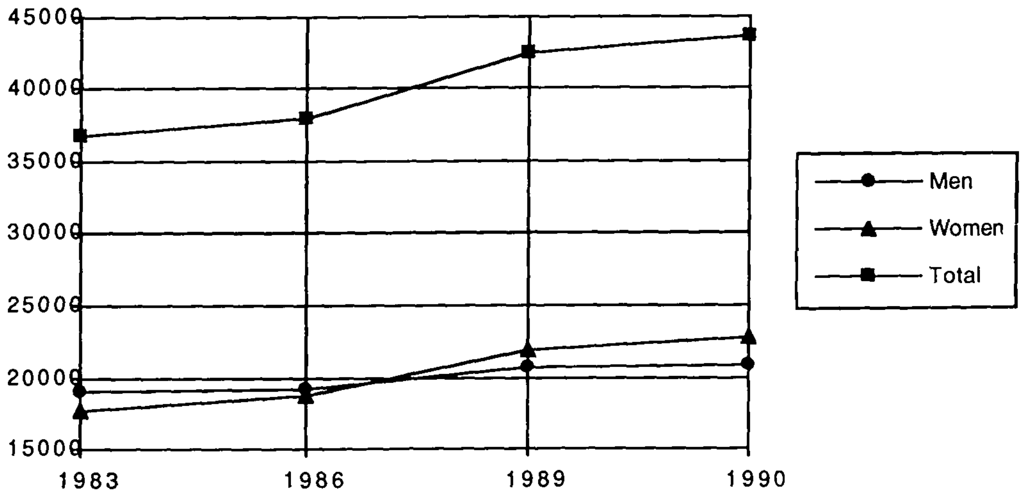
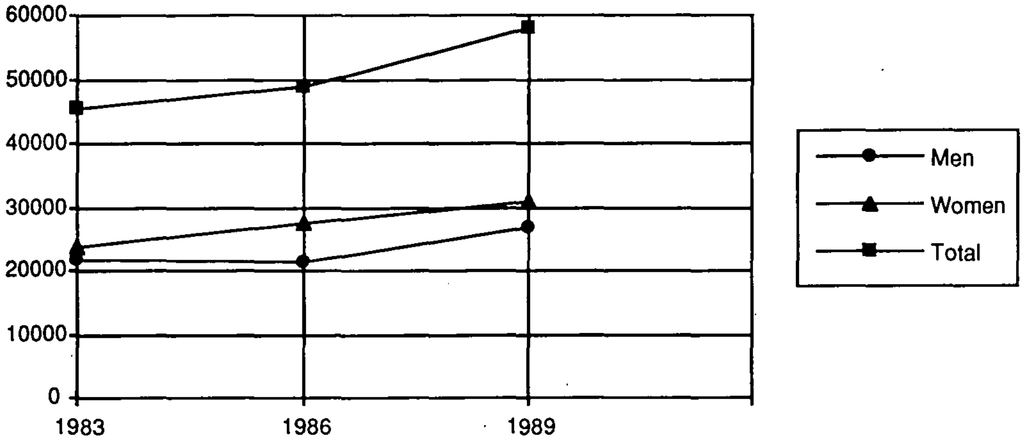


Table 5: Number of Secondary Teachers

Year	Men	Women	Total
1983	21843	23871	45714
1986	21532	27466	48998
1989	26945	31030	57975

Chart 4: Number of Secondary Teachers



Appendix 5

Table 6: Number of Secondary Science Teachers by sex

Year: 1990, Gymnasia

	Phys.	Chem.	Biol.	Geol.	Bo/Zo	Total
Men	1251	304	151	244	556	2506
Women	637	200	247	102	500	1686
	1888	504	398	346	1056	4192

Year: 1990, Academic Lykea

Men	1489	381	93	69	251	2283
Women	334	157	89	17	82	679
	1823	538	182	86	333	2962

Chart 5: Number of Gymnasia Science Teachers by sex

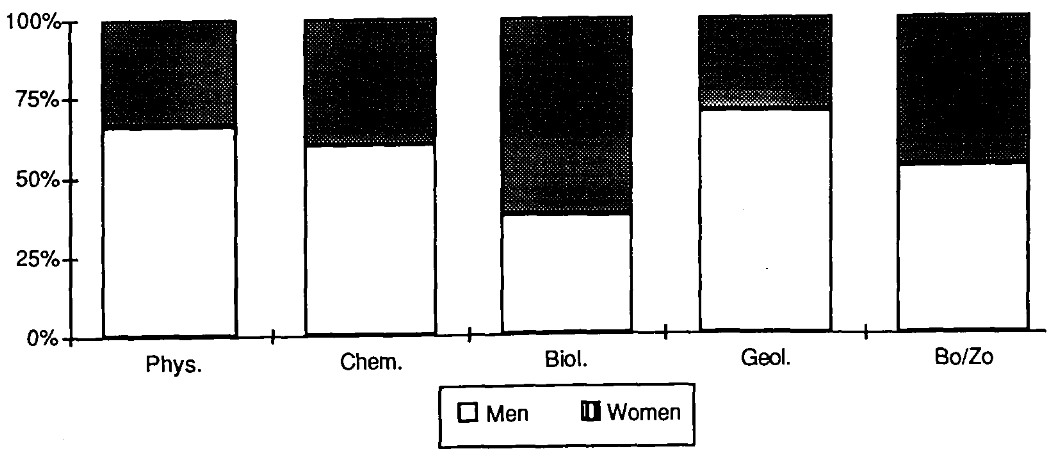
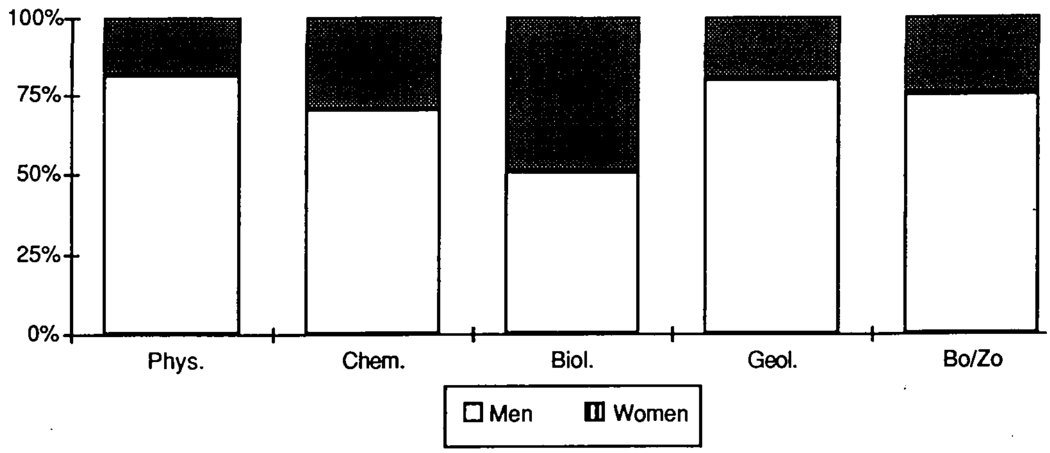


Chart 6: Number of Lykea Science Teachers by sex



Appendix 6[12]

Table 7: Number of students

Secondary Schools

Year	Primary Schools	Gymnasia	Lykea			
			Academic	**Technical**	**Multilateral**	**Lykea Total**
1981	900461	429362	210271	46890		257161
1983	888440	437788	252594	71815		324409
1986	865660	450270	251766	78334		330100
1989	834688	442918	250602	86897	15372	352871
1990	813353	442815	253481	87427	19474	360382

Table 8: Ratio of pupils to teachers in Primary Schools

Year	Ratio
1983	24.1
1986	23.4
1989	20.4
1990	19.1

Table 9: Ratio of pupils to teachers in Lower secondary State Schools (Gymnasia)

Year	Ratio
1988	16.4
1989	15.6
1990	14.9

12. The data for all Appendices were taken from the *Annual Reports on Education of the National Statistical Service of Greece*. My appreciation is expressed to E. Chodrou and N. Charitos for their helpful cooperation.

Table 10: Ratio of pupils to teachers in Upper Secondary State Academic Schools (Lykea)

Year	Ratio
1988	14.1
1989	13.8
1990	13.6

Report from Italy

Giuseppe Marucci

Introduction

Diagram 1 illustrates the organisation of Italian schools.

The arrangement of schools in Italy arose mainly through two important reforms which took place before the country became a republic: the 1859 Casati Law, which shows traces of the post-unitary spirit of the nation, and the Gentile reform in 1923 which gives strong hints of a philosophical neo-idealistic policy.

After the Constitution of the Italian Republic in 1947, there was a radical process of reform for middle schools (11 to 14 years old, compulsory and unique education), and for primary schools (6 to 11 years old) in 1990. The class teacher now has responsibility for the teaching arrangements: as a rule, three teachers work with two classes and divide the disciplines between them. Secondary schools are still waiting for a reform to take place, despite the fact that various proposals have been put forward during the last 20 years.

National teaching syllabi exist in Italy and the educational system is the same throughout the country. The introduction of a notable differentiation in the organisation and curriculum will be seen if a new law regarding school autonomy (provided for in Law No. 537 of 1993:) is put into effect.

Given these neo-idealistic roots, which have had repercussions on teacher training, science teaching has never been very experimental and, compared to humanities, is at a disadvantage in terms of its perceived importance in cultural and personal training.

The most important subject was, and still is, Italian (language and literature).

Science teaching gained importance in Italy during the sixties with the development of new technology and the economic 'boom' that required sufficient preparation in the appropriate areas and which has led to increased enrollment in technical institutes and in science-based university degree courses.

Classical secondary school, the main Italian high school, has begun losing both pupils and importance to Scientific Secondary schools and to the above-mentioned technical, industrial and commercial institutes.

State vocational schools, which were placed alongside regional schools, had an extremely poor curricular and organisational policy and therefore remained Type B schools.

It is only during the last three years, due to the Ministerial Decree of 24/4/1992, that these schools have been reformed and brought to a creditable standard equivalent to that of a secondary school.

The following material refers to the years of primary education through to the first two years (*biennio*) of secondary school (6 to 19 years old), which tends to be essentially one and the same. It includes compulsory education (five years of primary school and three years of middle school) and two years of secondary school which seem to be quite similar in all types of schools.

We shall not be taking into consideration either nursery school, as there is too much to define, nor the last three years of secondary school as it is too differentiated.

This analysis of science education includes mathematics, even if this discipline has always been considered to be of greater importance than natural sciences, owing to its formative logical-thinking aspects of education.

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

In Italy there is a national syllabus and a divisional timetable for teachers set out by the Ministry of Education prepared with the (compulsory) collaboration of the National Council of Education (CNPI).

There is not an actual single curriculum for science going from primary to secondary education, yet the curriculum for mathematics can be said to be quite vertical.

Teachers of mathematics sometimes coincide with science teachers, but this usually results in a preference for mathematics teaching and has reached such a point that the timetable set by the ministry has been reconsidered in favour of mathematics.

When the primary syllabus was renewed in 1985 (Presidential Decree No I04, 12/2/1985), certain disciplines were singled out - in particular mathematics and science. These disciplines contribute to the realisation of a cultural literacy.

Probability, statistics and computer science are completely new aspects of mathematics, but they serve to accentuate problem-solving. Science is emphasised more than physical and chemical phenomena, the environment and natural cycles, organisms, plants, animals, Man, Man and nature, which helps the move towards integrated teaching.

The syllabus and timetable reform for middle schools in 1979 (Ministerial Decree 1979) foresees a teaching post and a unique subject for science and mathematics, chemistry, physics and natural sciences for a total of six hours a week for each of the three years.

The importance of laboratory activities can be seen in the connection between mathematics and the reality and importance of problem-solving. There is no recommendation pronounced by the ministry as to the percentage of time to be spent on lab work.

There are certain syllabi set out for pupils for the first two years of secondary school which have been in use since the fifties and sixties and which are often exceeded by practical teaching and suggestions made in textbooks.

Experimental syllabi (*brocca syllabi*) have recently been launched (1991-1992) for the first two years of secondary school (14 to 16 years old) and tend to bring subjects and timetables together.

- Mathematics and computer science are taught for a total of four or five hours per week in first and second year classes.

- Earth sciences are taught for three hours in the first year classes.
- Biology is taught for three hours in the second year classes.
- Physics-chemistry laboratory work is carried out in the first and second year classes in scientific, technical and economics schools.

The ministry has specified that a minimum of 50% should be spent in the lab doing experimental activities.

In schools and institutes where there is no experimental *biennio* (first two years), physics and chemistry are studied during the three year period (*triennio*) without the recognition of the need to combine the two or to understand the basics.

It has been declared that a minimum of 30% should be dedicated to physics lab work.

In Table 1, there is a summary of the different timetables for mathematics and science teaching from primary education to the first two years (*biennio*) of secondary school.

1.2 Which sciences are to be taught

Even if technology and science can be traced within the curricula, one may still notice a considerable difference between various schools.

In the old primary syllabus, science was integrated and mainly undifferentiated; in the new syllabus of 1985, the specified disciplines have differentiated mathematics from science, and science has been divided into themes.

The new primary syllabus, states that, "the specific aim of primary education is to examine facts and phenomena to which one has direct access or which can be realised with the help of simple apparatus, [...] activities to be done can be grouped together under theme headings [...] some examples are: the behaviour of light, anatomy and physiology of the eye, sound and hearing....".

The direction of themes stimulates an integration of the scientific areas, even if in a rather traditional manner.

In middle schools, both the mathematics and science syllabi are structured on a basic theme which should favour an interdisciplinary approach and integration.

However, this is determined by the texts which are followed; those that illustrate a practical approach to research and integrated methodology are not often used. The highest level of integration between science and technology, compared to other levels of education, has been recorded in Italian middle schools

In secondary schools, the integration between (earth) sciences, biology, physics and chemistry is rather poor, although some attempts at teacher cooperation are evident.

1.3 Realistic data on the above

As far as the above is concerned, it is possible to trace some data from non-homogenous surveys regarding different subjects and different methods.

In primary schools, the need to put subjects into curriculum areas - of which there are generally three due to organisational problems with teaching (three teachers to two classes) - has brought about an aggregation of disciplines in the following areas:

- Italian language, mathematics & science, history
- geography
- social studies

The results emerge from a survey made by Technical Inspectors of the Ministry of Education. Nevertheless, the combination of mathematics and science risks a return to the situation of the old syllabus; it would be better to present science with the particular importance that the new syllabus has assigned to it. This can be done only if the four curriculum areas, which point to mathematics and science being distinct from one another, are singled out.

From some surveys carried out by the Association of Physics Teachers in middle schools, there appears to be a strong connection between mathematics and science in approximately 50% of the cases examined. And even if this is advantageous to mathematics, it is a connection that was not as evident between science and technology (approximately 30%).

In a recent study carried out by a publishing house in March 1994, it was found that physics and chemistry in secondary schools are integrated much less than biology and science.

1.4 Recommended learning activities

In all school syllabi there are recommendations for particular teaching methods that should result in the acquisition of scientific skills, methods and procedures. These are related to the claim for experimental activities at various levels, with an increase in the actual structure as one passes from one school level to another. Again it is suggested that the quality of teacher intervention in the themes studied should be considered more important than concern about quantity, and that all the themes should be dealt with.

Elements of the history of science are now present, although still under used; connections with the real world occur in an incidental way as there are no intentional links with technology.

Those involved in the world of science, however, do have one complaint: that there is insufficient emphasis on textbooks especially in relation to the growth of science and the interaction between scientific theories. Everything is presented in a linear way; the structure found in school textbooks often resembles that of university manuals.

1.5 Mandatory tests and examinations

In Italy there are no objective national tests. The traditional methods of oral and written tests and essays are used. Nevertheless, in the last few years structured tests have been used, prepared by the teachers themselves or even taken from teaching reviews or research.

The claim to an '*in situ* evaluation' - for example, assessment during experiments or actual observation of phenomena - is quite rare.

The Department provides a guide to how final exams should be conducted and which subjects are to be tested.

Exams are set at the end of primary school (5th year), at the end of middle school (3rd year) and at the end of secondary school (5th year).

In the intervening years, there are intermediary and final assessments (*scrutini*) usually every four months; the evaluation is brief compared to the progress made by pupils during this period.

It is also necessary for pupils to be assessed at the end of the first two years of secondary school for them to continue with studies in the third year.

In Italy, the exams passed at the end of middle school and secondary school are recognised on a national level.

In general, official evaluation tests in the sciences are of an oral kind although there are some exceptions at the end of middle school when a written test is taken.

1.6 New trends and reforms underway

Primary and middle schools can be considered to have been reformed from the point of view of the syllabi, even if middle schools need to have their syllabi of 1979 reviewed again, especially in light of the cultural and technological evolution which is evident in some areas of science.

Contrary to the programmes of 1975, the new programmes of the elementary school (1985) put forward a desire to develop a new attitude toward scientific knowledge, identifying specifically doing/thinking, the fundamental aspects of behaviour and scientific rationality. In Italy, the situation in the elementary schools where there are different teachers for different subjects (atypical in other European countries) highlights the fact that the new organisation in *moduli* does not enhance teaching because the timetable is too rigid; however this subdivision has enhanced scientific subjects, even though the experiments can only serve as examples and the outcomes are variable.

If we want to establish a situation whereby the schools are autonomous, it will be necessary to organise an efficient system of documentation and communication relevant to teaching experiences.

Secondary schools, however, are seen to be suffering from a lack of reform that has determined the growth of experimentation which is often different for different schools.

Much controversy and many critiques with regard to the Ministry of Education have been generated by scientific associations and university groups researching the teaching of the science syllabi, and, in particular, physics and chemistry and their timetables compared to those of biology and earth sciences.

At the moment physics and chemistry do not have a recognised basic role in education and this should be taken into consideration.

The autonomy of scholastic unity, soon to be brought into effect in Italy, will probably accentuate the role of the scientific disciplines in secondary schools and bring them closer to their functions in the real world. On one hand, assessment should be characterised by the school or institute at which it is carried out, yet, on the other hand, it should also be connected to the National System of Evaluation.

2. How is science delivered?

2.1 Organisation and authority

The Secretary of State for Education is the central authority within the Italian Government.

The Ministry of Education is divided into Departments (General Divisions). Each department has a General Manager.

The Departments administer primary schools, middle schools, secondary (technical, classical and professional) institutes, cultural exchanges and general affairs.

Local authorities consist of Provincial Education Offices (*Provveditorati agli Studi*) and Scholastic Superintendencies which operate on the regional level. Most of the power is in the hands of the Provincial Education Offices (the nomination of teachers, teachers' exams, administrative relations with the Scholastic Unity, etc.), while the Superintendencies deal with school buildings and secondary school teachers' exams.

At a local level, however, there is little power over curricular innovation, and only in an indirect way, by the Provincial Education Offices in the nomination of particular teachers (*Operatori tecnologici*, *Insegnanti di Progetto*) or the set-up of activities that can support or integrate other curricular activities.

It is possible to introduce and try out innovative teaching methods at a local level. Schools allow the introduction of curricula that are highly innovative, (e.g. transformational geometry instead of algebra, which is the main point in the programme of mathematics) while waiting for school autonomy; some innovations are very different from the traditional ones (e.g. in artistic and technical areas).

In some regions, local authorities, IRRSAEs and Education Superintendents have been collaborating for sometime on areas of teacher training and experiments in schools with innovative curricula and support material. This collaboration deals with interdisciplinary subjects such as: environmental education, health education, highway code, family problems, peace, gender discrimination, and also with lifelong learning and adult training.

In the north and centre of Italy, some schools are also experimenting with the use of museums as resources highlighting the cultural heritage, combined with the provision of a good guidebook which may be useful to teachers.

It would be important to establish links between active schools and centres of educational research that are not operating in the same territory.

Local authorities provide school buildings and necessary equipment and apparatus (excluding teaching material) and can favour certain pupil activities through the accomplishment of their 'right to study'.

Schools can propose a teaching or organisational innovation to the Department. Besides this, schools can ask for and obtain staff training funds from the ministry on an annual basis.

Training activities are organised directly by the same Ministry of Education and Provincial Education Offices, or by the Regional Institutes for Research, Experimentation and Educational Innovation (IRRSAE: *Istituto Regionale per la ricerca, la sperimentazione e Il'Aggiornamento educativi*), which were created in 1974 to assist in and promote the up-dating of courses and experimentation, and activate a system of educative documentation.

These institutes should have had an effect on innovation and training, making the most of autonomy; however, the absence of direct contact with schools, the 'politicisation' of the 'groups of direction' and the lack of links between eventual local centres have limited the amount of efficient action which could have been taken.

In Italy, unfortunately, decentralised territorial structures which support the promotion of innovation have never taken off; that is to say that while the Ministry of Education announces plans for the opening of local teaching centres, these plans are more often than not never put into effect.

Activities in the science laboratory have suffered in consequence. Teachers in this domain want feedback; they need to discuss activities with colleagues and experts, try them out, test materials, draw up work plans, etc., before taking projects into the classroom.

Assistance is also required from inspectors who are divided in Italy according to school levels and disciplinary sections. In the area of science teaching, they have occasionally been responsible for national plans of innovation. Professional teachers' associations have had an important role to play from the beginning in physics, natural sciences, chemistry and mathematics through the organisation of annual conferences, thematic meetings and courses designed to bring people up to date.

Museums, botanical gardens and exhibitions are, however, rarely used as they are not sufficiently interactive; there are only a few in the country and they do not really present exhibits in a style suitable for learning. Teachers do not give a great deal of attention to these informal teaching opportunities if they are not used to support their lessons.

The relationship between the Ministry of the Environment and the Ministry of Education is difficult when taking into consideration educational projects on the environment. It has reached such a point that the Ministry of the Environment has started creating centres for environmental education, although these are not very well coordinated with Ministry of Education directives.

Authorities on a regional, provincial or local level, have created various centres and staged scientific activities from time to time (for example, *Musis* in Rome).

Two other autonomous Institutes created in 1974 are: *Biblioteca di Documentazione Pedagogica* (BDP), a documentation library with its head office in Florence, and *Centro Europeo dell'Educazione* (CEDE), the European Education Centre, with its head office in Frascati, near Rome.

CEDE is in charge of the IEA survey for Italy.

2.2 Resources and funding

Regarding laboratory equipment and apparatus, it cannot be said that middle schools and secondary schools are not provided for; it is rather the schools themselves that do not put to use the material available. Equipment is often purchased that is not easy to use or that requires the experience of a particular teacher. In primary schools, there is usually a good deal of equipment used for demonstrations.

Materials and apparatus are bought with the schools' own funds, which are very low in primary and middle schools. Some surveys have been made on the use of equipment in the teaching of science.

In primary and middle schools, library work in science is rather limited and appears significant only when used to back up class work. What is really needed in secondary schools are specialised tests, but these do not usually exist.

School textbooks have the most influence on science teaching, because teachers' backgrounds, and the degrees and diplomas they possess are so varied. Teachers also tend to use textbooks as a guide to delivering lessons, thus avoiding direct observation and experimental teaching; from time to time, "students are told to read experiments" explained and illustrated in textbooks.

However, in Italy, there is a need for an immediate rationalisation of the teaching-learning situation; textbooks with a rather different approach are rarely referred to. This also explains why so little use is made of the work schemes referred to by some of the more active teachers or proposed by these same textbooks. In the first two experimental years of secondary school, there are no comprehensive books and more use is made of diverse sources .

Some statistical data regarding equipment and apparatus is traceable in surveys undertaken in middle and secondary schools. Middle school studies have been carried out by Inspectors, the *Associazione insegnanti di fisica* or AIF (Association of Physics Teachers), the *Comitato di Coordinamento delle Associazioni Scientifiche Italiane* or COASSI (Coordinating Committees for Italian Scientific Associations) and various publishing houses.

See Table 2 for the data regarding middle schools (1980, 1984).

For secondary schools there is a recent survey concerning physics and chemistry laboratories that takes note of a substantial equipment allowance for physics labs and a lower one for chemistry labs. Science labs are usually equipped with equipment for demonstrations. The results of a survey conducted by the Ministry of Education in 1985, although not on science in particular, indicate the equipment allocations for teaching different subjects. There are interesting comparisons between the various school levels and geographical areas (see Table 2).

The results of a survey conducted by the Ministry of Education in 1985, although not on science in particular, indicate the equipment allocations for teaching different subjects. There are interesting comparisons between the various school levels and geographical areas (see Table 2).

Computer science equipment is totally different from science equipment. There has been a large increase in outside financial aid and backing from the families themselves. Secondary schools have also benefited from the National Computer Science Plan (PNI - *Piano Nazionale Informatico*) promised by the Ministry of Education, which provides computers and lab equipment.

Relevant data can be found in Table 3, provided by the Ministry of Education for middle and secondary schools and by some Provincial Education Offices for primary schools.

2.3 Methods of teaching

Methods of teaching vary according to a teacher's preparation and sensitivity. Very few teachers manage to bring up-to-date methods learnt on courses into the classroom because they tend to allow theory to get into the way.

Lessons tend to follow a 'traditional' format and may conclude with a class discussion.

In primary and middle schools, students are oriented towards scientific topics through references to common situations or personal experience; experimental situations are rarely used to begin a topic. There is also a tendency, diffused in the sixties and seventies, not to take advantage of group-based activities - mainly owing to the fact that teachers do not feel so well rewarded - but to turn to the textbooks available.

The 'surveys' undertaken in primary and middle schools are often reduced to bibliographic consultation and written summaries.

In secondary schools, structured or demonstrative experiments prevail; little apparatus is used even when working in small groups. The announcement of a specific timetable for laboratory work is expected in the near future.

Homework is rather insignificant and hardly ever of an experimental nature. Each school uses its lab and experimental activities differently. A reduction in use can be observed in Italy from north to south.

2.4 Sources of pedagogic innovation

Pedagogic innovation should be expressed through the reform of syllabi by the Ministry of Education, but this is a very slow process in Italy. Much more significant, however, are innovations derived from official and practical interventions practised by teachers following the stimulus and advice of professional associations and university groups studying educational methods; teaching groups and opportunities for bringing teaching methods up to date are significant and often lead to innovation.

3. Going beyond school

Even if sciences are socially accepted, science education in schools is only formally recognised and its contents and methods are scarcely noted. This explains the difficulties which exist between science education and technology education: technology education fails to use the foundation which science education provides.

3.1 Use of out-of-school resources

The integration of out-of-school resources in Italy with the school curriculum is rare. Very often science museums, reserves and parks are used as 'guided tours and educational trips' as officially recommended. However, although these are used by most schools, they are not usually very well coordinated.

It is the pupils themselves that introduce the use of the media, usually television, which is then sometimes brought into the science classroom when there is access to audiovisual equipment.

The relationship between schools and out-of-school resources in Italy has always been difficult because, traditionally, school represents a 'serious' training place, whereas out-of-school is perceived as more for games and playing, often on a superficial level. The *Consiglio Nazionale delle Ricerche* or CNR (the National Research Council), which is based in Rome, has made a noteworthy effort in producing a catalogue which lists all the Italian and international centres that provide teaching activities and from which schools could benefit.

3.2 Consideration of public science-based issues within lessons

Themes of social value do appear in the curriculum, for example, energy and environmental problems. There has been an attempt at a more educational, rather than informative, approach, but as yet no conclusions have been drawn up owing to divergent interpretations of 'Environmental Education' and a lack of agreement between the Ministry of the Environment and the Ministry of Education.

The energy theme is studied in depth at some secondary schools.

The teaching of Sex Education, recently under discussion, has been handed over in part to the science curriculum although it has not been fully developed, especially with regard to young people's problems and connected pathological situations.

3.3 Science education and vocational training

From primary to secondary education there is not always an emphasis on vocational training because at primary and middle school level one goes from a simplified style of learning to a more structurally divided science education that is not complete until the end of the first two years of secondary school. Only in the next three years, when pupils study mechanics, technical design, electronics, chemical analyses, etc. would a major link between science and technology be seen to be relevant to science-based jobs.

As for the relationship between sciences and the world of work, the Director of Professional Training of the Ministry of Education has made a notable effort to renew the curricula (1992), paying particular attention to the formative value of scientific education, and considering the possibilities of professional outcomes.

The various initiatives of the project *Scuola Lavoro* and the European Week of Sciences have contributed to the improvement of the relationship between scientific education at school and the outside world.

There is very little orientation towards science-based jobs at present in middle schools. This takes place only at university.

3.4 Science clubs and cultural associations

There are very few science clubs in Italy. Professional associations for science teachers and scientific societies, on the other hand, are extremely active, and it is probably these which have of late maintained the generally high opinion reserved for the teaching of science alongside the teaching of humanities. These bodies have always been punctual in their in-depth studies and curricular innovations, putting pressure on the Ministry of Education and encouraging the majority of teachers to accept innovations already practised by more active teachers.

The following associations are active in Italy: AIF, the *Associazione Insegnanti di Fisica* (Association for Physics Teachers), ANISN, the *Associazione Nazionale Insegnanti di Scienze Naturali* (National Association for Teachers of Natural Sciences), UMI, the *Unione Matematica Italiana* (Italian Mathematics Union), MATHESIS, the *Associazione per lo sviluppo delle Scienze Matematiche e Fisiche* (Association for the Development of Mathematical Sciences and Physics), and the *Società Italiana di Chimica* (Italian Chemistry Society).

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

The 1983 *Seconda Indagine Internazionale sulle Scienze* (IEA-SISS - Second International Science Survey), published in 1989, is the last survey to have been completed.

The *Terzo Studio Internazionale IEA sulla Matematica e le Scienze* (TIMSS - Third International Mathematics and Science Study) is now underway.

The IEA-SISS survey took four groups into consideration:

1) fifth year Primary school pupils

2) third year Middle school and first year Secondary school pupils

3) pupils attending the last year of normal Secondary school

4) pupils attending the last year of experimental courses at Secondary school.

Samples were taken in different regions throughout Italy.

Tests were taken in: biology, chemistry, physics, earth sciences.

Apart from the expected territorial differences and differences between males and females, the most significant information to emerge was that relating to the comparison between final year secondary school pupils in normal and experimental classes. The results for the experimental classes were decidedly better than those of the normal classes, except for the north-west of the country which is traditionally privileged. Differences between males and females remain in experimental classes and the results did not appear to be in favour of female pupils.

Results of the sub-test for each subject do not vary.

See Tables 4 and 5 for a full report.

The new IEA-TIMSS survey looks at mathematics and science learning and hopes to grasp the following: international variations between mathematics and science curricula, international training variations and the use of up-dated teaching techniques by physics and mathematics teachers, the influence of textbooks, the effectively taught content of mathematics and science, the efficiency of different methods of teaching, pupil progress with particular reference to problem-solving, students' and teachers' attitudes and opinions, and the role of technology in the teaching and learning of science.

Parallel to the IEA, Frascati-based CEDE has conducted a survey called VAMIO - *Verifica Abilità Matematiche Istruzione Obbligo* (Checking Mathematical Skills in Compulsory Education), which, in its original form, is an elaborate questionnaire. The research extends to the middle of 1984 and was carried out by administering a test to third year middle school pupils and/or using the entry test to secondary school. (See Table 6).

The method used is similar to that used by the IEA. The survey was set up to discover which curriculum was really carried out in the classroom.

In each of the 157 cases, the subjects were asked to assign one of three value levels:

IMP	=	the importance of the topic compared to the time dedicated to it
ANN	=	in which year the topics are carried out
DIFF	=	the level of difficulty of the topic for pupils

Results can be traced in Table 6 which also serves to illustrate the importance of the topic.

Another survey has been promoted by the Ministry of Education, together with CENSIS - *Centre Studi Investimenti Sociali* (Social Investment Study Centre), concerning linguistic and mathematical skills in primary schools. It was conducted after the launching of 'New Syllabi' (*Nuovi Programmi*) in 1985. The results for mathematics were quite positive.

These results are clearly illustrated in Table 7.

Other ideas raised which have an influence on learning were: social context of the pupils and the schools; the class in which a pupil finds him or herself; pupils' origins in Italy (this was considered to be of importance because a difference between pupils in the north-west, north-east, central Italy, the south and the islands has been confirmed); family background (this has a subtle influence even if it scored less in Italian tests); school conditions in terms of the buildings and the situation of the school in the locality; teaching arrangements; the number of pupils in each class (fewer pupils do not usually play a part in greater productivity).

4.2 Public or political concerns about educational standards

A national evaluation system is desirable on both a national and regional level. It is often felt that the individual initiatives of the various institutes should adhere to a minimum content on a national level.

For science, and physics in particular, some studies have been carried out in the past and they discuss 'minimum content'; from 1976 onwards they were developed by a commission in an office of SIF (*Società Italiana di Fisica* - Italian Physics Society) working together with the CNR, the AIF and representatives of other associations.

The problem of minimum content arises again during staff meetings for end-of-term evaluations and at the beginning of the school year because the syllabi leave space for choice; it is always difficult at the moment of evaluation to make comparisons with other schools if an 'external' minimum content reference does not exist.

4.3 Suggested reforms

Suggested reforms include distinguishing a standard literacy and minimum knowledge, in particular for science, from a person's general maturation level. In addition, stricter guidelines for experimental activities are necessary, together with a school revision of materials (especially for primary and middle schools) and with related teacher training.

Within these suggested reforms, stress is put on: 'vertical' curricula, which constitute a formative continuum from the elementary school to the first two years of *liceo*; schools with minimum aims, rather than minimum contents; schools with a lack of cohesion between experimental curricula and final exams; a more prescriptive use of laboratory work and experience at lower levels of school and a less prescriptive one at higher levels (the opposite of what is taking place at the moment); experimental practice as a compulsory part of the learning process; renewal of books following the aims of innovation instead of renewal based on purely commercial factors.

A project looking at experiments in trans-national curricula in ordinary schools could help Italy move closer to the cultures of different countries and adopt the best of each in terms of materials, organisation of work and methods; it would also be a real step forward towards the recognition of diplomas in different countries.

5. Pupil interest and motivations

As far as science and its components are concerned, pupil interest and motivation have not often been the subject of research (it is one of the IEA-TIMSS objectives) and for this reason it will not be discussed at great length here. To a certain extent, interests and motivation are traceable on the learning outcomes scale already illustrated.

5.1 Options for choice within science

Options for choice within science are extremely limited due to the existence of national syllabi. In reality, the only options available are in the following cases: in schools which use group work; when activities are organised according to standards which allow an enrichment of the curriculum timetable. This is possible above all in 'full-time' institutes or where after-school time permits. It is also possible in schools with "resource teachers" who are directly assigned to a school or who are there for the purpose of a particular topic.

In some secondary schools there are options for innovative integrated or optional courses. Only during experimentation can the existence of a common subject basis and the choice of different subjects prove itself. This is all achieved during the first two years of secondary school.

5.2 Pupils' perspectives on the value of science

The images of science held by most is filtered in by the mass media. The image of the scientist and science is rather stereotypical and not considered very seriously by the world of science, which could play an important role in changing these perceptions.

6. Training, status and morale of scientific teachers

6.1 Initial training

Primary school teaching staff are different from other teachers in that they do not need a university degree in order to be able to teach; a diploma taken at an *Istituto magistrale* (a secondary school which prepares students for teaching) is sufficient.

For middle and secondary school teachers, however, a degree is necessary; where science subjects are concerned, different types of degrees are required, e.g. physics, chemistry, natural sciences, biological sciences, engineering, etc.

Unfortunately, university courses do not devote any time to pedagogical aspects; although there are sometimes exceptions to be found under the heading 'didactic studies', these are isolated subjects which cannot honestly be integrated into a university degree course.

In order to be able to teach after a university degree course, teachers must sit a written examination - an exam which has recently included more about teaching methods. Science tests are of a rather classical type; oral tests are slightly different, but still subject-based. For middle school teaching, these tests emphasise teaching methodology and for some middle and secondary schools there is also a practical test. For primary school teachers, the exam is primarily concerned with teaching methods.

During the first year of teaching there follows (for primary, middle and secondary school teachers) the so-called 'probationary year' (*anno di formazione*), which consists of a period of monitoring by a senior teacher and in a training course (40 hours) that considers the science subjects, teaching and scholastic themes.

The results of surveys carried out by COASSI and AIF regarding degrees for science teachers in middle school are illustrated in Table 8. Biological science and natural science degrees are more prevalent than mathematics degrees.

6.2 Decision-making authority for the above

Initial teacher training guidelines are given by the Ministry of Education and the Ministry of Universities. According to Law 382 of 1990, universities should have taken on all responsibility for initial teacher training, even for private school teachers; this, however, is not the case.

With regards to in-service training, the Ministry of Education has a national plan to help teachers keep up to date. In this plan, a budget has been provided and is awarded to single or associated schools and, in part, awarded to Provincial Education Offices in order to promote initiatives on a provincial level, and to IRRSAEs for regional initiatives.

6.3 Continuing training

Unfortunately for teachers in Italy there is no sabbatical year and no part-time release available from teaching in order to follow a one-year training course or to follow teaching research at university. Frequent directives are issued by Provincial Education Offices, the Ministry of Education, universities and associations, and IRRSAEs, but these end up estranging teachers from their class work, sometimes transforming them into administrative, rather than teaching, staff.

Five days a year are usually put aside for teachers to participate in meetings or training courses during which they are released from school work if there is a possibility of substitution at no extra expense.

In-service training takes up 40 hours a year outside teaching time and follows themes decided upon by the Teachers College, or themes put forward by the Department for Provincial Education Offices, IRRSAEs or associations.

Science courses for professional up-dating are often cancelled owing to a lack of interest. There are difficulties involved in the organisation of active courses which involve experimental work. They often risk being too theoretical; they tend to lack innovation compared to technological subjects because multimedia equipment is rarely used.

Some national plans for training teachers who are already in service have been launched by the Ministry of Education through large institutional innovations (a national plan for the improvement of access to the latest information in secondary schools; a Several-Year Plan on updating teachers on new programmes in the elementary schools; mini-seminars on new Programmes of Professional Training).

The intervention of the universities in the in-service training produces courses which are excessively theoretical. To deal with this problem, some regions have created 'Didactical Laboratories' and 'Groups of Didactical Research' that collaborate with science Faculties, the CNR, and IRRSAEs, and in which university staff, researchers and teachers work together.

6.4 Number, teacher/pupil ratio, gender, age profile

Table 9 illustrates the low pupil/teacher ratio owing to the decrease in the birth rate and an excess of teachers.

As for the differences in gender, it would be useful to devote more space within the curricula to 'perceived' differences.

6.5 Drop-out rates, late entries, maternal leave

Table 10 illustrates data regarding the drop-out rates and the number of pupils repeating a school year, especially between primary and middle school, middle and secondary school and the second and third years of secondary school. Numbers differ according to the area.

6.6 Status and salary

The social status of teachers is on a decline at the moment, even if they are still considered an intellectual, socially elevated profession. The salary is an average one and possibilities of promotion are limited to headmasterships and inspectorates.

Salaries are related to the number of teaching hours, which amount to 18 hours per week in middle and secondary schools and 24 hours in primary schools. Eighty hours a year are then added for activities connected to school functions (e.g. staff meetings, etc.) and 40 hours a year for in-service training.

In comparison with other public administrative workers of the same level, teachers' hours of work are more convenient and summer and winter holidays are longer.

7. Equality of opportunity?

7.1 Different status of the schools

Public schools are governed by the state and their teachers are nominated and paid by the state. Non-state maintained schools fall into two groups: private schools which must respect safety and hygiene rules only, and schools which are legally recognised by the state in terms of the syllabi to be carried out, the equipment to be used and the academic level of the teachers.

Officially recognised schools are the same as state maintained schools apart from the fact that their teachers are paid by the school.

According to the Constitution, the state cannot control both private and public schools and this is being debated at great length in Italy at the present time. There is a movement towards a 'school voucher' to be awarded to families who can then spend it at whichever school they think appropriate.

As far as science education is concerned, facilities for teaching in non-state maintained schools do not exactly exceed those maintained by the state. More often than not their labs are a facade used to secure enrolments and it is also well known that public schools have a reputation for humanities rather than science teaching.

Non-State maintained schools are mostly managed by religious sects, but they do not tend to differ from one another in their policies.

7.2 Regional differences

Regional differences are quite considerable. It suffices to look at the data published by CENSIS and ISTAT and, for science in particular, the AIF data: a survey for computer science by the General Managers of Middle Schools of the Ministry of Education and data from the National Computer Science Plan (*Piano Nazionale Informatico* - PNI) launched by the General Managers of Secondary schools.

This is worsened by the variation in the subsidies and apparatus between north and central Italy where funds are often donated by local authorities - funds which exceed those contributed by the state.

It is interesting to note from these surveys the differences in middle school funds for computer science where a National Plan, supported by the Department for Education, does not exist.

7.3 Immigration and migrant populations

Learning difficulties for immigrants are more evident at evening classes (both for middle school '150 hour courses' and secondary school courses) and beginners' courses, used mainly for language learning.

In the first of these courses, science is presented in themes which are chosen according to the origins and interests of the students. During the second type, there are traditional themes. On elementary courses they are absent, but students on these courses usually already have a degree or diploma taken in the country of origin.

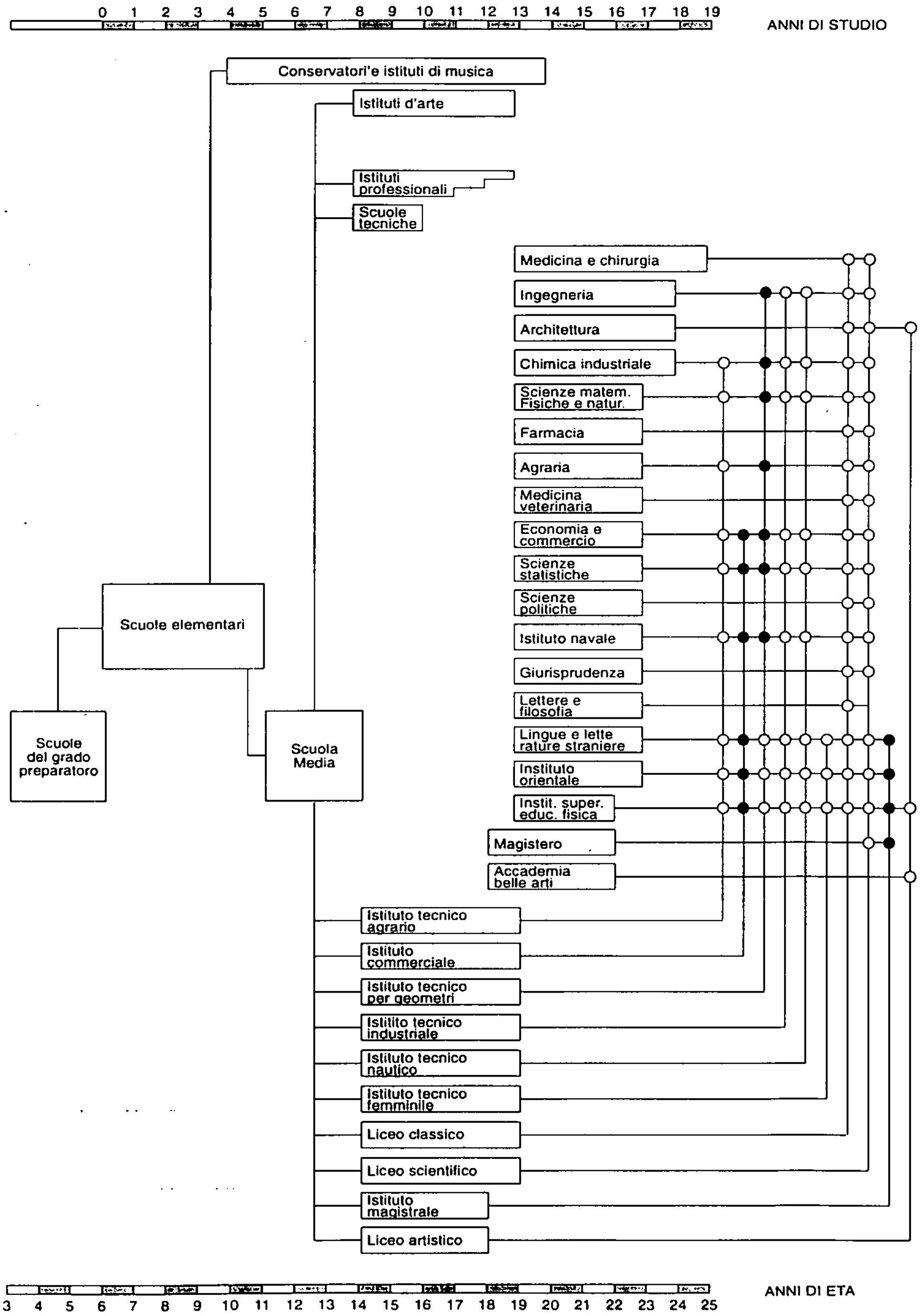
As for the problem of immigration, the different character of scientific culture in various societies should be taken into account. It would be useful to identify unifying themes, such as 'highway code education' or 'sciences in daily life'. These would also highlight the genesis of basic scientific concepts in different cultures.

7.4 *Special education for handicapped children?*

Children with special educational needs in Italy have really only been receiving attention since the seventies, and they are now given 'support' teachers. Specialisation courses for these teachers have been created which last two years. A number of subjects are covered as well as problems related to the presentation of mathematical concepts and classroom activities. Science, however, is not dealt with.

Handicapped children in Italy attend normal classes in which there are fewer pupils. Tests and final evaluations make allowances for their handicaps. These pupils can attend normal classes at all school levels. During secondary education, each subject is taught by a different teacher and passing from the first year into the second year can be a question of merely attending classes. After the first two years of secondary school, no particular provision is made for pupils with a handicap.

Diagram 1 : Schema dell'ordinamento scolastico italiano[1]



1. Fonte : Isittuto Centrale di Statistica.

Table 1: Programmi ed orari di insegnamento
1a - Scuola elementare

		lunedì					martedì								mercoledì					giovedì					venerdì								sabato				
carico cognitivo	ATTIVITA'	l. italiana	l. italiana	matematica	matematica	Compiti	matematica	l. it. / st.	ed. immm.	ed. immm.	l. italiana	l. stran.	relig.	Compiti	l. italiana	l. italiana	storia	geogr.	Compiti	s. soc.	ed. mot	l. stran.	l. ital.	Compiti	l. italiana	l. it./mat.	matematica	scienze	ed. suono	relig.	ed. mot.	Compiti	scienze	geo./sc.	ed. suono	l. stran.	Compiti
O	Lezione																																				
T	Verifiche																																				
L	Es. nozionistiche																																				
A	Lettura																																				
	Stesura tesi																																				
O	Uscite																																				
I	Ricer./lav. grup.																																				
D	Attività espres.																																				
E	Es. creative																																				
M	Discus. testi col.																																				
OS	Es. pratiche																																				
S	Att. manuali																																				
A	Att. motorie																																				
B	Gioco																																				

Fig. 3: tabella dei carichi cognitivi (da Progetto FOREPRINT-IRRSAE Veneto) nella scuola elementare

1b - Scuola Media (1)

Orario settimanale delle lezioni

Materie d'insegnamento	**Ore settimanali**			**Prove d'esame**
	1ª classe	**2ª classe**	**3ª classe**	
Religione	1	1	1	--
Italiano	7	7	6	s.o.
Storia, educazione civica e geografia	4	4	5	o.
Lingua straniera	3	3	3	s.o.
Scienze matematiche, chimiche, fisiche e naturali	6	6	6	s. (1) o.
Educazione tecnica	3	3	3	o.
Educazione artistica	2	2	2	o.
Educazione musicale	2	2	2	o.
Educazione fisica	2	2	2	o.
Totali	**30**	**30**	**30**	

(1) La prova scritta riguarda soltanto la matematica.
Avvertenza S. = scritto; O. = orale

(1) Decreto Presidente della Repubblica, n. 50, 6 febbraio 1979.

1c - Scuola Superiore

Liceo Classico

Orario di insegnamento (1)

Materia	**Ginnasio superiore**		**Liceo classico**		
	IV	V	I	II	III
Lingua e lettere italiane	5	5	4	4	4
Lingua e lettere latine	5	5	4	4	4
Lingua e lettere greche	4	4	3	3	3
Lingua e letteratura straniera	4	4	--	--	--
Storia	2	2	3	3	3
Geografia	2	2	--	--	--
Filosofia	--	--	3	3	3
Scienze naturali chimica e geografia	--	--	4	3	2
Matematica	2	2	3	2	2
Fisica	--	--	--	2	3
Storia dell'arte	--	--	1	1	2
Religione	1	1	1	1	1
Educazione fisica	2	2	2	2	2
Totali	**27**	**27**	**28**	**28**	**29**

(1) Decreto Ministeriale 1° dicembre 1952.

Istituto Tecnico Commerciale

Orario settimanale delle lezioni (1)

Materia	Biennio		Triennio			Prove d'esame
	I	II	III	IV	V	
Religione	1	1	1	1	1	
Lingua e lettere italiane	5	5	3	3	3	s.o.
Storia ed educazione civica	2	2	2	2	2	o.
Prima lingua straniera	3	3	3	--	--	s.o.
Seconda lingua straniera	3	3	3	3	3	s.o.
Matematica	4	4	2	2	2	o.
Fisica	2	2	--	--	--	o.
Scienze naturali	3	--	--	--	--	o.
Chimica e merceologia	--	2	2	--	--	o.
Geografia generale ed economica	2	2	2	2	2	o.
Ragioneria	--	--	3	4	4	s.o.
Computisteria e tecnica commerciale	--	--	3	3	2	s.o.
Economia politica, scienza delle finanze, statistica economica	--	--	2	3	3	o.
Diritto	--	--	4	3	3	o.
TOTALI	25	24	30	26	25	
Esercitazioni pratiche						
Dattilografia	2	1	--	--	--	p.
Stenografia	2	2	--	--	--	p.
Calcolo computistico	--	2	--	--	--	p.
Ragioneria e macchine contabili	--	--	--	1	2	p.o.
Tecnica commerciale e macchine calcolatrici	--	--	--	2	2	p.o.
Educazione fisica	2	2	2	2	2	p.
TOTALI GENERALI	31	31	32	31	31	

(1) Decreto Presidente della Repubblica, N° 1222, 30 Settembre 1961.

Scuola Media: Indagine AIF (1984)

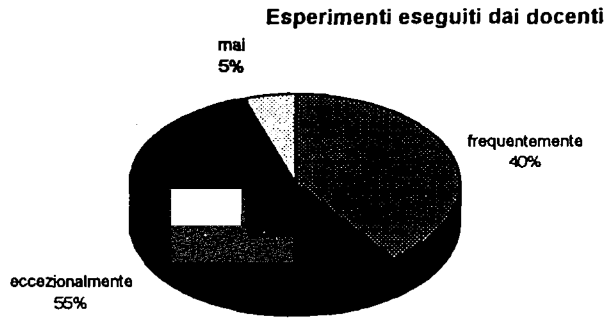
Presenza a scuola di:	
- Aula-laboratorio di Scienze	61%
- Materiale per esperienze dimostrative	92%

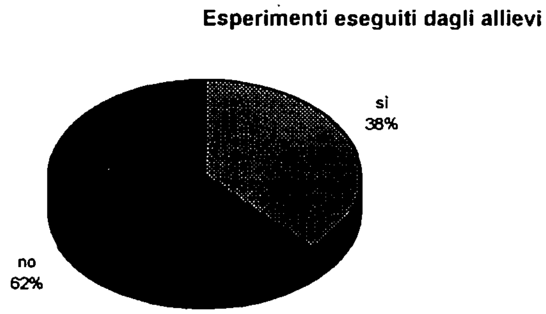
Cause del mancato uso del materiale:	
- Materiale inadatto	30%
- Mancanza di tempo	28%
- Incapacità dell'insegnante	16%
- Motivi di disciplina	10%
- Motivi logistici	6%
- Altri motivi	10%

Impostazione sperimentale del lavoro in classe:	
- Materiale per esercitazioni a gruppi	52%
- Materiale soddisfacente per esercitazioni a gruppi	17%

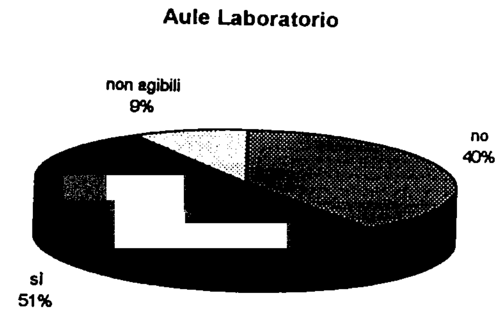
Table 2: Uilizzazione dei laboratori e dotazione materiali

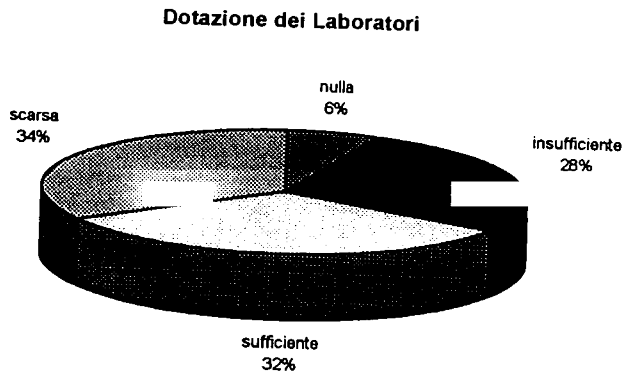
2a - Scuola media : indagine coassi (1980)





Può essere interessante un confronto con i dati riguardanti la disponibilità di aule da laboratorio e la dotazione dei laboratori.





2b: Tutti i tipi di scuola: Dotazione di materiali audivisivi (Indagine MPI - 1985) (1)

Distribuzione in valori assoluti e percentuali delle modalita' di riposta, secondo le ripartizioni geografiche.

	Risposte		Non risposte			Universo		
	V.A.	% di colonna	% di riga	V.A.	% di colonna	% di riga	V.A.	% di colonna
Nord	6.350	42,0	82,4	1.353	33,0	17,6	7.703	40,1
Centr	3.259	21,5	77,9	924	22,6	22,1	4.183	21,8
Sud	3.763	24,9	76,5	1.153	28,2	23,5	4.916	25,5
Isole	1.756	11,6	72,6	662	16,2	27,4	2.418	12,6
Italia	15.128	100,0	78,7	4.092	100,0	21,3	19.220	100,0

(1) Da "Annali della Pubblica Istruzione", N° 3, Roma, 1986.

Table 3: Dotazione attrezzature informatiche (hardway)

3a - Scuola superiore (1)

3a-I - Nel PNI (Piano Nazionale Informatico)

Numero medio di apparecchi, secondo ordine di studi

	Ordine di studi			
	Totale	**Classico**	**Tecnico**	**Professionale**
A) PC (Personal Computer)	13.1	12.2	14.4	12.3
B) Altri tipi di elaboratori	0.3	0.4	0.2	0.1
C) Terminali	0.6	0.3	1.0	0.4
D) Stampanti	8.6	7.8	9.3	8.6

3a-II - Fuori dal PNI

Numero medio di apparecchi, secondo ordine di studi

	Ordine di studi			
	Totale	Classico	Tecnico	Professionale
A) PC (Personal Computer)	13.2	3.1	20.5	16.2
B) Altri tipi di elaboratori	0.9	0.1	1.9	0.4
C) Terminali	1.3	0.3	2.5	0.5
D) Stampanti	9.0	1.9	12.8	13.5

(1) Da "Rapporto Doxa sulle esperienze della scuola media superiore, nell'ambito del Piano Nazionale per l'Informatica", Milano, 1990.

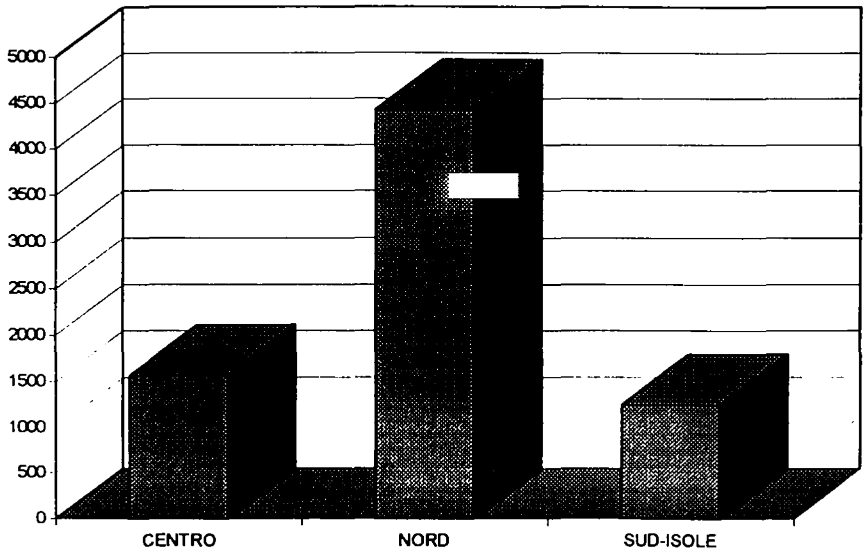
3b - Scuola media (1)

Dotazione hardware (nelle diverse circoscrizioni geografiche)

Circoscrizione territoriale	Scuole	Classi	Alunni	P.C. ms-dos	P.C altro.	Totale PC	Stampanti
NORD	746	10.905	208.118	2.603	1.821	4.424	1.874
CENTRO	388	6.004	114.874	1.008	554	1.562	710
SUD-ISOLE	716	12.836	249.717	880	365	1.245	687
Totale	1.850	29.745	572.709	4.491	2.740	7.231	3.271

(1) Ricerca della Direzione Generale Istruzione Secondaria di Primo Grado, MPI, Roma, 1993.

Dotazione di PC



3c - Scuola elementare (1)

1) Numero delle scuole dotate di computers per uso didattico 58 (32,5%)

2) Totale computers presenti nelle scuole:

166 12 scuole ne hanno più di 4 (6,7%)

3) Marche presenti nell'ordine:

110 (66,2%) Commodore 64;
8 (4,8%) IBM compatibili;
8 (4,8%) Commodore 128;
40 (24%) Altre marche

(Sharp, Apple II, Apple Macintosh, Commodore Amiga, Olivetti Prodest, Olivetti M-19, ZX Spectrum, Sinclair QL, Olivetti M-24, Commodore Plus, Sistema operativo MSX)

4. Totale laboratori di informatica 24 (13,4%)

(1) Da "Il computer nell'educazione", Provveditorato agli Studi di Roma, Roma, 1989.

Table 4: Risultati generali IEA-SISS (1983)

Distribuzione punteggi per Aree

	Popolazione Sperimentale			Popolazione Terra		
	Media	Dev Std	Casi	Media	Dev Std	Casi
1 Nord Ovest	15.9089	5.8711	444	16.6642	5.1852	1865
2 Nord Est	19.0318	4.7944	323	17.5529	4.8100	1233
3 Centro	17.0710	5.0805	573	15.8919	4.9903	1690
4 Sud-Isole	17.5825	6.0207	161	13.7079	5.4469	3048
Italia	**17.2042**	**5.4829**	**1500**	**15.4876**	**5.4045**	**7835**
Totale casi : 1516				**Totale casi : 7887**		
Non Risposte : 16 o 1.1 PCT				**Non Risposte : 52 o 0.7 PCT**		

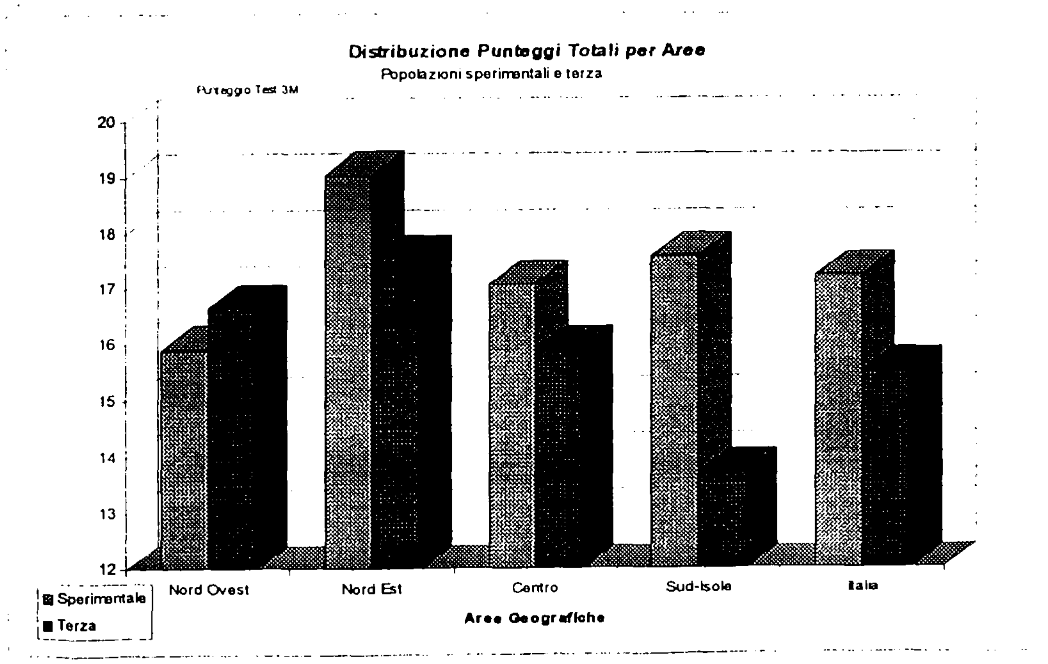


Table 5: Risultati IEA-SISS per sesso (1983)

Distribuzione punteggi per Sesso

		Popolazione Sperimentale			**Popolazione Terza**		
Casi		Media	Dev	Std	Media	Dev	Std
Strato Sesso	Nord Ovest	15.9307	5.7938	432	16.6790	5.1678	1836
	Maschi	17.8308	6.2371	158	18.2886	4.8937	922
	Femmine	14.8368	5.2290	274	15.0537	4.9251	913
Strato Sesso	Nord-Est	19.1065	4.7942	306	17.5711	4.7994	1206
	Maschi	20.8522	4.4740	159	19.0222	4.5273	613
	Femmine	17.2148	4.4082	147	16.0691	4.6105	593
Strato Sesso	Centro	17.0360	5.0935	556	15.8739	4.9833	1636
	Maschi	18.9350	4.7962	271	17.2301	4.7989	802
	Femmine	15.2374	4.7059	286	14.5683	4.8084	833
Strato Sesso	Sud-Isole	17.6004	5.9860	157	13.7504	5.4249	2936
	Maschi	18.4531	5.2997	105	14.9758	5.3664	1378
	Femmine	15.8950	6.9082	52	12.6662	5.2441	1558
Italia		**17.2040**	**5.4657**	**1451**	**15.5179**	**5.3840**	**7613**
Totale Casi : 1516 **Non Risponde : 65 o 4.3 PCT**					**Totale Casi : 7613** **Non Risponde : 274 o 3.5**		

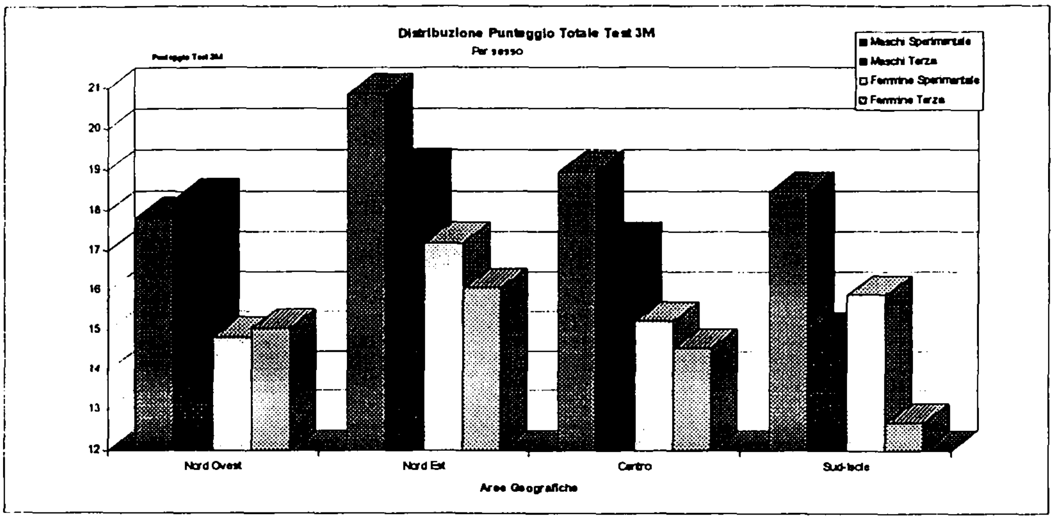

Distribuzione Punteggio Totale Test 3M
Per sesso
Maschi Sperimentale
Maschi Terza
Femmine Sperimentale
Femmine Terza
21
20
19
18
17
16
15
14
13
12
Nord Ovest
Nord Est
Centro
Sud-Isole
Aree Geografiche

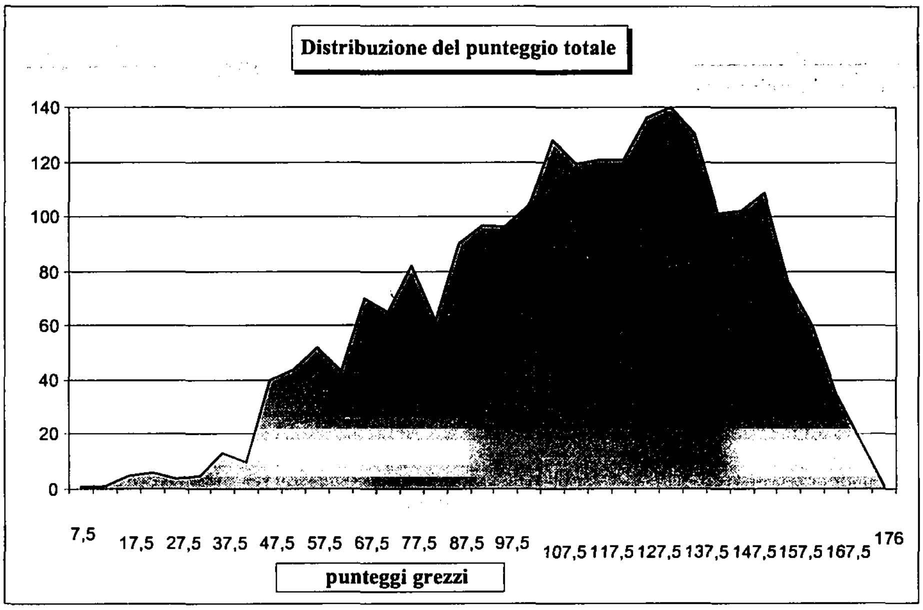
Table 6: Risultati generali "vamio" (1984) (1)

Argomenti del programma maggiormente svolti

		0	**1**	**2**	**3**	**4**	**5**
Geometria prima rappresentazione del mondo fisico (A)							
01	Studio delle figure del piano a partire da modell	2	19	18	19	33	10
03	Disegno di figure geometriche piane	1	14	19	17	41	7
04	Nomenclatura relativa ai poligoni	1	25	25	12	33	4
06	Calcolo di perimetri ed aree di quadrilateri	0	1	3	17	57	20
10	Figure equivalenti	1	4	14	22	47	13
12	Studio di poligoni regolari	1	7	24	28	32	8
13	Il teorema di Pitagora	0	1	6	21	50	22
14	Applicazioni del teorema di Pitagora alla soluzione di problemi geometrici	0	0	1	10	54	36
15	Uso di riga, squadra e compasso nelle costruzioni geometriche	12	27	17	10	29	
24	Studio delle figure solide a partire da modellinaturali	1	17	21	16	39	5
25	Poliedri regolari	5	21	23	15	33	4
28	Cubo	1	6	26	23	40	3
30	Parallelepipedo	0	5	25	23	44	4
31	Prisma	1	5	24	24	44	3
32	Piramide	1	5	21	26	45	4
33	Cilindro	1	4	23	24	44	4
34	Cono	2	4	23	24	44	4
37	Solidi composti	7	11	20	19	38	5

Matematica del certo e matematica del probabile (C)
nessun argomento
(1) Da "Ricerca Educativa", N° 4, Frascati, 1988.

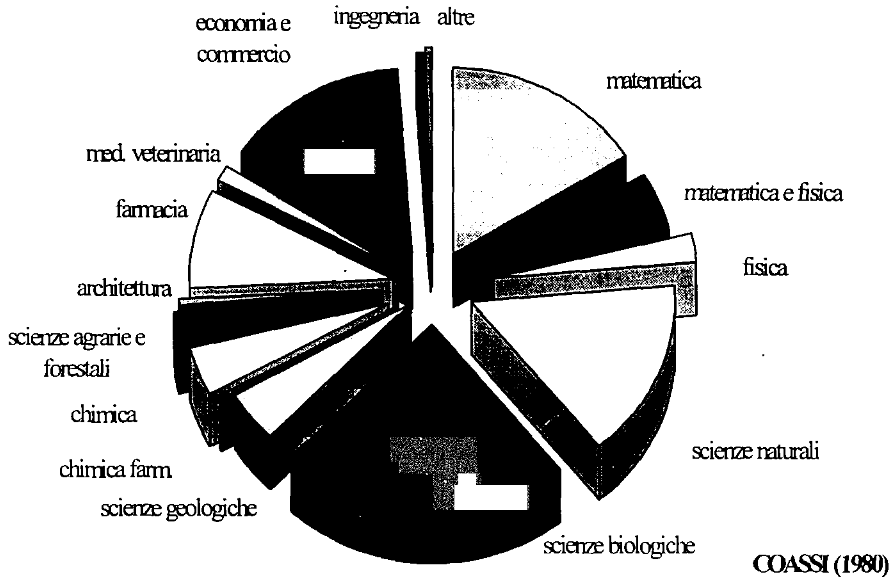
Table 7: Attuazione I nuovi programmi di matematica nella scuola elementare (indagine censis - mpi) [1]



1. Materiale non pubblicato, Ufficio Studi MPI.

Table 8: Lauree degli insegnanti di scienze nella scuola media

10a - Indagine coassi ed AIF



Laurea	AIF (1984)	COASSI
Matematica	21	16,2
Matematica e Fisica	3	5,0
Fisica	4	2,5
Chimica	2	4,2
Scienze geologiche	5	4,5
Scienze naturali	16	15,4
Scienze biologiche	32	23,0
Scienze agrarie e forestali	2	2,5
Farmacia	6	8,5
Economia e Commercio	9	14,9
Altre	-	3,3

Table 9: Number, teacher/pupil ratio (1)

Personale insegnante di ruolo e non di ruolo, classi e alunni delle scuole statati (valori assoluti, valori medi e variazioni)

	1987-88	1988-89	1989-90	1990-91	1991-92	Var. assoluta 1987-	Var.% 1987-
Materna							
Alunni	804.927	806.944	812.376	816.955	809.397(a)	4.470	0,6
Docenti	71.116	74.717	77.029	78.129	79.005	7.979	11,2
Alunni per docente	11,3	10,8	10,5	10,5	10,2		
Alunni per classe	23,0	22,6	22,6	22,6	22,7		
Elementare							
Alunni	3.107.008	2.996.568	2.887.015	2.809.412	2.743.581(a)	-363.427	-11,7
Docenti	275.207	277.460	274.438	268.138	279.545	4.338	1,6
Alunni per docente	11,3	10,8	10,5	10,5	9,8		
Alunni per classe	15,4	15,3	15,4	15,6	15,7		
Media inferiore							
Alunni	2.500.241	2.378.657	2.281.228	2.159.700	2.053.541	-446.700	-17,9
Docenti	286.211	279.842	277.339	273.442	266.431	-29.780	-6,9
Alunni per docente	8,7	8,5	8,2	7,9	7,7		
Alunni per classe	20,4	20,1	20,0	20,0	19,5		
Secondaria superiore(*)							
Alunni	2.458.353	2.527.507	2.578.398	2.590.452	2.593.772	135.419	5,5
Docenti	245.500	257.734	255.555	258.492	265.331	19.831	8,1
Alunni per docente	10,9	10,0	9,8	10,1	9,8		
Alunni per classe	21,8	21,0	20,6	21,5	21,1		
Totale							
Alunni	8.870.529	8.709.676	8.559.017	8.385.519	8.200.291	-670.238	-7,6
Docenti	878.034	889.753	884.361	878.201	890.402	12.368	1,4
Alunni per docente	10,1	9,8	9,7	9,5	9,2		
Alunni per classe	18,8	18,6	18,6	18,7	18,3		

(*) Escluse le Acc. BB.AA., Conservatori di musica e Accademie nazionali

(a) dati stimati

Fonte: elaborazione Censis su dati Istat e Ministero Pubblica Istruzione

Numero medio di alunni per insegnante in alcuni Paesi sviluppati

NAZIONI	Elementare	Media	Secondaria
Francia	17,0	14,9	11,6
Italia	12,8	8,8	9,7
Regno Unito	21,4	17,5	16,0
Svezia	11,1	10,9	12,4
Giappone	21,5	19,2	17,2

Nota: dati relativi alla scuola statale e non statale.

(1) Da OCDE, 1992.

Segue Tav. 10 (1)

Variazione percentuale annua degli iscritti alla scuola dell'obbligo (statale e non)

	Scuola elementare		Scuola media		Scuola elementare e scuola media in complesso
Anni	In complesso	Al primo anno	In complesso	Al primo anno	
1986-1987	-5,0	-4,3	-1,8	-3,3	-3,6
1987-1988	-4,2	-2,1	-3,4	-4,0	-3,8
1988-1989	-3,8	-1,3	-5,5	-5,8	-4,0
1989-1990	-3,1	-2,4	-4,5	-5,2	-3,7
1990-1991(a)	-2,7	-2,0	-5,3	-5,9	-3,8
1991-1992(a)	-2,3	-1,5	-5,1	-5,2	-3,5

(a) dati provvsori

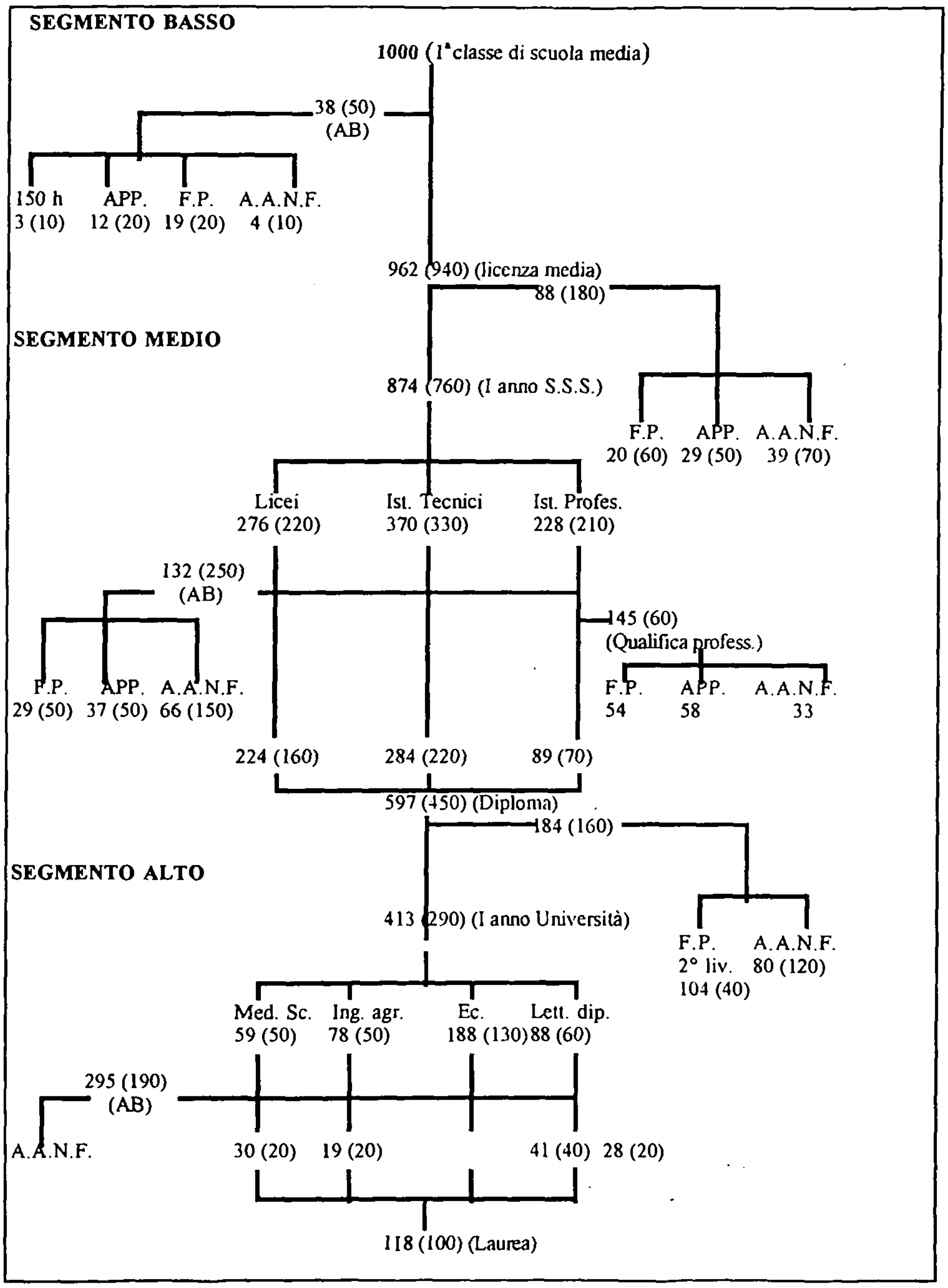
Variazione percentuale annua degli alunni iscritti in complesso e al primo anno della scuola secondaria superiore

I scritti in complesso					
Tipo di scuola	**Tra 1986-87 e 1987-**	**Tra 1987-88 e 1988-**	**Tra 1988-89 e 1989-90 (a)**	**Tra 1989-90 e 1990-91 (a)**	**Tra 1990-91 e 1991-92 (a)**
Istituti professionali	0,5	0,8	2,6	0,8	0,8
Istituti tecnici in complesso	2,3	3,2	1,0	-0,2	-0,8
Industriali	1,9	1,6	-1,0	0,5	-1,7
Commerciali	3,3	4,6	1,8	-1,0	-1,1
Geometri	1,2	4,1	2,9	3,9	3,3
Scuola e istituti magistrali	-0,6	-0,6	0,1	-1,5	-1,4
Licei Scientifici (b)	4,7	5,0	4,2	1,4	1,9
Licei ginnasi	2,7	2,4	2,4	-0,9	0,7
Istituti d'arte e licei artistici	7,9	6,8	3,8	2,9	1,7
Totale	2,3	2,9	2,0	0,4	0,1
	iscritti al primo anno (c)				
Istituti professionali	-1,7	0,7	0,7	-2,6	-0,9
Istituti tecnici in complesso	0,3	0,6	-2,4	-3,4	-3,9
Industriali	-0,8	-0,8	-1,5	-1,3	-5,5
Commerciali	0,8	0,7	-4,2	-5,4	-4,4
Geometri	2,4	4,0	2,7	0,8	3,0
Scuola e istituti magistrali	-1,9	-1,5	-3,0	-5,3	-3,1
Licei Scientifici (b)	4,3	3,2	2,5	-1,8	1,8
Licei ginnasi	2,9	4,0	-1,1	-1,8	0,4
Istituti d'arte e licei artistici	7,3	4,7	-3,5	-3,7	0,4
Totale	0,7	1,5	-1,2	-3,0	-1,7

(a) dati provvisori (b) compresi i licei linguistici (c) al netto dei ripetenti

(1) Da Istituto Centrale di Statistica, Annuari Statistiche Pubblica Istruzione.

Table 10: Drop out rate (1) - Tavola dei flussi nel sistema scolastico italiano



(1) Da "Rapporto CENSIS", 1993.

Report from Ireland

Peter E. Childs

Introduction

1. The statistics of Irish education[1]

976,181 young people (49.4% female) are in full time education in the Republic of Ireland out of a population of 3.523 million (1992/93). When the number of parents is included with students it means that most of the population has some stake in education. The numbers at each level of full-time education are shown in Table 1 (1992/93). After years of rising numbers in school due to a high birth rate and expanded educational provision, numbers are now peaking in the upper primary/lower secondary system as a large cohort moves up through the educational system. This is shown in Figure 1. This demographic change has major implications for the future: for class size, teacher/pupil ratios, numbers of teachers, number of teacher-training places and numbers of schools. Major changes are expected in the next 10 years or so. Ireland has one of the highest percentages of the population in dependent age groups (39.3% compared to an EC12 average of 32.7% in 1988) and one of the highest unemployment rates (17.1% in 1989). The latest OECD report shows Ireland to have the youngest population in the EU, apart from Turkey, with 43% between the ages of 5 to 29, compared to an EU average of 36%.

The majority of the population is still classed as rural but a significant proportion live in cities, particularly in Dublin. Greater Dublin (Dublin Borough and County) with a population of 1,024,429 (29.1%) dominates and skews the educational statistics. 21.2% of the population is found in the five County

1. The most recent statistics are used in this report, and where possible data from 1994 has been used. However, official government statistics are published in arrears and the latest ones published in December 1994 refer to the year 92-93. In other cases it has been possible to include 1994 data. There is thus some inconsistency in the text due to deficiencies in the raw data.

Boroughs of Cork, Dublin, Galway, Limerick and Waterford. Dublin and other urban areas have quite large schools, whereas in the rest of the country small schools are the norm (Table 2). The average size of the 3,405 first-level schools is 155 pupils and that of the 823 second-level schools is 440 (92/93). (These figures include all schools, whether state-aided or not.)

The history of educational provision in Ireland also means that one town may have three or more small schools: boys and girls single-sex, religious-run Catholic schools, a mixed vocational school run by the local education authority, and some may have a small mixed Protestant school as well. This situation coupled with demographic and curriculum changes have resulted in a continuing programme of school closures and mergers, which will change the educational landscape dramatically in the future.

Teachers are public employees and in 1993 there were an estimated 54,048 employed in education, 26.3% of all public employees. In 1992/93, 20,761 were employed at first level and 21,885 at second level. The breakdown by level and sex is shown in Table 3. Teaching at first level is predominantly female, whereas at second-level numbers are almost equal. (No statistics are available of the numbers teaching science subjects at second level, although it is estimated to be around 2,700 teachers.)

The Republic of Ireland is over 95% Roman Catholic and the primary and secondary school system is dominated by church-run schools, many of them run by religious orders. The fall in vocations in recent years has meant that the number of religious in schools and religious principals has fallen markedly and more and more schools have been handed over to lay principals in the last few years.

Table 4 shows the breakdown by age of the school population on 1/1/89. Essentially the whole age cohort is in full-time education from age 5 to14, although compulsory schooling runs from age 6 to age 15. Children can start school at 4 and the majority have done so by age 5. Ireland is unusual in providing the option of state-funded pre-primary education from age 4, although compulsory schooling does not start until age 6.

It can be seen from Table 4 that the population peak occurred in 1989 at age 8, and that this large cohort was aged 13 in 1994, having just entered second level. Figure 1 shows how numbers in each level of education are expected to change from 1992 onwards due to the decline in the birth rate (Figure 2). Compulsory schooling ends at age 15, but second-level schooling now ends for most pupils at age 17 (18 for some doing a six-year senior cycle) and at 17, 73.2% are still in full-time education. The participation rates above age 15 have risen steadily in the last few years and continue to do so. The percentage of girls in the school population is remarkably constant from ages 5-15 at just under 49%, and increases beyond 15 as more boys drop out of education than girls.

If we consider the 1989 12 year-old cohort moving through the system (Table 5) we can see how small the numbers of those dropping out of full-time education are at present. This means that the Leaving Certificate examination, taken on average at age 17 after 5 years of second-level education, is now taken by a much wider range of ability compared to 20 years ago. However, the examinations have in the main not been changed to accommodate the change in the student population. Significant changes to the Leaving Certificate examination are being introduced to broaden its appeal and relevance.

Irish schools receive about 60% of the support received by other EC schools, and as a result although Ireland is near the top of the EC league in educational spending as a percentage of GNP (at just over 6%), and although 13.2% (1993) of public spending goes on education, it is at the bottom of the EU league in actual spending per child (see Figure 3 and Table 6). Ireland has a small population, a low population density, a high percentage of young people in school, and a small, rather stagnant economy on the periphery of Europe. This means large classes, limited resources and a high demand for education form the backdrop for considering the state of science education in Ireland. (These figures have been reinforced in the latest OECD report 'Education at a glance', published in 1995.)

Until the late 1960s the second-level system was essentially bipartite, split between private, fee-paying 'secondary' schools and free, state-run and financed vocational schools. The system at present is effectively quadripartite: fee-paying, private 'secondary' schools; 'free' private 'secondary schools'; free, state-run vocational schools and free, state-run community and comprehensive schools. The numbers is each sector are shown in Table 7. Of the 467 secondary schools, 75 have boarding and day pupils, and 4 are boarding only.

The number of schools has declined slowly over the past few years as small schools have closed or amalgamated. The majority of second-level schools are religious/denominational schools (59.4%), as are the majority of primary schools.

The essentially private, religious second-level schools are known as 'secondary' schools, and offer, in the main, a traditional, academic curriculum, i.e. without the vocational (practical or technical) subjects. Until quite recently a majority were still single sex. 'Free' second-level education and school transport were not introduced in Ireland until 1967, and since then the numbers at second level, and the numbers staying on at school up to age 15 (the end of compulsory schooling) and beyond have increased year by year (Table 8 and Figure 4). (Also see Table 4.) The alternative state-run schools formed a separate system and were known as vocational schools (31.5% of schools). These are run by regional Vocational Education Committees (VECs), are mixed-sex and initially offered mostly the practical subjects, although they now offer nearly the whole range of subjects. Originally they tended to cater for the less academic pupils, and were often less well financed than the semi-private secondary schools. However, many of the secondary schools now operate an open-door entry policy and have poorer pupil/teacher ratios and lower per capita income. Since the early 1970s, a hybrid alternative system of community schools, comprehensive schools and community colleges has grown up, often by the merger of small boys-only and girls-only secondary schools and the mixed vocational schools in a town. This trend is increasing as the number of students falls and the total number of schools decreases each year. The mixed nature of the system in terms of school type, management and financing means that there are wide variations in provision of facilities, resources, etc. from one school to another.

In June 1994 more than 135,000 students sat the Junior Certificate and Leaving Certificate examinations over a period of two weeks in 4,000 exam centres throughout the country. The number of students applying to sit the Leaving Certificate was 66,033 (up from 63,234 in 1993 and 59,509 in 1992). Of these, 7,748 were school-based repeat students, 4,845 external repeat candidates, with 777 sitting the exam under the vocational training opportunities scheme (VTOS). In the last ten years, with increasing competition for third-level places, more and more students have been repeating the Leaving Certificate examination to improve their grades. Much of this growth has been in private fee-paying 'crammer' schools outside the normal education system. This has complicated exam statistics because a significant proportion of students each year are sitting the exam for a second time, competing with first-time examinees. This has tended to increase the standards for third-level courses and reduced the chances for first-time examinees, bringing another source of inequity into the system. Because the repeat schools are expensive, they are an option only for financially well-off students. However, students can repeat the examination in state schools on payment of a moderate fee.

In 1994, 70,463 candidates applied to sit the Junior Certificate (68,426 in 1993); and the majority of these will carry on into full-time education and attempt the Leaving Certificate in 1996.

There are 7 universities in Ireland and 12 other third-level institutions offering science as certificate (2 years), diploma (3 years) or degree (three or four years) courses. There is no shortage of science places but science, as measured by numbers of applicants and points required for entry, is well down the list of student preferences. Only one science course featured in the top 20 student preferences. The Central Applications Office (CAO) had 60,068 applications in 1994 (57,337 in 1993 and 54,573 in 1992). In 1992, 25,830 places were available on third-level courses at universities and R.T.C.s, and from 1989 to 1992, 8,000 new places were created to meet the increased demand. This expansion is continuing and will do so for some time as the enlarged cohort moves through the second-level system and into third level.

2. Educational Developments

Ireland is at present going through a period of profound debate and change in education at all levels, unprecedented in the history of the State. There has been more discussion, more significant publications and more actual changes in the system in the last ten years than in the previous fifty years, apart from the introduction of free education in 1967. Since 1984 there have been three excellent, energetic women Ministers of Education who have initiated and implemented, or proposed, a number of significant changes in the system. Some significant developments in the last ten years are summarised below.

An important report on in-service education was published in 1984 and immediately shelved. In 1984 the interim Curriculum and Examinations Board (CEB) was set up with the intention to make it a statutory body responsible for curriculum and assessment. (Education in Ireland is highly centralised, with the Department of Education controlling the curriculum, assessment, schools inspection and funding of schools.) The CEB arose from a radical, though short-term, development plan, the 'Programme for Action in Education 1984-87'. A change of government meant that the CEB was never established; instead it metamorphosed into the National Council for Curriculum and Assessment (NCCA) in 1987, but not before it had recommended and set in place work on a new junior cycle (12-15) curriculum and published some important discussion papers. In 1985 a Transition Year Option (TYO) was introduced into a limited number of schools giving a six-year second-level cycle. In the same year an innovative Intervention Project was started by the Department of Education to introduce and promote physics and chemistry in schools where it was not offered, particularly in girls' schools. The NCCA was given only advisory powers and remained subject to the Department of Education, instead of being an independent and autonomous body as was originally envisaged. Despite this weakening of its authority it has still managed to initiate radical change in the educational system.

The new Junior Certificate was introduced in 1989 and first examined in 1992. This was the most important change in curriculum and assessment at this level (which corresponds to the end of compulsory schooling) since the foundation of the state in 1922. It included, for example, a new junior science course for all pupils, which replaced four existing syllabi and unified science provision across all types of school.

In 1991 the OECD commissioned a second 'Review of Irish Education', the first having been produced in 1966. This was followed in 1992 by a wide-ranging Green Paper on Education, 'Education for a changing world', based on the OECD report and the Culliton Report from the Industrial Policy Review Group, which recommended a greater emphasis on vocational and technical training. After running through three Ministers of Education in as many months, a large-scale consultative process was set in place on the Green Paper and its proposals for the future of Irish education. Written submissions were invited (and over 1,000 were received) and a series of public meetings were held around the country to discuss the Green Paper, culminating in a two-week National Education Convention in October 1993. The 'Report on the National Education Convention' was published in April 1994. All the important bodies involved in education were represented at the National Education Convention, and most made written and oral submissions. The discussion was attended by the Minister and her officials at the Department of Education, and the Convention Report was sent to the Minister of Education to help in the preparation of a White Paper on Education, expected at the end of 1994. This White Paper promised to be one of the most influential education documents ever published in Ireland, and was intended to lay the legislative framework for education into the next century. Among the submissions made to the Convention was the report by the National Economic and Social Council (NESC) on 'Education and Training Policies for

Economic and Social Development' (October 1993). Education was a significant part of the government's 'Programme for a Partnership Government, 1993-1997' published in 1993. The government emphasised its ongoing commitment to education in these words: *"We regard education as the key to our future prosperity and to equality and equal opportunities for all our citizens."*

The NCCA in 1992 commissioned and published the first-ever analysis of the Leaving Certificate results (for the 1991 results), and this was followed in 1994 by an analysis of the 1992 results. Discussion documents on assessment and certification and the shape of the future Leaving Certificate programmes have been published. The Leaving Certificate Vocational Programme was introduced in 1994 on a pilot basis and the Leaving Certificate Applied Programme to be introduced in 1995. These new departures modify the long-established and highly-regarded Leaving Certificate programme, originally designed for high achievers, to cater for the needs of a greater proportion of the school population.

A Review Body on Primary Education was set up and a separate 'Review of the Primary Curriculum' was completed under the NCCA in 1990 and *inter alia* recommended a larger role for science in the primary school. An NCCA committee on the primary curriculum is working on proposals for a new primary science curriculum. The Department of Education funded a two-year Primary Science Project in Galway in 1986 and an independent project, the Primary Schools Science Project, was set up in Limerick in 1987 to produce and pilot materials in conjunction with local teachers. In 1994, PSSP produced their Guidelines for Primary Science, 'Primary Science Starts Here'.

There have also been some important changes in entry procedures for third level in the last 3 to 4 years:

1) Firstly, the Leaving Certificate results were computerised so that results could be produced simultaneously with the UK A-level results, and made available to the various Irish third-level colleges. From 1991 an analysis of the results was published in newspapers almost as soon as the results were released. Prior to this, statistics from the Department of Education were years late in appearing. (The Junior Certificate results still appear in September after schools have resumed.)

2) Secondly, some universities had a separate matriculation examination which provided an alternative entry route to university, and this provided a second attempt at the Leaving Certificate examination for those who could afford it. The matriculation was offered for the last time in 1992.

3) Thirdly, two separate clearing houses dealt with university courses (the Central Applications Office, CAO - founded in 1976) and regional technical college applications (Colleges Applications Services, CAS - founded in 1990). From 1993 the two systems provided a single application form for all college places.

4) Fourthly, the Leaving Certificate grades were subdivided to give a finer selection instrument in 1992 (see Table 9). Each candidate achieves a total score (the 'points') based on his/her six best Leaving Certificate subjects. This score is then used to select people for third-level places, according to their preferences. Each candidate may choose 10 degree and 10 non-degree courses and will be awarded the highest preference for which they are eligible, subject to demand. The number of first preferences and the cut-off points give a direct indication of the popularity of different courses and the standard required to win a place. However, the entry standard for different courses is largely determined by the number of places available, i.e. by supply and demand.

5) Fifthly, whereas various colleges used to compute their entry points on different bases, from 1993 all colleges have used a common points system, so that a single system operates across the whole third level. This has proved to be a very efficient and equitable way of allocating places to the best candidates according to their own preferences. A random selection is only used when a number of candidates at the same points level are competing for the final places. Offers of places are made in several rounds, and candidates offered a lower choice on the first round may move up to a higher offer if a place becomes available. Applications must be made by the 1st February, but it is possible to change one's choices at a later date, up to the 1st July at the latest.

6) Sixthly, some control over repeating students has been imposed by requiring that all six subjects offered for third-level entry must have been taken at a single sitting of the examination. Prior to 1992 students could combine their best grades from more than one sitting which gave an additional advantage to repeating students. This series of changes for third-level entry have simplified the system, making it more equitable; and it has proved to be an efficient and fair system for allocating places.

Some of the significant events and publications in Irish education are summarised in Table 10.

3. Educational system

a) Primary level

Figure 6(a) shows the structure of the Irish education system from first to third level. Compulsory schooling runs from 6 to 15 years of age. However, the majority of children go to school at 4 for two years of schooling prior to first class. Primary schooling then lasts for six years (first to sixth class) and children move on to second-level school at age 12 (see Table 4 for attendance at different ages). Virtually the whole national school system is denominational, the majority of schools (over 95%) being managed by the Roman Catholic Church, largely through the local bishop.

Education is nominally free (except in a small number of fee-paying schools), but in practice schools have to make up the gap between government support and actual needs. Schools have to raise 10% of capital spending for new buildings. There is a national primary school curriculum, introduced in 1971 and it is in the process of being revised. There is no formal science in the curriculum, although it was intended to be included under the heading of social and environmental education, along with history, geography and civics. Most of the time in national schools is spent on Irish, English and mathematics (compulsory throughout the educational system) and religion also has a major part. Table 11 shows the amount of time allocated to Social and Environmental Studies in different years of the primary school.

There have been two pilot projects on primary science: a small-scale 2-year project with class 5 and 6 pupils in Galway schools, and a more extensive Primary Schools Science Project in Limerick schools which has been running since 1986, including all 8 years of primary schooling. The physical sciences have a smaller role in these projects than the natural sciences. Essentially the majority of primary pupils do not study science before they enter second-level school. This is reflected in the poor performance of Irish students aged 13 in the IAEP studies in 1988 and 1992. It is hoped that in the future primary science will be part of the curriculum for all pupils. This has been recommended by the Primary Education Review Body (1990) and an NCCA committee is working on a science curriculum for primary schools. This will draw on the experience gained in the pilot projects.

b) Second level

Second-level schooling for the majority of pupils takes at present 5 years, with a minority of schools taking 6 years with an extra 'transition' year. All schools now have the option to move to a six-year secondary cycle from 1994, where year 4 is a non-exam year. This means that in 1997 a much smaller cohort will take the Leaving Certificate examination with a drop in third-level entries (see Figure 5). The structure of the second-level cycle is shown in Figure 6(b).

The first three years (the junior cycle) lead up to a national examination at age 15, the Junior Certificate. This was introduced in 1989 and examined for the first time in 1992. It replaced the Intermediate Certificate and Group Certificate examinations, and ensured that every pupil would be taking the same curriculum and the same examination for the first time. Most of the subject syllabi were rewritten, with a change of approach, assessment and content. Most subjects are offered at two levels, ordinary and higher - although mathematics and Irish have three levels. There are 28 subjects on offer.

Beyond the junior cycle all pupils now have the option of a non-examined transition year, subject to the schools both providing it and offering it. A majority of schools will avail of this option from 1994, although in the previous years only 162 schools were allowed to do it. However, in the schools that offer it, it is not available to all students. In most schools this is a year for personal development between junior and senior cycles. Some schools have used it in the past either for a four-year junior cycle or for a three-year senior cycle, but this is discouraged.

In the senior cycle there are now a number of options:

1) the traditional Leaving Certificate course in 6 to 8 subjects from a total of 31 subjects;

2) the Leaving Certificate Vocational Programme (LCVP) with a minimum of 5 L.C. subjects plus other vocational courses (from September 1994);

3) the Leaving Certificate Applied Programme (LCAP) from September 1995.

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

a) Primary education

There is no fixed allocation of time for science at present in the primary curriculum. It is included as nature study under Social and Environmental Studies which have a maximum formal allocation of 2.5 hours per week in the top classes (see Table 11). Although no comprehensive survey has been done, it would probably be true to say that the majority (more than 90%) of children leaving primary school have no formal science.

b) Secondary education

1. Junior secondary

In the junior science course it is recommended that the course last for 240-270 hours over three years; and this is usually done with 4 to 5 single 35-45 minute periods, two of which should be offered as a double period for laboratory work.

2. Senior secondary

The L.C. science courses would usually be allocated 4-5 35-45 minute periods per subject, including at least one double period timetabled in a laboratory, totalling about 180 hours over two years.

1.2 Which sciences are to be taught

a) Primary science

Science as such is not a separate subject in the primary school curriculum, which was introduced in 1971. Elementary science is part of Social and Environmental Studies (Figure 7) along with history, civics and GEOGRAPHY. The 'Primary School Curriculum: Teacher's Handbook' Vol. 2 describes the content of the environmental studies/elementary science for each year of primary schooling. It is quite detailed and is concerned mainly with nature study and simple biology. However, very little of this syllabus is actually taught.

b) Junior science

Science at junior secondary level in Ireland has always been general science rather than separate sciences, and science has thus only been a single subject up to age 15/16. Until 1989 there were several alternative science syllabi on offer at junior level: syllabus A, syllabus E, Common Course (including ISCIP, the Integrated Science Curriculum Innovation Project) and the Group Certificate in General and Rural Science. Most secondary schools did syllabus A; vocational schools offered A, E and the group certificate; ISCIP was a 20 year-old innovative science project running in about 60 schools that never got beyond the pilot stage.

A decision was made by the interim CEB to reform science education, following a discussion paper 'Science, Technology and the Post-Primary Curriculum' (CEB,1987) later implemented by the NCCA, by replacing the Intermediate and Group Certificate examinations with a single unified system. The Junior Certificate would have a new curriculum, a new teaching approach and a new examination. The Junior Certificate was introduced in 1989 and examined first in 1992. All pupils, whatever their school, now take the same science syllabus and science is part of the curriculum for almost all students up to age 15/16. 96% of schools offer junior science and it is essentially a compulsory subject with the vast majority of boys and a slightly smaller majority of girls taking it. (In some girls-only schools home economics is still done as an alternative to science).

The Junior Certificate science syllabus is shown in outline in Table 12. The core subjects are biology, chemistry and physics, plus applied science options. The sciences are taught in separate blocks not as an integrated course.

The syllabus is taken at two levels: ordinary and higher levels. Ordinary-level students do the core plus any three extensions. Higher-level students do the core, physics, chemistry and biology, and either applied science (2 out of 6 options) or the local studies option. (However, because of resource implications the Local Studies option is confined to schools that previously offered the General and Rural Science Group Certificate or Syllabus E courses.)

The new syllabus emphasises a practical, hands-on approach to science and stresses the relevance of science to everyday life. Thirty percent of the syllabus deals with the social and applied aspects of science, a common feature of all new science courses designed by the NCCA syllabus committees.

c) L.C. science courses

The majority of Irish students now stay on after age 15/16 and the Junior Certificate examination to follow one of the Leaving Certificate programmes now on offer, leads to a national examination after two years at age 17/18. The numbers taking the two state examinations for the past few years are shown in Table 13 and Figure 8 shows how the proportion staying on after compulsory schooling to take the second state examination has increased over the last quarter century.

In the L.C. course a number of separate or specialised science courses are on offer: agricultural science, biology, chemistry, physics and combined physics with chemistry. these are all offered at higher and ordinary level. the numbers taking each course at each level in 1994 are shown in Table 14. Biology is the most popular science (offered by nearly every school), followed by physics, chemistry, agricultural science and physics with chemistry.

Following the introduction of the new junior science course in 1989 and its perceived mismatch with the subsequent science courses in content and approach, the syllabi in physics (1996), chemistry (1996) and biology (1997) are being substantially revised and will be introduced in the specified years. Agricultural science and the combined physics with chemistry course will be revised.

The numbers taking the state examinations is shown in Table 13 and Figure 8 shows how the proportion staying on after 15 to take the second state examination has increased over the past decade.

In the traditional L.C. programme, students were required to take a minimum of 5 subjects, although six are counted for third-level entry. Three of these are effectively compulsory: English, Irish and mathematics. Students have some degree of choice of the other subjects, subject to timetable constraints, availability, etc. The small size of many Irish schools means that the full range of subjects is not available to all students. Subjects are put in one of five groups: language group, science group (mathematics, physics, chemistry, biology, combined physics and chemistry, applied mathematics), business studies, applied sciences (which includes *inter alia* combined physics and chemistry, agricultural science and home economics (social and scientific)), and social studies. The 'Rules and Programmes for Secondary Schools' (Department of Education) state: *"It is recommended that each pupil take at least three subjects from the group of subjects for which he is best suited, and at least two subjects from outside the group..."* (unchanged from 1975/76 to 1992/93).

Table 15 shows how many schools offer each of the main L.C. science subjects, by school type, and as a percentage of the total schools offering the L.C. course.

There is a clear difference in availability of the different sciences, so that physics and chemistry, for example, are not available to a sizeable proportion of students. Also there is a marked difference in availability by school type, with the choice in vocational schools being particularly restricted. Over the period 1981-89 all the main sciences showed an increase in schools offering them, particularly in the case of physics where numbers increased by 32% over this period. (These figures for 1988-89 are substantially the same in the 1994 examination.)

Depending on the school attended a student's science options can vary widely, and even when a subject is available in a school it may not be offered to all students, or to both boys and girls equally.

A large proportion of students take at least one science subject, usually biology; physics and chemistry tend to be taken by the brightest students as reflected by the higher/ordinary balance (Figure 11 and Table 27) and biology by weaker candidates. The popularity of the science subjects in 1994 in descending order was biology, physics, chemistry, agricultural science and physics & chemistry.

An analysis of entries for the 1994 examination entries shows how many schools of what type offer from 5 to 1 science subjects (Table 16). Notice that the number of schools offering science subjects is only 752 in 1994, so that a small number of schools offer no L.C. science subject. The majority of schools (73.8%) offer a choice of three or more science subjects at L.C. level, including the three main sciences. However, there are disparities between school types with 85.0% of secondary schools and 87.0% of Comm./Comp. schools offering three or more sciences but only 46.9% of vocational schools offering the same choice.

d) Specific courses

Detailed statistics for the 1994 L.C. examination are given in Table 27 and the individual science subjects are discussed below. Outline syllabi for these subjects are given in Appendix 2.

1. Agricultural Science

This course has significant overlap with the biology course and students may not take the two courses together. Despite the importance of agriculture in the Irish economy, agricultural science has a very low uptake. The syllabus is being revised and the overlap with the biology syllabus reduced so that students may take both courses in future if so desired. It is unique among the L.C. science courses in that the final assessment includes marks for course work. Agricultural science is the 19th most popular subject and 9.4% of students taking it are girls and 67.4% of all students take it at the higher level (1994).

2. Biology

This is the most popular L.C. science subject, and is taken mostly by girls. Where a science course has to be taken, it seems that weaker students tend to opt for biology and it is offered in more schools than any other science subject. The syllabus is being revised at the moment for implementation in 1997. It was last revised in 1977. Biology is the 5th most popular subject and 66.4% of the students taking it are girls and 59.4% of all students take it at the higher level (1994).

3. Chemistry

This course was last revised in 1983 and a new syllabus will be introduced from September 1995 following the changes at Junior Certificate level. The existing course has a strong emphasis on practical work and on industrial/applied aspects of chemistry. The 1983 syllabus included aims and objectives (unlike earlier syllabi) and recommends 40% of the time be spent on practical work. Chemistry has declined in popularity in the last few years from about 20% to 13% of the L.C. cohort (Table 17) and has been overtaken by physics since 1988. The new syllabus has been totally reorganised with new areas introduced, and with 30% social/applied content in line with NCCA policy. It is hoped that it will be more attractive to a wider cross-section of pupils and it is due to be introduced in 1996. Chemistry is the 15th most popular subject and 47.1% of students taking it are girls and 78.5% of all students take it at the higher level (1994).

4. Physics

This course was last revised in 1984 and a new, revised syllabus is being introduced in September 1996, allowing for changes in the junior science course. The 1984 syllabus included aims and objectives and a list of mandatory experiments. Physics used to be the third most popular science, but since 1987 it has overtaken chemistry and has shown the greatest growth in availability (see Table 16), particularly in mixed schools. The Intervention Project has resulted in physics (and to a lesser extent chemistry) being introduced in a number of new schools, particularly girls-only schools (see the papers by O'Donnabhain and Porter, 1991 and O'Brien and Porter, 1994). Physics is the 11th most popular subject and 24.7% of the students taking it are girls and 66.4% of all students take it at the higher level (1994).

5. Combined physics & chemistry

This course is an alternative to the single-subject physics and chemistry courses, and provides an option for smaller schools who cannot offer both. Take-up is relatively small and the syllabus has not been revised in the last 20 or more years. It is due for revision when the single science subjects have all been revised, although its viability has been questioned. Physics & chemistry is the 20th most popular subject; 28.8% of the students taking it are girls and 61.9% of all students take it at the higher level (1994).

d) Other senior cycle courses

1. Senior Certificate Programme

A pilot programme has been running in about 60 schools since 1986 as an alternative to the Leaving Certificate. The programme involves work and communication skills, general technology, food and agriculture, computer applications, mathematics, social and cultural studies and Irish. It is modular and each module is assessed partly by course work (50%) and partly by examination, with the Senior Certificate provided by the Department of Education. It is intended to subsume this programme within the new Leaving Certificate Applied Programme (LCAP) due to start in 1995 (see below).

2. Leaving Certificate Vocational Programme

This programme was established on a pilot basis in 1989 but uptake has only been 5% of the L.C. cohort. Few take science and it is not required in the programme. It is hoped to increase this to 30% with the programme being offered on a phased basis from September 1994. It is intended to enhance the overall vocational orientation of the Senior Cycle curriculum. It is being funded under Ireland's National Development Plan (1994-1999) by EU Structural Funds. Participating schools will receive support for resources, training and equipment. Figure 9 shows the structure of the LCVP. It consists of a core (Irish, a continental language, an approved L.C. subject and three link modules), and two other L.C. subjects from a specialist group (which includes the sciences) or from services group (which has business organisation plus one other subject e.g. agricultural science). The mandatory link modules are Enterprise Education, Preparation for Work and Work Experience. A minimum of five L.C. subjects must be taken so that students are qualified for third-level entry. Maths is not compulsory, but students would be able to take up to two science subjects (agricultural science with chemistry or physics or biology or business organisation). Take-up is limited to those schools that provide at least two of the required technical subjects, and this disadvantages girls.

3. Leaving Certificate Applied Programme (Senior Certificate)

The new Leaving Certificate Applied Programme (LCAP) represents a third level within the Leaving Certificate programme. It replaces the existing Senior Certificate and Vocational Preparation and Training (VPT1) programmes. It is expected to implement the new programme in September 1995. It is intended as an alternative course for those who currently take L.C. ordinary-level courses that may not be "responsive to their aptitudes, abilities and needs."

4. Transition year

Until 1994 the Transition Year Option was only taken by 162 schools. The option meant that pupils took a six-year rather than a five-year second-level cycle, taking six years to reach the final school leaving examination. The majority of schools used the extra year as a transition year between the junior and senior cycles, though some had a four-year junior or three-year senior cycle. From 1994 the majority of schools will be offering this option, though not all pupils need take it. It is intended to be a non-exam year when pupils can develop social and personal skills, and can mature so that they are better able to make subject and career choices.

5. Vocational Preparation and Training Programme (VPTP)

This alternative senior cycle programme has been available since 1984 for those who have completed compulsory schooling (more than 15 years old) and need additional skills to compete in the jobs market. VPT programmes have three sections: vocational studies, work experience and preparation for working life. VPTPs are offered as two one-year, self-contained programmes (VPT1 and VPT2) from 1985 and are now called Post-Leaving Certificate courses (PLCs). VPT1 is a one-year basic course and the VPT2 is no longer restricted to one year and is commonly two years. In 1991-92, 5,879 students took VPT1 and 15,837 students VPT2/PLC. Since 1991 the National Council for Vocational Awards (NCCA) has been responsible for certification and assessment of second-level vocational programmes. It is intended to combine the Senior Certificate and VPT1 programmes into the new Leaving Certificate Applied programme from

1995. Courses will be developed in various areas including science, which will be a modular course including food & agriculture, horticulture, electronics, etc

1.3 Realistic data on the above

Table 17 shows the numbers taking the various L.C. science subjects over the past few years.

The principal features of these data are the decline of chemistry relative to physics, compared to the stability in numbers of the other sciences. Physics has increased greatly in popularity since 1987, with a 10.8% rise in the period from 1987 to 1992, while chemistry has declined drastically over the same period, down 21.0%.

Table 18 shows the gender breakdown of the different L.C. science subjects in 1992. There is very pronounced differentiation between biology (2/1 in favour of girls) and physics, physics & chemistry, and agricultural science. The gender imbalance is considered in more detail below.

Figure 10 shows the percentage of girls taking each L.C. subject in 1991. The proportion of girls overall was 53%, so subjects less than this are under-represented and those greater than this are over-represented. This position has not changed to any great extent over the past 10 years or so (see the report by Gleeson, 1992). Figure 11 shows the percentage of all L.C. subjects taken at higher level in 1991 and again this has not changed significantly in recent years.

1.4 Recommended learning activities

a) Laboratory work

Laboratory work is seen as an essential component of science courses at junior and senior secondary levels. However, teachers and schools are not always equipped to deliver the practical-based courses specified in the latest syllabi. In junior science the emphasis is on pupil-centred, guided-discovery laboratory work. However, in reality the laboratory experience of a student depends very much on the school (its resources and philosophy) and on the individual teacher. In the 1983 chemistry and 1984 physics syllabi practical work was emphasised and specific experiments were listed. For physics these were mandatory and the 1995 chemistry syllabus will also have a mandatory list of experiments. In practice, despite the official emphasis on practical work, many students still do very little practical work themselves at both junior level and at the L.C. level.

One unpublished study on the L.C. chemistry course (Smyth, 1988) showed that only 21.8% of students spent the recommended 40% of time on practical work, and students spent on average only 26.5% of their time on practicals (4.05% did none at all).

b) Field studies/local studies

Schools who used to take the General & Rural science Course put strong emphasis on field work and local studies. The same schools have been allowed to continue this approach in the new junior science course Local Studies option. The new junior science course encourages teachers to use their local environment, to conduct field trips, etc., but the implementation of this would vary widely from school to school, and from teacher to teacher. The L.C. biology course has a section on ecology which recommends two 3-hour field sessions (over two years). Agricultural science includes the option of field work.

c) History of science

This has no explicit place in any of science curricula, although most subjects have brief historical introductions to topics, e.g. atomic structure in chemistry. The new emphasis on 30% of content devoted to social/applied material should increase the coverage of the history of science in all the science syllabi as background/personal interest material.

d) Science in industry

The 30% of time for social/applied material includes an emphasis on science in industry. This was a major aim of the existing L.C. chemistry syllabus and this has been strengthened in the new syllabus. However, the main part of the industrial chemistry in the new syllabus is dealt with in an option, so only part of the student cohort will do it. It encourages a case-study approach to industry, including an industrial visit.

e) Controversies/issues

There is virtually no reference to controversial issues within the actual science syllabi. Again the requirement for 30% of time to be spent on social and applied topics will increase the coverage of issues. The existing L.C. syllabus mentioned such topics as acid rain, the greenhouse effect and nitrate pollution, and in the new L.C. chemistry syllabus there is an increased emphasis on environmental chemistry, including current issues; but this is again offered as an option.

1.5 Mandatory tests and examinations

Ireland has a national examination system, with state exams at age 15/16 (the Junior Certificate) after three years at secondary school and at age 17/18 (the Leaving Certificate) after a further two year course. (From 1994 a majority of schools, over 450 out of 790, will be introducing an extra 'transition' year between the two examination courses.)

The examinations are set and marked under the supervision of the Department of Education, which controls every aspect of the educational system. The Inspectorate in the Department of Education is responsible for the setting, administration and marking of papers. Almost the whole assessment of courses is based on a final examination taken at two levels - higher and ordinary. (Alternative level courses are offered in mathematics and Irish.) No marks are currently available for course work, except in the case of the Local studies option at junior science and in L.C. agricultural science (25%). However, the whole question of school-based assessment is under discussion at present (see the 'NCCA discussion document, Assessment and Certification in the Senior Cycle', 1993) and there is strong pressure from government and parents to include some school-based assessment in future. (It is already an established part of technology courses, art and languages. Art and languages are examined externally by visiting teachers.) The food & agriculture module in the Senior Certificate (soon to become the Leaving Certificate Applied Programme) has 50% of marks from course work.

Most pupils attempt the same examinations at present. These were originally designed for an 'academic' student and consequently even the ordinary-level courses are not suitable for a large proportion of pupils. The two surveys of the L.C. results done to date, for 1991 and 1992, show how unsuitable the current examinations are for many pupils attempting them. At L.C. level the new Leaving Certificate Applied Programme (LCAP) and Leaving Certificate Vocational Programme (LCVP) are being introduced to widen the choice available in the senior cycle and to give a better choice to less academic or less able students.

The national examinations are taken over a period of about two weeks in June, subjects being offered in order of popularity. The Junior Certificate and Leaving Certificate examinations are run simultaneously. Only one sitting is offered per year. The rest of the school population finishes school at the end of May until the beginning of September, giving Ireland's second-level pupils one of the longest summer breaks in Europe and one of the shortest school years. (Primary schools finish at the end of June.)

The exams are invigilated by teachers from other schools (supervisors) and marked by a panel of subject teachers in each subject during June and July, under the supervision of departmental inspectors and a Chief Examiner. After checking and moderating the results, they are collated and entered on computer by the Examination Branch in Athlone, and the L.C. results are available in mid-August (at the same time as the UK A-level results). By contrast, the Junior Certificate results come out in mid-September, after the school year has restarted and students have already made L.C. subject choices and started on their courses. The examination results have only been computerised in the last three years and this has speeded up the issuing of results and their statistical analysis. It is hoped to be able to issue all the results in future before the start of the new school year.

The marking schemes are known to the examiners but are not published; nor is an examiner's report published. It has been recommended that this should be done so that pupils and all teachers (not just those who are examiners) know on what criteria marks are awarded. This type of feedback is long over due. Another problem with the examination results is the apparent lack of comparability from one subject to another. There is no evidence of standardisation of marks and it would appear, though this is not explicitly stated, that each subject is individually criterion-referenced.

1. Junior Certificate - Higher, Ordinary, Foundation

Students are usually offered 8 or more subjects (from a choice of 28) at ordinary or higher level. Mathematics and Irish have a foundation level as well. Junior science is offered at honours and ordinary level. 51% of the candidates at this level are boys, but more boys than girls drop out of full-time education at this point. The majority of pupils take science as one of their subjects. In 1994, 40,646 (69.7%) pupils took science at higher level and 17,684 at ordinary level. Overall 46.8% of the students taking science were girls (50.6% of the higher level and 39.0% of the lower level students were girls). The Local Studies option was taken by 2.8% of the total either at higher or lower level.

2. Leaving Certificate - Honours, Ordinary, Foundation

Most students do 6 or 7 subjects (from a choice of 32 subjects), at either ordinary of higher level. The majority of students do at least one science, usually biology, but there is no prescribed mix of subjects apart from the effectively compulsory subjects (English, Irish, maths). Eighty-two percent of all L.C. entries are in only 10 subjects.

The analyses of the 1991 and 1992 L.C. results (published in 1992 and 1994 respectively) show that the typical L.C. candidate is a girl (53% of candidates are female), and sits seven subjects, three at higher level and four at ordinary level. Three-quarters of candidates sit seven subjects, and 8% sat eight subjects.

The 10 most popular subjects overall in 1994 were:

1) English (100%)

2) Mathematics (99%)

3) Irish (88%)

4) French (59%)

5) Biology (49%)

6) Geography (41%)

7) Business organisation (39%)

8) Geography (38%).

9) Home economics (social & scientific) (35%)

10)History (28%)

11)Accounting (21%)

About 12% of students repeat the Leaving Certificate (56% male, 44% female) and to repeat candidates now have to take all subjects again as only results obtained at one sitting count for third-level entry (since 1992). The subjects taken by students of different ability are interesting. The top ten subjects taken by students with mean L.C. scores of 245 or greater (the mean score) are shown in Table 19(a), and it can be seen that this includes mathematics, applied mathematics, physics and chemistry (biology is 11th.).

Twelve percent of students attempting the examination get less than D in five subjects (in the past these would have been regarded as failing the Leaving Certificate examination) ; 26% get five Ds (this used to be the requirement for a minimum pass in the Leaving Certificate examination) and the majority (62%)

get one or more honours (C or above on a higher-level paper). Only one science is among the ten subjects with the lowest scoring students (Table 19(b)). The pattern for the ordinary-level courses is similar. It is worth noting that no analysis of L.C. results had ever been done before the study of the 1991 results commissioned by the NCCA, and this data was not available in the public domain for study. This marks a major step forward in openness and accountability. One other feature of the 1992 results was the disparity in grades between subjects. Table 20(a) and (b) shows the ten highest scoring and the ten lowest scoring subjects, based on the percentage of As and Bs awarded, compared to the mean across all subjects at higher level.

Table 21(a) and (b) shows the breakdown on grades for L.C. subjects for 1993. Table 9 above showed the grades and marks required. The first three points on the ordinary-level examination overlap with the bottom four grades of the higher-level examination. There is no published information on how the L.C. examinations are marked but from the disparity of grades between subjects it would appear that the marks are criterion-referenced and so there is no real way of comparing different subjects in one sitting, or the same subject over different years.

One noteworthy point is that the marks required to get an A1 or A2 grade are very high (Table 9) and achievement at this level is very demanding, given the range of subjects students must offer.

1.6 New trends and reforms underway

a) NCCA proposals for the senior cycle

These have been referred to above to some degree. The NCCA is discussing at present the nature of assessment for senior cycle courses and is working on the final form of the new Leaving Certificate Applied Option (LCAP). The Leaving Certificate Vocational Programme (LCVP) is being expanded from September 1994. These two developments are intended to broaden the relevance of the L.C. course so that it fits the needs of a greater percentage of the L.C. cohort. The whole question of school-based assessment is a live issue at both junior and senior cycles.

b) Expanded transition year

This starts in September 1994 and although all schools are not yet involved it is hoped that eventually all pupils will have this option and it will become the norm for all students. Very little work has been done on developing suitable teaching materials for this course and it is left very much up to individual schools to develop their own policy and course.

c) Increased in-career provision

There has been a large increase in the funds allocated to in-career (in-service) education over the next 5 years. The new In-Career Education unit has been set up in the Department of Education to administer these funds and to coordinate provision of courses. A proper structure for in-career education still has to be developed as the 1984 report on in-service education (Department of Education, 1984) was never implemented.

2. How is science delivered?

2.1 Organisation and authority

All matters to do with education at primary and second levels are controlled centrally by the Department of Education: finance (salaries, recurrent, capital), syllabus, examinations, inspection.

The Department of Education deals directly with the managers of secondary and community schools. Vocational schools are administered via the Vocational Education Committees (VECs). There are proposals to decentralise this administration and provide greater autonomy for schools (see 'Education for a Changing World', Green Paper on Education 1992; J.Coolahan, 'Report on the National Education Convention', 1994)

2.2 Resources and funding

Irish schools are under-resourced compared to other schools in Europe. This was the conclusion of the OECD report on Ireland (1991). The system is described as an aided one in that the government pays most of the costs for salaries, buildings and running expenses, but does not own most of the schools.

"In comparative standards it can be argued, indeed, that the Irish education system is very productive because it achieves so much with substantially fewer publicly-provided resources than in most OECD countries." (OECD Report, p. 45 1991)

The OECD report has a breakdown of Education spending by category for 1985 in comparison to other OECD countries; 80% of the budget goes on salaries. New schools have good, well-equipped, modern laboratories, but this is not true of the majority of the schools which have old, poorly-equipped laboratories. There is no current grant for laboratory equipment, although there is a grant for schools introducing a new science subject. The grant of £1500 per subject was withdrawn ten years ago and was replaced by a block equipment grant given *per capita* for all practical subjects. Many representations have been made to the Department of Education by the Irish Science Teacher's Association about this, and the new system of funding is felt to be inadequate. Additional resources have not been provided when new syllabi are introduced. Schools receive a capitation grant of £158 per pupil (except for fee-paying schools). This is increased to £173 for schools designated disadvantaged. A special one-off additional grant of £50 per pupil has been awarded (June 1994) to schools offering the Transition Year option in September 1994, but the teacher's unions regard this as inadequate. The shortfall of income by schools is made up largely by parental contributions, and by subvention (in some cases) by the school proprietor. Often when clerical or religious teachers were employed, some or all of their salaries were used to run the schools; but their numbers have decreased markedly in the last decade. Table 6 shows expenditure on education in 1992 broken down by level. Spending *per capita* at first, second and third level is in the ratio 1 / 1.42 ; 3.15 (first / second / third level). The latest OECD report (1985) shows Ireland to be virtually bottom of the OECD league in spending at pre-school, primary and second levels. The amounts and OECD averages in US$ are: $1,770 at primary level (average $4,170), $2,770 at second level (average $5,170) and $7,270 at third level (average $10,030).

Non-teaching staff are very rare in Irish schools, beyond the school secretary. Hardly any schools have technical help in the laboratories or workshops, unless they are wealthy, private schools or unless advantage is taken of a youth employment or other scheme to recruit short-term help. Science teachers in particular have a very difficult job in preparing for practical classes and managing laboratories without any technical assistance. Grants are now available to schools to employ extra support staff and a new scheme has just been announced whereby unemployed people may be taken on by schools and trained as technicians in the schools.

Library provision is very patchy among schools, and there is probably more provision in primary schools than in second-level schools, where each classroom usually has its own class library. As the OECD Report says *"...many Irish schools appear spartan and short of space compared with schools in many OECD countries... There are shortages of ordinary teaching and learning aids, special equipment laboratories, libraries, new instructional technology, and recreational areas."* (OECD Report, p. 45 1991).

2.3 Methods of teaching

There is very little research information on how science is actually taught in Irish schools. It would probably be true to say that the majority of science, at junior and senior level, is taught didactically, i.e. by lecture mode. There is very little group work or pupil-led investigation, although this is what was intended in the new junior science course. The study by Smith (1988) on what practical work was done in L.C. chemistry revealed that 26.5% was devoted to practicals (rather than 40% as recommended) and 10.0% on demonstrations; however, 19.3% of students saw no demonstrations and 4.05% did no experiments in the two-year course. Mixed schools did less practicals than single-sex schools, and more practicals were done in urban schools than rural schools. Lack of resources and lack of time were the main obstacles cited by chemistry teachers

Many secondary schools have a selective entrance policy, although the Minister of Education has declared her opposition to this and said that all schools must publish their selection criteria. The result of this has been that secondary schools have tended to cream off the most academic pupils, particularly into single-sex schools, and the vocational schools have a higher population of lower ability children and those with learning difficulties or special needs. An ESRI study in 1987 of 95 schools looked at streaming in schools (Hannan D.F. and Boyle, M. 'The origins and consequences of selection and streaming in Irish schools', ESRI Paper no. 136, 1987). Table 22 shows the extent of streaming in schools covered in the ESRI study.

2.4 Sources of pedagogic innovation

There has been very little innovation in science education in Ireland due to the rigid, centrally-controlled educational system. In most subjects there has just been one syllabus down through the years and changes in that syllabus have been the prerogative of the Department of Education. As many as 20 years or more may elapse between curricula revisions. Any innovations have been in the form of pilot projects, e.g. the ISCIP project in the 1970s, but this remained a pilot project and its integrated, discovery-led approach to science was never allowed to diffuse out into the mainstream of science education. The most substantial project in primary science (the Limerick-based Primary Schools Science project) was a local initiative funded partly by the institutions involved, partly by private money and then by a research grant from the Department of Education's Research Committee that allowed one teacher to be seconded for four years. Other curricula projects in primary education, e.g. health education, development education, have been funded in the same way. There are no private foundations or trusts funding educational innovation in Ireland, unlike the UK or the US., for example. The system is also very conservative and so syllabus changes tend to be revisions rather than radical new approaches (see for example the new revised L.C. science syllabi).

What innovation there is, is thus largely due to individual effort based on reading science education journals, going to conferences, etc. and then diffusion to other teachers via ISTA meetings or publications for science teachers (e.g. the ISTA journal *Science*, and *Chemistry in Action!*)

3. Going beyond school

3.1 Use of out-of school resources

Ireland at present has no science museum or hands-on science centres, although there is one in the North of Ireland and at least one is planned for the Dublin area. Irish newspapers have very poor science coverage and none has a regular science page. Any coverage tends to concentrate on medicine and health, environment, weather or nature. However, Irish teachers have ready access to UK newspapers and magazines, and most urban centres have access to multi-channel TV. There is very little science coverage on the RTE channels and only a limited amount of schools broadcasting.

Industrial visits are quite popular, but this depends on the school and the teacher. The industrial emphasis in the L.C. chemistry course has encouraged plant visits, and the new syllabus recommends at least one structured industrial visit. The Transition Year Option encourages industrial visits and short periods of work experience.

3.2 Consideration of public science-based issues within lessons

These are not part of the science syllabi and for that reason are unlikely to be covered, as most Irish teachers like to use a textbook and stick rigidly to the syllabus. However, some teachers would use topical issues in their lessons and the emphasis on 30% content on social and applied topics in the junior science course and in the new L.C. science syllabi should encourage attention to science-based issues.

3.3 Science education and vocational training

The mainstream courses do not provide vocational training. The LCVP and LCAP (see above) have an emphasis on vocational training and work experience, etc. but there is very little science in these programs.

3.4 Science clubs and cultural associations

Very few schools, as far as the author knows, have science clubs and there is no national club. The Royal Dublin Society runs such a club in the Dublin area and organises summer science workshops, which are open nation-wide.

3.5 Other out of school activities

One of the greatest success stories in Irish science is the Aer Lingus Young Scientist's Exhibition, which has been running since 1966. This is an all-Ireland 'science project fair' and each year hosts around 1,000 projects selected from an even greater number of applicants. The exhibition is sponsored by Aer Lingus, which provides very generous prizes. The winners of this event have gone on to take a disproportionate share of the European Young Scientist's Awards. A survey of entrants from 1966 to 1991 found that 66% of 18,000 participants were female. Overall, young women were under-represented among the prize winners (21 out of 33 were male) but from 1980 to 1990 girls won the top award 7 out of 10 times. Girls favoured biology/environmental projects, boys favoured physics. Girls also showed a preference for group projects, but only 5% of groups were mixed. This reflects the fact that a lot of science teaching in Ireland, North and South, is still done in single-sex schools.

Other companies have also sponsored local science fairs or quizzes around the country. For example, Bayer has sponsored the Science Quiz for the past four years in conjunction with the ISTA; in 1995 the quiz became national. Pfizer Pharmaceuticals has been running a chemistry quiz for schools in the Cork area for the past seven years.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Ireland has done very poorly in the two International Association for the Evaluation of Educational Achievement (IEA) surveys published to date (1988 and 1992), performing near the bottom in science at age 13. This is a reflection of the lack of primary science and the late transfer to second level (usually at age 12), so that very little formal science has been done by age 13.

The quality of science at the upper levels of the school system and in third level is high and at this level Irish students can compete successfully abroad. Science-based industries often cite the well-educated workforce as a reason for locating in Ireland.

4.2 Public or political concerns about educational standards

The IEA did cause some national concern and was one of the reasons why the Primary Education Review Body recommended very strongly that science should be a formal part of the primary curriculum.

4.3 Suggested reforms

These have been mentioned above in various contexts. The whole educational system is undergoing a major overhaul and revision at present. The most important reform will probably be to provide alternative school leaving examinations at the Leaving Certificate level which cater for the wide range of abilities and aspirations in the students staying on at age 17/18. Next in importance should be the development of a proper primary science programme for all primary students. The most important challenge at primary and secondary levels is probably the provision of adequate resources (in materials, personnel and training) to enable science teachers to do the job effectively. The lack of equipment, laboratories, technical assistance and in-service education are major constraints affecting the delivery of science in Irish schools.

5. Pupil interest and motivations

In general, Irish students are interested in science and well-motivated in school, although this would probably not be true in inner-city areas. Education is very important to Irish parents and there is evidence to show that unemployment is linked to lack of educational qualifications. Staying on at school beyond the age of compulsory schooling is now the norm.

5.1 Generally by age and gender

The only evidence here is in the numbers of girls and boys doing different subjects. Up to age 15/16 there is no significant differentiation by gender.

5.2 By type of science or topic by age/gender

Table 18 and Figure 10 show the gender preferences for different science subjects in 1992. In the L.C. cycle the preference of girls for biology is much greater than for chemistry, with physics third in line.

5.3 Options for choice within science

This was covered above, and Tables 15 and 16 indicate the number of schools offering different sciences, and the number of science subjects offered by school type.

5.4 Pupils' perspectives on the value of science

There is very little hard evidence on pupils' attitudes to science in Ireland. However, as we can see from the L.C. statistics and the demand for third-level places, most pupils do not opt for science or for science-based courses at third level. Only one science course is in the top 20 courses at Irish universities and most science degrees have low demand and thus low entry requirements (points). Science does not have a good image and chemistry and the chemical industry have received a lot of bad media coverage and sustained attack from environmental groups over the past 10 years. This is undoubtedly one of the reasons why chemistry numbers have declined in this period. Science is seen as the cause and not a possible solution to environmental problems in Ireland, in common with other countries. Environmental courses at third level are very popular.

6. Training, status and morale of scientific teachers

6.1 Initial training

a) Primary

All primary teachers are trained through one of the five Colleges of Education; all the courses are now to degree level and usually last three years. Education, teaching subjects and methodology are integrated through the courses and the students go out on teaching practice every year. The colleges are linked to one or other of the Irish universities, which award their degrees. The main emphasis of these courses is on Irish, English and mathematics (the compulsory school subjects), with very little formal attention being given to primary science - and then always within the context of Social and Environmental Studies. The intake for primary teaching is highly qualified, owing to the high demand for places; and most of those coming in would have one or more L.C. science subjects.

Numbers entering training colleges is controlled by the Department of Education, which fixes quotas. The numbers have been cut back drastically in the last few years due to over supply; one college was closed in 1988.

b) Secondary

The majority (over 80%) of science teachers have been trained by taking a 3 or 4-year science degree plus a one-year higher diploma in education in one of the university departments of education. This year includes courses in educational theory, science methodology and at least 100 hours teaching experience over the year, usually on the basis of one day per week in a school. The majority of science teachers thus have a primary science degree, usually with at least two science subjects, with a predominance of biology graduates. About 20% of science teachers have been produced by a different route, via courses integrating education, subject specialism and methodology (concurrent model). Until 1980 or so many of these teachers would have been non-graduates, and since then a four-year teacher education programme in General and Rural Science has been available at Thomond College, Limerick (now amalgamated into the University of Limerick). This produces teachers of junior science, L.C. biology and agricultural science. From October 1994 this B.Sc. degree in science education is being revised to produce teachers of junior science, L.C. biological science and either chemistry or physics. A small number of graduates with physical education and chemistry (plus general science) have been produced since 1972. Courses are available for up-grading those science teachers with diplomas to degree level, as the aim is to have an all-graduate teaching profession. Figure 12 shows the output of teachers from the colleges of education (producing primary and secondary teachers), but not those taking the higher diploma in education. The drop in graduates in 1991 was due to cut-backs implemented three or four years before.

Numbers on the higher diploma course have also been cut back this year. In 1993, 1,027 places were allocated and this has been reduced to 800 in 1994 and

700 in 1995. Enrolment in these courses is controlled by the Higher Education Authority (HEA) who determines funding for third-level institutions. Demand for places is still very high because of the recession and the five universities running H.Dip.Ed. courses had 3-5 applicants per place. The reduction is in response to the falling birth rate and the projected decline in second-level enrolment after 1997.

Teachers for secondary schools must satisfy the Teacher Registration Council. New teachers have to complete a satisfactory probationary year.

6.2 Decision-making authority for the above

The numbers of teachers in training at primary and second level is decided centrally by the Department of Education which fixes quotas directly for colleges of education and indirectly, via the HEA, for the universities. The cutbacks in education and falling rolls have meant that numbers in teacher training have been reduced dramatically over the past few years.

6.3 Continuing training

The provision for in-career education, secondment and sabbatical leave are very limited in Ireland. The funds for in-career education are administered by the Department of Education and until this year have been about £250,000 per year. The new In-Career Education unit has been set up in the Department of Education and £6 million has been earmarked for in-career education over the next five years. This covers all primary and second-level teachers in all subjects and, given the number of teachers and the demand, even the increased budget is inadequate.

Extra funds were allocated for training for the junior science courses (along with other new subjects) but teachers were not very satisfied with what was provided. Every teacher in the country was given a number of in-service days at a local centre, in large groups. A lot of money was spent but not very effectively. The ISTA has a grant from the Department of Education which it uses to put on local lectures and courses for its members. The Department of Education also runs courses each year in specific subjects, catering for a very small number of teachers. Phases II and III of the Intervention Project have an ongoing in-service element. A network of science resource centres, based in schools, is being set up under the scheme to make up for deficiencies in science-teaching equipment in schools. The Intervention Project is also in the process of producing a set of teacher's handbooks on various aspects of the physics and chemistry syllabi. Other professional bodies, e.g. the Institute of Chemistry of Ireland, Institute of Biology, etc., have also put on courses for teachers. Most of these non-departmental courses are at the teacher's own expense.

There is very little opportunity for secondment or leave of absence (sabbatical leave). The NCCA has seconded a number of teachers at primary and secondary level to work on new syllabi as Education Officers. This has been very effective in getting new syllabi ready on time. Otherwise if a teacher wants to take study leave it must either be unpaid or he/she must pay their substitute out of their own pocket. Such leave requires sanction by the school management and by the Department of Education.

6.4 Number, teacher/pupil ratio, gender, age profile

The number and sex of teachers at primary and second level is given in Table 3. The majority of teachers at primary level are female, whereas at secondary levels the numbers in terms of gender are almost equal. Pupil-teacher ratios are higher in primary schools (25.8) than in second-level schools (17.1). Ireland has very large classes, particularly at primary level, and classes of 40 are not uncommon. Classes of 30 are the norm at second level. Ireland has the least favourable PTR of any EU country (except Turkey) at primary and second level, although it is due to drop by September 1995 to 22.9 in primary schools. *"The high ratio is held culpable, among other factors, for the problem of dealing effectively with underachievers, the inability of schools and teachers to innovate, increasing stress among teachers, the impossibility of assigning time during school hours for in-service training, and the inflexibility of the curriculum."* (OECD Report, p. 81 1991)

The Irish teaching profession is also an ageing profession due to the lack of recruitment in recent years. The age profile is shown in Table 23, although this does not include teachers in the Vocational School system. At primary and second-level, 20.3% of the teaching force is over 50 and potentially eligible for early retirement. The unions and the Department of Education are currently negotiating the details of an early retirement scheme and there is strong pressure from teachers for such a scheme. At present recruitment into the profession and mobility within it are both very small and early retirement of older teachers would revitalise and loosen up the system, and provide jobs for unemployed teachers.

6.5 Drop-out rates, late entries, maternal leave

No information is available to the author's knowledge on drop-out rates from teaching, or on late entries to the profession. Teachers from outside Ireland must have a qualification in Irish to be registered as full-time permanent teachers. Maternity leave is available to teachers in accord with EU practice.

6.6 Status and salary

Second-level teachers have a common basic pay scale with 26 increments. The basic starting salary (from 1/6/94) is £12,859 rising to a maximum of £24,995. There are increments for graded posts of responsibility and for special functions ranging from £2,765 to £1,049 per year. There is also an increment for the posts of principal and vice-principal, depending on school size. The maximum increment for principal is £10,506 and for vice-principal £6,636. In addition to the basic scale there are also increments for educational qualifications: for a Higher Diploma in Education (pass or honours), and for a primary, master's or doctor's degree, as indicated below. There are also various other special allowances.

6.7 Teacher supports : professional associations, magazines, unions, conferences

a) Professional associations

The Irish Science Teacher's Association (ISTA) is the main body representing science teachers in the Republic in all schools. It has been established for just over 30 years and has a membership of just over 1,000, less than half of the estimated number of science teachers. It is very active in organising meetings and short courses on a local level through local branches, lobbying government, producing teaching materials, organising an annual weekend conference and publishing the journal *Science* for members three times a year. It is also represented on the science syllabus committees. There is also the smaller association for agricultural science teachers.

b) Publications

Science is produced by the ISTA three times a year for members only. *Chemistry in Action!* is produced by Dr. Peter Childs at the University of Limerick for chemistry teachers, and is funded in part by donations from chemical industries and sent out free of charge to individual teachers. In addition, the teachers unions produce journals for their members which contain material of interest to science teachers, e.g. on health and safety.

c) Conferences

The ISTA has an annual weekend conference, open to members and non-members; ChemEd-Ireland is a one-day conference running since 1982 on some topic in chemical education at the University of Limerick; the Irish branches of the Institute of Biology and the Institute of Physics organise one-day conferences, lectures and workshops for teachers; the Institute of Chemistry of Ireland organises an annual two-day Teacher's Refresher Course for chemistry teachers; there is an annual one or two-day conference/study tour on some aspects of the chemical industry organised by the Schools Information Centre on the Irish Chemical Industry (based at the University of Limerick). In addition there are conferences organised by the Irish Association for Curriculum Development (IACD) and the Educational Studies Association of Ireland (ESAI).

d) Unions

Teachers are represented by three powerful and influential unions, which are in the process of merging into one 'super' union. Primary teachers in the whole of Ireland, North and South, are represented by the Irish National Teacher's Organisation (INTO). Second-level teachers are presented by two unions, representing the two main sectors of second-level education: the Association of Secondary Teachers of Ireland (ASTI) represents teachers in the secondary (private) sector; the Teacher's Union of Ireland (TUI) represents second-level teachers in vocational schools and most of the teachers in community schools, and also teachers in some third-level colleges. Each union publishes its own magazine/journal for members, holds an annual conference and is represented on syllabus committees.

7. Equality of opportunity?

7.1 Different status of the schools

a) Primary level

At primary level there is essentially only one school type across the whole country - the national school. However, the vast majority of these are church schools, controlled and owned by the Roman Catholic Church (over 90%) or the Church of Ireland. In recent years a number of multi-denominational schools have been opened by groups of concerned parents. Many primary schools are single sex and there would be a wide variation in school size, with many small schools (see Table 2)

b) Secondary level

At second level there is a quadripartite system of education (see Table 7 for statistics), with a total (91-92) of 790 schools:

1. Fee-paying Secondary schools: privately owned and managed, mostly by the Roman Catholic Church.

2. Free Secondary schools: privately owned and managed, mainly by the Roman Catholic Church (over 90%) or the Church of Ireland or smaller Christian denominations, but most of costs (salaries, running costs, capital costs) are met by the State.

3. Vocational schools: run by local Vocational Education Committees, almost totally state-funded and officially non-denominational, though with strong church representation on Boards of Management.

4. Community/comprehensive schools: these are state schools, often formed by a merger of smaller schools, non-denominational but with considerable church representation on Boards of Management. Completely state-funded.

The total number of schools has fallen in recent years as smaller schools have merged or closed due to demographic changes. This process is expected to continue for some years as the system contracts by around 23% over the next 10 years or so. Many small towns had three small schools: boy's only and girl's only secondary (semi-private, religious) schools and a mixed vocational school. In many areas these are merging to form one new school, usually a Community School, and this trend is expected to continue during the next decade.

7.2 Regional differences

Emigration has been a particular problem in rural areas in the last decade, reducing school sizes and the viability of country schools. There has also been a move towards the cities and city schools have grown at the expense of rural schools.

Staying on rates at school and participation in higher education is dependent on the area and thus the social/economic class a child belongs to. A recent study in Dublin has highlighted the disparity in educational opportunity and achievement in the different areas of the city. A similar study has shown marked differences in third-level participation by county, the highest rates being for the western, largely rural, counties. The data by region is shown in Table 26 showing the percentages of the 1993 cohort doing the L.C. examination, applying for third level and entering third level.

The higher participation rates in the western regions reflects in part the greater provision of local third-level places particularly in the Regional Technical Colleges. The East Coast, including Dublin, is poorly served for non-degree places and, as many Irish students prefer to study near home (for financial and personal reasons), this disadvantages students in Dublin and the surrounding area. Within Dublin itself there are major differences in participation by area depending on the socio-economic situation, e.g. in Dublin 18, 49% of the age cohort went on to third level and in Dublin 17, 10% went to third level. As the *Irish Times* comment expressed it (25/10/94): *"The further you move eastwards from the Atlantic seaboard, the more ignorant people become - or so the educational map of Ireland would indicate. Levels of education are much higher in the western counties than in the east of Ireland - a higher percentage of young people sit the Leaving Cert., more of them apply for third-level places, they have a greater success rate in the CAO/CAS system and more of them end up going to college."*

7.3 Immigration and migrant populations

1) There has been very little immigration into Ireland but substantial emigration, particularly of young, qualified people, has taken place in the 80s as a result of unemployment in Ireland. There are small non-national populations in major cities, particularly Dublin and other major cities. The first Muslim school opened in Dublin in 1994.

2) The largest minority group in Ireland are the travellers. They are a mobile population, with a very low schooling rate and a low life expectancy. Very few of them are settled and there are a few special schools catering specifically for travellers. The new White Paper on Education has a target of getting all traveller children to finish primary education by the end of the century, and eventually the junior cycle at second level

7.4 Special education for handicapped children?

There are a number of special schools in the Republic catering for the needs of handicapped children.

7.5 Remedial education provision

In general provision for remedial children is poor, although some large primary schools would have remedial teachers. There has been an increased provision for remedial teachers in recent budgets.

8. changes in the system

8.1 Recent innovations and the reaction to them

As indicated in the rest of this report the education system, particularly at second level, is in a state of profound change. In general these changes have been well received and there is a lot of goodwill from teachers and parents. A Government White Paper on Education was published in April 1995 and this will provide a legal framework for future developments. The major innovation here was the degree of consultation undertaken by the Department of Education in preparation for this White Paper. The White Paper makes many proposals which will affect education at all levels, and it still remains to be seen which proposals will in fact be implemented and on what time scale.

8.2 Areas of public concern but no solutions

The control of schools and the adequate financing of education, particularly in deprived areas, increased use of school-based assessment, and mechanisms for dealing with poor teachers are four topics of current general concern which have not been effectively solved as yet. Many of these concerns are addressed in the White Paper (April 1995).

Science teachers have their own specific and long-standing grievances: lack of technical help in schools; inadequate resources for all schools for practical work; inadequate in-service provision for teachers, particularly when new courses are introduced.

8.3 Ongoing change and/or controversy - committees working on new curricula, revision of teacher education, etc.

Many topics relating to this have been mentioned above and are ongoing: revision of L.C. syllabi to allow for changes at Junior Certificate level; broadening the scope of the Leaving Certificate examination to make it more suitable for a wider range of students through the LCVP and LCAP, which are in development at present.

Very little is happening in the revision of teaching training. However, the University of Limerick has just relaunched its B.Sc. (Education) to produce teachers of biological science with either chemistry or physics. This is the only concurrent science teacher education programme in the republic.

The courses for training primary teachers will be revised to include a more specific emphasis on primary science, though this has not yet been formalised.

8.4 Apparent changes in the hierarchy of influence - political or sectional

There is ongoing debate at present over the control of education and the restructuring to give more regional and local control of schools. Proposals to change the way things have been done are being strongly resisted by the various interest groups (both the churches and the Vocational Education Committees) and an accommodation has now been reached. A White Paper on Education was published in April 1995, and this has proposed major alterations in: the management of primary schools (though not yet secondary schools), effectively removing them from church control; the state ownership of new school property; the decentralisation of the control of education with the setting up of ten Regional Education Boards and some changes in the system of Vocational Education Committees. Legislation still has to be drafted to bring these changes into being, but they represent a major shake-up of the way education is organised and managed in Ireland at school level.

8.5 Technology Education

The technical subjects in Irish schools are traditionally woodwork (now called materials technology), metalwork, technical drawing (now called technical graphics) in the Junior Certificate, and construction studies, engineering science and technical drawing in the Leaving Certificate. Table 27 shows the statistics for these in the 1994 Leaving Certificate examination: technical drawing was 14th in popularity, construction studies 16th and engineering science 18th. The most striking thing about these subjects is the low percentage of girls taking them (less than 4% in each subject). These subjects have also been traditionally taught in the Vocational Schools, to what were considered less academic pupils. This has changed in the last 20 years and the subjects have diffused into the secondary school system, as well as being offered in the newer Community and Comprehensive schools. A new Junior Certificate subject, technology, was offered for the first time a few years ago to a number of pilot schools. In 1994 the technology examination was taken by 2,328 pupils (28% girls) at higher level and 501 (40% girls) at ordinary level. This subject offers a new approach to technology, involving, for example, electronics and information technology, and an L.C. syllabus is being constructed.

No technology is taught in primary schools.

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Appendix 1

This appendix includes all the tables and figures referred to in the text of the report.

Table 1: Student Numbers at each level

Level	1988/89	1990/91	1992/93 (%)
First level	560,116	543,744	529,811 (54.3%)
Second level	339,327	343,045	362,230 (37.1%)
Third level	60,747	68,270	84,140 (8.6%)
Total	**960,190**	**955,059**	**976,181 (100%)**

Figure 1: Projected numbers in full-time education 1992-2006 Irish Times 16/11/93)

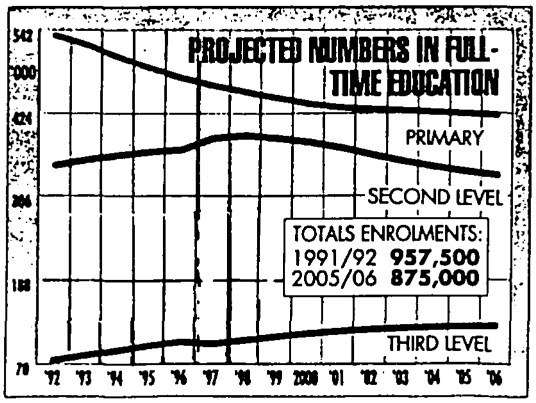

Table 2: School size (90/91)

	<100	100-200	200-300	>300		
First level	1,427	953	363	492		
	<100	**100-200**	**200-300**	**300-500**	**500-800**	**>800**
Second level	32	80	140	246	244	50

Table 3: Number and sex of full-time teachers

	Male (%)	Female (%)	Total
(a) 90-91			
First level	4,830 (23.6%)	15,600 (76.4%)	20,430 (100%)
Second level	9,256 (49.1%)	9,577(50.9%)	18,833 (100%)
Totals	**14,086**	**25,177**	**39,263**
(b) 92-93			
First level	4,828 (23.3%)	15,933 (76.7%)	20,761 (100%)
Second level			21,885 (100%)
Totals			**42,646**

Note:

(a) the breakdown by sex for second-level schools is not known for 1992-93, so these figures are given for 1990-91;

(b) the second-level figures for 92-93 include 2,078 part-time teachers)

Figure 2: Birth rate projections to 2005 (Irish Times 16/11/93)

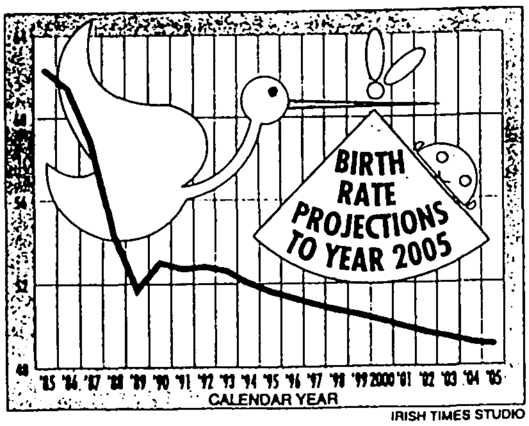

Table 4: Number and % of cohort receiving full-time education (1/1/89) (Dept. of Education Annual Statistical Report 1988/89)

Age	Boys	Girls	Total	% cohort
Pre-primary:				
3 and under	198	454	652	1.1
4	16,983	16,988	33,971	55.7
Primary:				
5	32,683	30,982	63.665	99.7
6	34,383	33,178	67,561	99.7
7	35,808	33,915	69,723	99.7
8	37,009	34,903	71,912	99.7
9	36,412	34,480	70,892	99.7
10	34,735	33,905	68,640	99.7
11	34,664	32,749	67,413	99.7
12	34,523	32,625	67,148	99.7
Secondary:				
13	34,660	32,842	67,502	99.7
14	35,072	33,654	68,726	99.7
15	33,357	32,867	66,224	95.8
Post-compulsory secondary:				
16	29,968	31,123	61,091	87.5
17	22,805	25,981	48,786	73.2
18	13,515	15,653	29,168	44.5
19	8,497	8,608	17,105	26.9
20 and over	18,119	14,629	32,748	12.2*
Total	**493,391**	**479,536**	**972,927**	**72.1+**

* Estimated as % of 20-24 age cohort +

% of the 4-24 age cohort

Table 5: Number and % of age cohort doing State examinations (1989-1994)

Date	Age		Numbe	% of age cohort
1989	Age 12		67,148	99.7%
1992	Age 15	Junior Cert.	60,394	89.7%
1994	Age 17	Leaving Cert.	52,663	78.2%
1994	Age 17	Third-level entry	(26,000	

*estimated

Figure 3: Public expenditure on education in Ireland (1962-92)

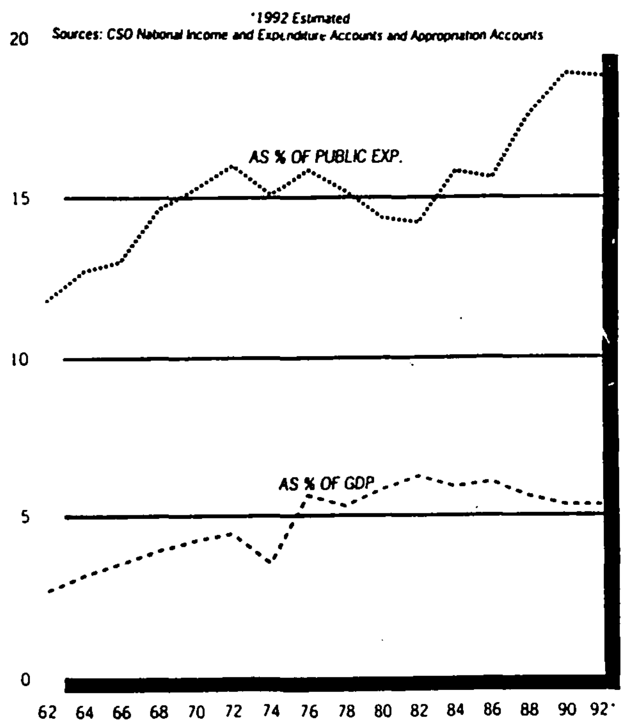

Table 6: Expenditure on education (1992)

Level	No. of students	£/capita
First level £538,200,000 (36.2%)	529,811 (54.3%)	£1,020
Second level £526,355,000 (35.4%)	362,230 (37.1%)	£1,453
Third level £270,491,000 (18.2%)	84,140 (8.6%)	£3,215
Total education budget £1,487,353,000 (100%)	976,181 (100%)	

Note: In 94-95 the education budget has topped $2 billion for the first time.

Table 7: Numbers of second-level schools in Ireland (1992)

(Dept. of Education List of Second-level Schools 1992-93)

School type	Number (%)
Aided by Department of Education:	
Fee-paying secondary	57 (7.3%)
Free secondary	410 (52.1%)
Vocational	248 (31.6%)
Community	16 (2.0%)
Comprehensive	54 (6.9%)
Other	2 (0.1%)
Total	**787 (100%)**
Aided by other departments	17
Private, non-aided	19

Table 8: Age-specific participation rates (1971-1991)

(NESC Report, 1993 based on Dept. of Education Annual Statistical Reports)

	Participation rates		
Age\Year	**1971**	**1981**	**1991**
15 yr. olds	71%	87%	99%
17 yr. olds	40%	53%	71%
18 yr. olds	20%	28%	45%
19 yr. olds	11%	16%	29%

Table 9: The Leaving Certificate grades and points

Grade	Mark	Points(HL)	Points(OL)
A1	90-100	100	60
A2	85-89	90	50
B1	80-84	85	45
B2	75-79	80	40
B3	70-74	75	35
C1	65-69	70	30
C2	60-64	65	25
C3	55-59	60	20
D1	50-54	55	15
D2	45-49	50	10
D3	40-44	45	5

Figure 4: Rate of full-time education at age 15 years (1965-90)

(NESC Report, 1993)

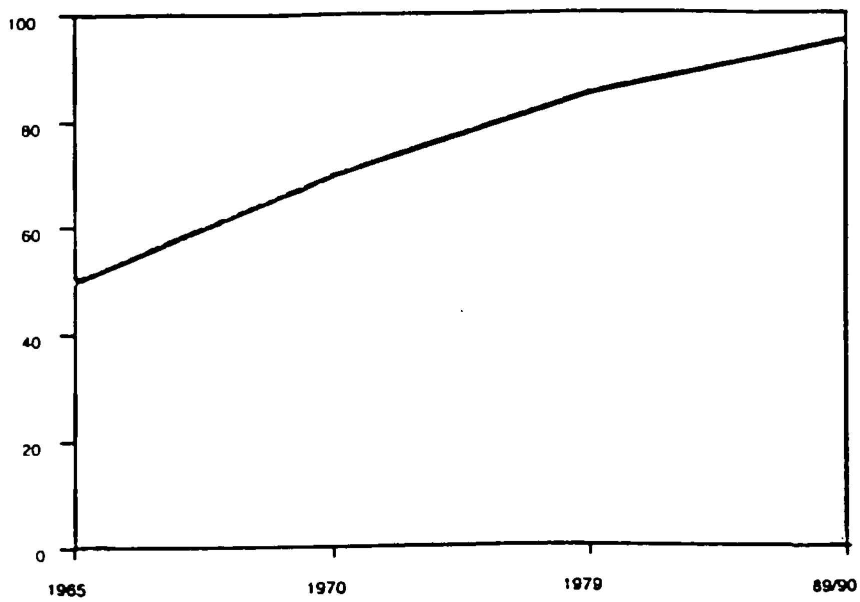

Table 10: Chronology of Irish Education

Date	Event or publication
1930	Vocational Education Act setting up the vocational systems
1961	Irish Science Teacher's Association founded
1966	**Investment in Education**
1967	Free second-level schooling and transport introduced Industrial Training Authority (AnCO) established
1970	Regional Technical Colleges established
1970	Community schools introduced
1971	**Primary School Curriculum**
1972	Minimum school leaving age raised to 15 National Council for Educational Awards established
1980	Publication of **Chemistry in Action!**
1982	Annual ChemEd-Ireland conference starts
1983	New syllabus in L.C. Chemistry introduced **Schooling and Sex Roles** D.Hannan et Al ESRI
1984	**Report of the Committee on In-service Education** Curriculum and Examinations Board established New syllabus in L.C. Chemistry introduced
1985	Transition Year Option introduced Intervention Project in Physics and Chemistry introduced
1986	**In Our Schools** CEB **Transition Year Programmes : Guidelines for Schools**
1987	Primary School Science Project (PSSP), Limerick
1988	**Education Policy in Twentieth Century Ireland** S. O Buachalla
1989	Junior Certificate introduced in schools (Junior Science courses replaces previous science syllabi) **Comprehensive Schooling in Ireland** N.Barber, ESRI Schools Information Centre on the Irish Chemical Industry (SICICI) founded
1990	**Report of the Review Body on Primary Education** Review of the Primary Curriculum
1991	**Review of Irish Education** OECD

1992	**The 1991 Leaving Certificate Examination - A Review of results**, NCCA
	Gender Equality in Education in the Republic of Ireland 1984-1991 J.Gleeson
	Report of the Industrial Policy Review Group (Culliton Report)
	Green Paper, Education for a Changing World
	Learning Science IAEP, ETS1993
	Education and Training Policies for Economic and Social Development, NESC National Education Convention
	The Leaving Certificate Applied Programme: Rationale, Philosophy and Operational Plan NCCA
	Assessment and Certification in the Senior Cycle: Issues and Directions NCCA
	A Programme for Reform - Curriculum and Assessment Policy towards the New Century, NCCA
	Education at a Glance OECD
1994	**Report on the National Education Convention**, J.Coolahan
	Primary Science Starts Here, PSSP
	The 1992 Leaving Certificate Examination - A Review of Results NCCA
	Expanded Transition Year introduced
	Leaving Certificate Vocational Programme - pilot phase
	Unit on In-Career Education established
1995	Introduction of the Leaving Certificate Applied Programme
	OECD Report **Education At A Glance** published
	White Paper on Education published (April)
1996	New L.C. syllabi in Chemistry and Physics to be introduced
1997	New L.C. syllabus in Biology to be introduced

Table 11: The allocation of time in the primary school curriculum

SUBJECT AREA	INFANTS	I, II, III	IV, V, VI
Irish	3½	5	5
English	3	4	4
Mathematics	3	4	3½
Social & Environmental Studies	1	2½	3
Art and Crafts	2½	2½	2½
Music	1	1	1
Physical Education	1	1	1
Religious Instruction	2½	2½	2½
	17½	22½	22½

Figure 5: Projected entry to third level 1992-2006
(Irish Times 17/11/94)

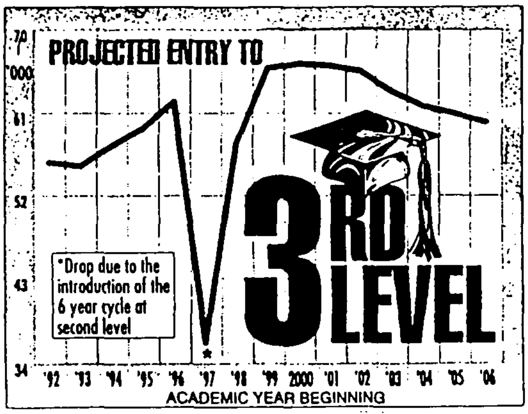

Figure 6
(a) The structure of the Irish education system

Year	**Level**	**Award/Course**		
24		Ph.D. (3 or more years)		
23			M.Sc. (1-2	
22				Graduate diplomas
	T			
21	**H**	Honours degree		NCEA Degree (top-up)
20	**I**		General degree	NCEA Diploma
19	**R**		(NUI)	NCEA Certificate
18	**D**	University entry		College entry
17	**S**	Leaving Certificate		
16	**E**			
	C	(Transition Year Option*)		
15	**O**	Junior Certificate	**Compulsory schooling starts**	
14	**N**			
13	**D**			
12	**P**	End of primary schooling		
11	**R**			
10	**I**			
9	**M**			
8	**A**			
7	**R**			
6	**Y**		**Compulsory schooling starts**	
5		Senior infants		
4		Junior infants		

(b) The structure of the Irish second-level cycle

(The blocks labelled Leaving Certificate may be the current programme or the new Leaving Certiifcate Vocational Programme (LCVP) or Leaving Certificate Applied Programme (LCAP), all three lasting for the equivalent of three years)

PROGRAMME OPTIONS FOR 6-YEAR POST-PRIMARY CYCLE

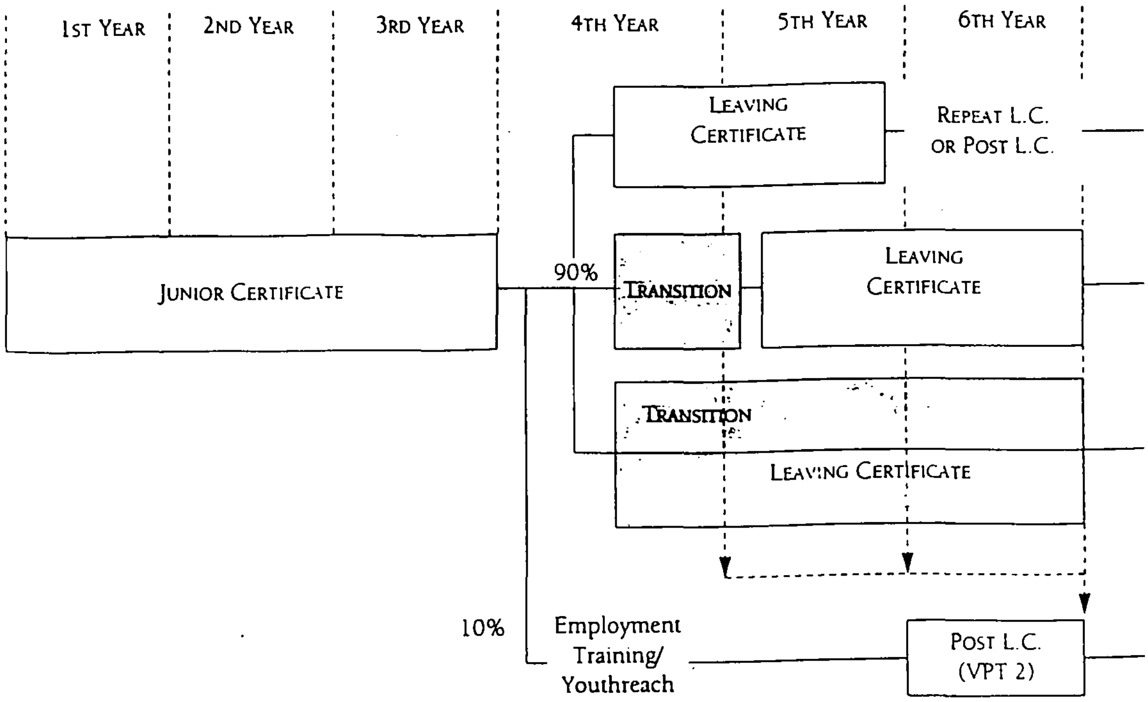

Figure 7: Science in the primary curriculum (Primary School Curriculum:

Teacher's Handbook Vol.1 Dept. Of Education 1971)

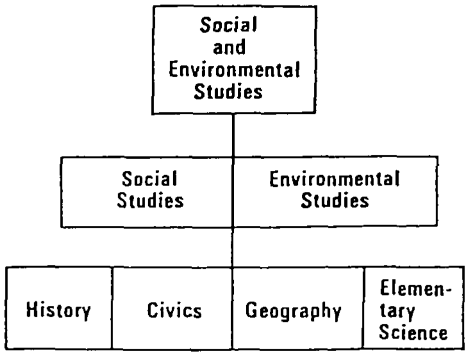

Table 12: The structure of the Junior Science Course

Common Core

Five extensions:

1. Physics

2. Chemistry

3. Biology

4. Applied Science options : Two from :

Materials
Horticulture
Energy conversion
Electronics
Earth science
Food science

5. Local studies (an option for a small number of schools)

Table 13: Number of examination candidates 1989-1994

	1994	1993	1992	1991	1990	1989
Total L.C.	66,033	63,234	59,504	55,146	54,038	51,159
Regular students	53,440	51,983	48,609	49,037		
External students	4,845	4,921	4,295	5,692		
Repeat students	7,748	6,330	6,600	6,605		
Inter. Cert./	70,463	68,426	*60,39	58,246	61,278	59,263
Junior Cert.						

Figure 8: Numbers taking the two state examinations

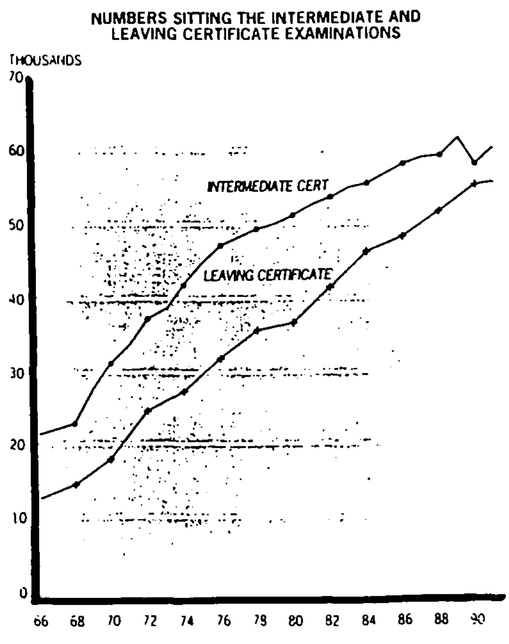

Table 14: Numbers taking L.C. Science subjects, Higher and Ordinary levels (1994)

Subject	O.L.	H.L. (%)	Total
Agricultural science	716	1482 (67.4%)	2198
Biology	11685	17090	28775
Chemistry		6250	7952
Physics	3772	7461	11233
Physics and Chemistry	626	1018 (61.9%)	1644

Table 15: Numbers of schools offering L.C. science subjects (1988-89)

Subject	Sec.	Voc.	Com/p	Total	Change 81-
	(487)	(225)	(65)*	(777)*	
Ag. Science	70	50	15	135 (17.4%)	
Biology	465	201	64	730 (94.0%)	+30 (+4%)
Chemistry	426	61	50	537 (69.1%)	+24 (+5%)
Physics	414	121	55	590 (75.9%)	+144 (+32%)
Physics & Chemistry+	63	48	18	129 (16.6%)	

x Community and Comprehensive schools grouped together

* Schools offering the Leaving Certificate course. In total in 1988-89 there were 812 second-level schools, which had reduced to 786 in 1992 (Table 7).

+ Some schools offer separate Physics and Chemistry and the combined course, but students may not take either of the separate sciences and the combined course.

Table 16: Number of science subjects offered by school type (1994)

Number	Secondary	Vocational	Comm./Com	Total (%)
Five	10	6	0	16
Four	82	29	19	130
Three	298	70	41	409
Two	57	82	7	146
One	12	37	2	51
Total schools	**459**	**224**	**69**	**752 (100%)**

Figure 9: The structure of the Leaving Certificate Vocational Programme

(The Leaving Certificate Vocational Programme: Guidelines for Schools, Department of Education 1993)

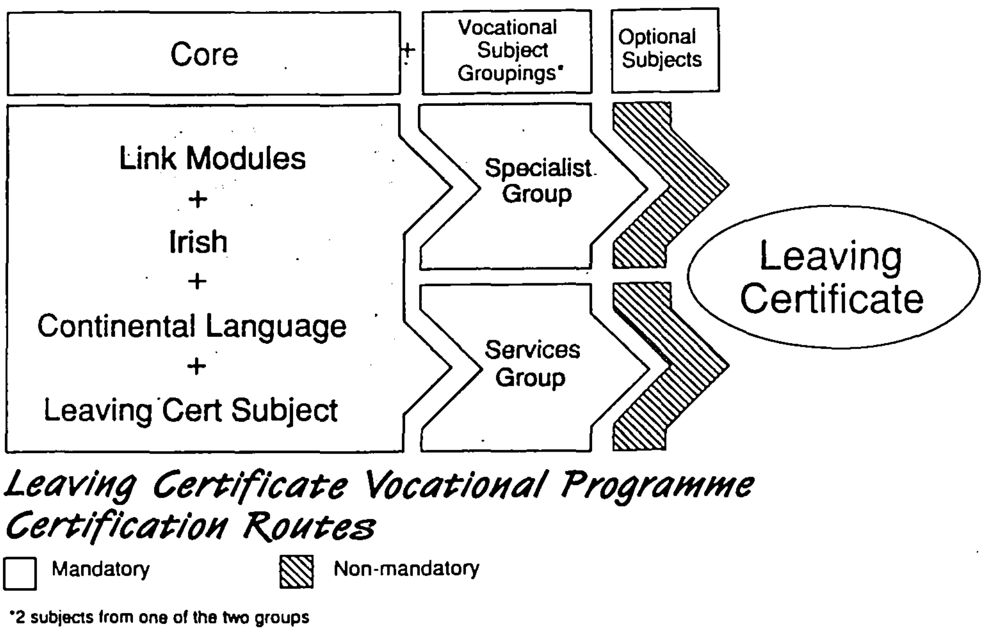

Figure 10: % Girls taking each L.C. Subject (1991)
(Department of Education Statistics/NCCA Report)

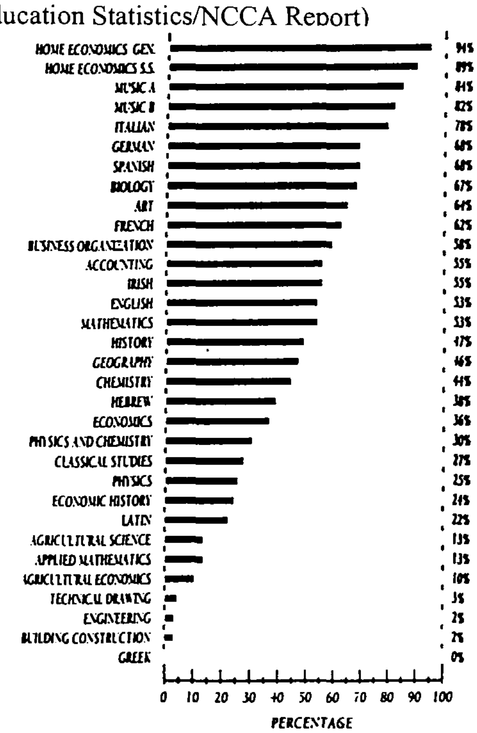

Figure 11: The % of students taking each L.C. subject at higher level (1991)
(Department of Education Statistics/NCCA Report)

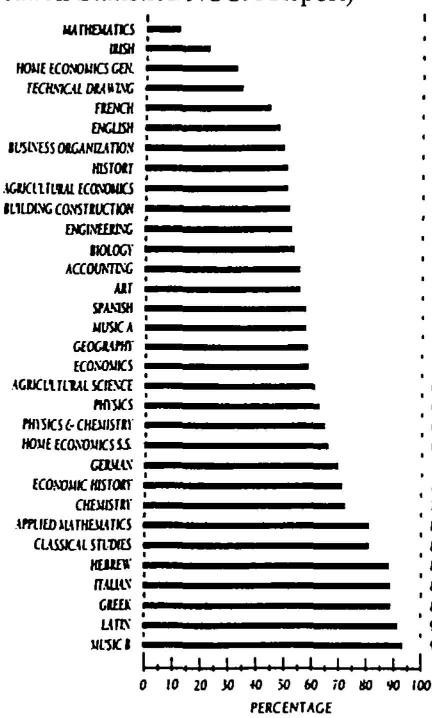

Table 17: Numbers doing L.C. Science subjects (1987-94)

(Department of Education Annual Statistical Reports

Year	Level	Ag.Sci.	Biol.	Chem.	Phys.	Phys.&Chem.
1994	HL	1482	17090	6250	7461	1018
	OL	716	11685	1702	3772	626
19931	HL	1580	15733	5880	7180	1047
	OL	746	10810	1631	3894	543
1992	HL	1430	15741	6349	7794	1166
	OL	770	11536	1777	3838	594
1991	HL	1490	16438	6621	7519	1159
	OL	838	11642	2204	3917	530
1990	HL	1220	16737	7061	7529	1187
	OL	939	11883	2278	3689	667
1989	HL	1266	15680	7105	7274	1220
	OL	889	12225	2458	3720	644
1988	HL	1227	15682	7192	7176	1172
	OL	770	11797	2603	3577	527
1987	HL	1265	15874	7508	7013	1175
	OL	771	11557	2779	3484	534

Table 18: Gender preferences of science subjects in 1994

Subject	HL	% Male	% Female	OL	% Male	% Female	Overall ratio, M/F
Ag. Science	1482	89	11	716	93	7	9.67:1
Biology	17090	30	70	11685	39	61	0.51:1
Chemistry	6250	50.5	49.5	1702	62	38	1.12:1
Physics	7461	70	30	3772	86	14	3.05:1
Physics & Chemistry	1018	61.5	38.5	626	87	13	2.47:1

Table 19

(a) Top ten L.C. subjects taken by brightest students (1992)

(The 1992 Leaving Certificate Examination: A Review of Results NCCA, 1994)

Subject (HL)	**% students in top half of ability range**
Latin	98
Applied maths	96
Mathematics	95
Irish	94
German	93
Chemistry	93
French	91
Physics	91
Music B	89
Accounting	86

(b) Ten L.C. subjects with the lowest scoring students (1992)

Subject (HL)	**% students in top half of ability range**
Home Economics (Gen.)	39
Construction studies	49
Engineering	52
Ag.Science	53
Art	56
Home Economics (S&S)	59
Geography	67
Business Organisation	70
Music A	72
Classical Studies	75

(Mean LC score is 245, based on the points in Table 9)

Table 20: (a) Ten subjects with the highest % of A's and B's at HL (1992)

(Source: as above)

Subject	% A's and B's	Deviation from mean
Applied maths	55	+28
Latin	49	+22
Music B	45	+18
Construction	42	+14
Spanish	38	+10
Chemistry	38	+10
German	37	+9
Economic Hist.	36	+8
Biology	35	+8
Engineering	34	+6

(b) Ten subjects with the lowest % of A's and B's at HL (1992)

Subject	% A's and B's	Deviation from mean
Music A	10	-18
Ag.Science	16	-11
Art	17	-10
Geography	18	-9
English	21	-6
Business Org.	23	-5
Physics & Chem.	25	-3
Economics	25	-3
Home Econ. (Gen)	26	-2
French	27	0

(Mean score is 27% A's and B's)

Table 21: Grades obtained in the L.C Science subjects (1994)

(a) Higher Level

Subject	%A	%B	%C	%D	%E	%F	%NG
Ag.Science 1	1.3	4.3	12.8	11.3	6.6	0.6	0.0
2	2.4	9.5	13.1	8.8			
3		10.1	11.9	7.3			
Total	**3.7**	**23.9**	**37.8**	**27.4**	**6.6**	**0.6**	**0.0**
Biology 1	3.2	6.2	9.4	8.5	7.5	1.6	0.1
2	5.4	8.8	11.3	7.8			
3		11.3	12.0	6.9			
Total	**8.6**	**26.3**	**32.7**	**23.2**	**7.5**	**1.6**	**0.1**
Chemistry 1	3.4	8.5	7.4	7.0	6.9	3.0	0.4
2	6.4	10.7	8.7	8.1			
3		8.9	9.4	11.2			
Total	**9.8**	**28.1**	**25.5**	**26.3**	**6.9**	**3.0**	**0.4**
Physics 1	3.8	5.8	8.1	7.0	3.1	0.4	
2	5.6	7.3	9.0	8.4			
3		9.3	10.9	12.9			
Total	**9.4**	**22.4**	**28.0**	**28.3**	**3.1**	**0.4**	
Physics & Chemistry 1	2.2	8.0	9.2	6.0	7.2	3.0	0.5
2	4.4	12.0	9.5	6.8			
3		13.3	9.8	8.2			
Total	**6.6**	**33.3**	**28.5**	**21.0**	**7.2**	**3.0**	**0.5**

(b) Ordinary Level

Subject	**%A**	**%B**	**%C**	**%D**	**%E**	**%F**	**%NG**
Ag.Science1	0.0	0.6	5.7	14.1	22.1	7.5	0.1
2	0.0	0.6	8.0	13.5			
3		2.1	8.5	17.2			
Total	**0.0**	**3.3**	**22.2**	**44.8**	**22.2**	**7.5**	**0.1**
Biology							
1	1.4	3.5	8.7	9.2	14.3	5.0	0.2
2	2.1	5.4	10.5	9.2			
3		7.9	10.7	11.0			
Total	**3.5**	**16.8**	**29.9**	**29.4**	**14.3**	**5.0**	**0.2**
Chemistry							
1	1.8	4.3	7.2	8.2	9.9	5.5	1.9
2	4.3	7.7	11.4	7.7			
3		10.6	11.4	8.1			
Total	**6.1**	**22.6**	**30.0**	**24.0**	**9.9**	**5.5**	**1.9**
Physics							
1	0.7	2.6	5.2	7.3	12.6	7.3	0.8
2	2.3	5.6	9.1	9.8			
3		8.7	12.2	15.9			
Total	**3.0**	**16.9**	**26.5**	**33.0**	**12.6**	**7.3**	**0.8**
Physics & Chemistry							
1	3.0	2.2	2.4	3.8	15.8	8.3	3.4
2	6.2	5.8	7.3	6.2			
3		11.8	13.3	10.4			
Total	**9.2**	**19.8**	**23.0**	**20.4**	**15.8**	**8.3**	**3.4**
%A	%B	%C	%D	%E	%E	NG	

Table 22: Extent of streaming in Iish schools (ESRI Report no. 136, 1987)

Type of class	First year	Inter-Cert	Leaving Cert.
Only one class per year	9.5	14.0	30.0
Full mixed ability	34.7	23.2	34.4
Two broad bands	6.4	11.7	8.9
Three broad bands	10.6	6.4	3.3
Rigidly streamed	34.7	40.4	22.4
Separate sexes	4.2	4.3	1.1

Figure 12: Graduates from teacher training colleges (Irish Independent 25/8/93)

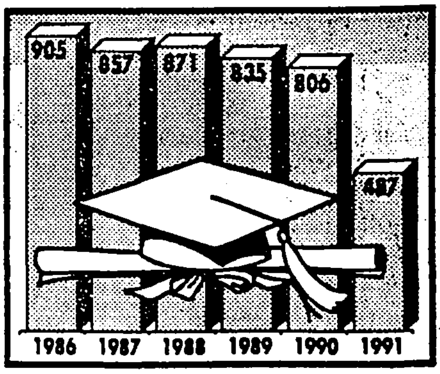

Table 22: Pupil-teacher ratios in Primary schools (OECD Report, p. 81 1991)

Year	Enrolment	No. of teachers	PTR
1961-62	484,618	14,091	34.4
1971-72	511,254	15,450	33.1
1981-82	556,434	19,926	27.9
1985-86	567,615	21,144	26.8
1992	529,811	20,761	25.8
1995			22.9

Table 23: Age profile of Irish teachers

Age	Prim.	Second.+	Com/p.*	Voc.x Total (%)
20-29	3,734	1,689	379	5,802 (15.8%)
30-39	7,248	3,918	974	12,140 (33.0%)
40-49	5,719	4,533	1,099	11,351 (30.9%)
50-59	3,606	2,208	490	6,304 (17.2%)
>60	534	529	95	1,158 (3.1%)
Total	**20,841**	**12,877**	**3,977**	**36,755**

+ Secondary = semi-private, religious schools

* Community and Comprehensive schools

x Vocational schools - no data available

Table 24: Allowances for qualifications (1/6/94)

a) Qualifications:

H.Dip.Ed.(pass)	£244
H.Dip.Ed. (1st. or 2nd. class honours)	£513
Primary degree (pass)	£765
Primary degree (1st. or 2nd. class honours)	£2,042
Master's Degree (pass)	£1,010
Master's degree (1st. or 2nd. class honours)	£2,281
Doctor's degree	£2,549

b) Special allowances:

Teaching through Irish	£657
Gaeltacht grant	£1,273
Island allowance	£765
Comprehensive schools	£1,026

Table 25: Gender distribution in senior posts

	Post-primary*		**Primary**	
Post	**Male**	**Female**	**Male**	**Female**
Principal	551	241	1,895	1,760
Vice-principal	344	219	347	1,667
A post	1,340	1,082	99	226
B post	2,245	2,449	423	1,358

* Secondary and Comm./Comp. schools only. Vocational schools not included.

Table 26: Educational indicators by region (1993 cohort)

Region	**% doing L.C.**	**% applying to 3rd level**	**% entering 3rd. level**
North-West	75	82	38
North-East	79	78	37
West	86	99	50
Mid-West	78	80	44
South-West	82	84	42
Midlands	77	80	40
South-East	79	77	38
East (exc. Dublin)	70	82	39
Dublin	76	77	36
Average	78	82	40

Entry to 3rd. level includes degree and non-degree courses.

Table 27: 1994 Leaving Certificate Results (top 20 subjects) (Department of Education Statistics)

Subj.	Total	%G	HL	%HL	%G	OL	%OL	%G
1. English	58340	51.4	29885	51.2	56.6	28455	48.8	45.8
2. Maths	58048	51.1	8183	14.1	40.3	43564	75.0	53.2
3. Irish	51387	53.7	14081	27.4	64.0	37306	72.6	49.9
4. French	34484	60.5	16656	48.3	63.5	17828	51.7	57.7
5. Biology	28775	66.4	17090	59.4	70.2	11685	40.6	60.9
6. Geog.	23756	45.1	16454	69.3	46.4	7302	30.7	42.1
7.Bus.Org.	22772	54.2	13137	57.7	54.0	9635	42.3	54.2
8.Home Ec. (Soc.&Sci.)	20475	83.7	15127	73.9	86.0	5348	26.1	77.2
9. History	16279	46.8	9734	59.8	49.5	6545	40.2	42.9
10. Acc.	12229	53.5	7597	62.1	49.2	4632	37.8	60.4
11. Physics	11233	24.7	7461	66.4	30.2	3772	33.6	16.0
12. German	10899	60.7	7095	65.1	64.9	3804	34.9	52.9
13. Art	10246	59.9	6541	63.8	63.2	3705	36.2	54.1
14.Tech.Dr.	8414	3.7	3553	42.2	4.4	4861	57.8	3.4
15. Chem.	7952	47.1	6250	78.5	49.5	1702	21.5	38.3
16. Cons.St.	6760	3.1	4420	65.4	2.5	2340	34.6	4.2
17. Econs.	5585	34.4	4177	74.8	33.7	1809	25.2	28.4
18. Engin.	5271	3.3	3233	61.3	2.5	2038	38.7	4.7
19. Ag.Sci.	2198	9.4	1482	67.4	10.6	716	32.6	6.8
20.P.&Chm	1644	28.8	1018	61.9	38.5	626	38.1	13.1

* Maths is also offered at a third level, Foundation level. In 1994 this was taken by 6351 pupils, 10.9% of the total maths cohort, and 50.5 of these were girls. The total maths figure includes Foundation level as does the overall % of girls doing maths.

Report from the Netherlands

H. Eijkelhof and P.Voogt

Introduction

The basic structure of the Dutch educational system is as follows. Children of ages 4 to 11 receive primary education. At the age of 12, children enter secondary education. Since 1993, pupils then follow a similar curriculum for two to four years (basic secondary education), but in most schools they are divided up into four streams: one pre-vocational (VBO) and three general streams, called MAVO (junior secondary), HAVO (senior general secondary) and VWO (pre-university). In upper secondary school, students either work towards final examinations in VBO and MAVO (one year), HAVO (two years) or VWO (three years), enter senior secondary vocational schools (MBO, two to four years) or participate in an apprenticeship system (one to four years). An outline of this system is presented in figure 1.

Diagram of the Dutch education system

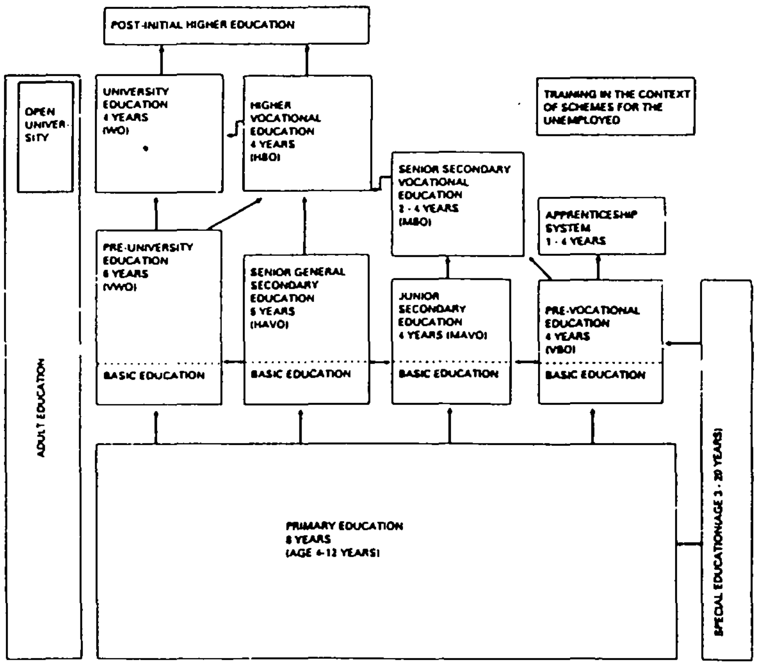

Figure 1: Dutch Education System

In order to avoid too many details in this paper, attention will be given mainly to primary education, basic secondary education and one part of upper secondary education (VWO).

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

Primary schools are free to decide how to organise the timetable and how much time to spend on science. However, these schools are required to submit the timetable to inspectors who compare these and give comments if too little time is devoted to a subject.

In most secondary schools lessons take 50 minutes, although there is a trend towards 45 minute lessons. Some double lessons are timetabled to allow for more extensive practical work, especially in upper secondary science teaching; this is a choice made by the schools.

Mathematics	400
Physics/chemistry	200
Biology	120
Technology	180
Home economics/health	100
Information technology	20

Schools are free to increase or decrease these numbers. The recommended timetable includes 840 hours which are intended to be used to teach religious education, a third foreign language or more lessons for the 15 official subjects.

In senior secondary schools a minimum timetable is prescribed. Schools tend to add a few lessons to this minimum. The following number of lessons per week are common in the VWO-stream in senior secondary education:

	Year 4	**Year 5**	**Year 6**
Physics	3	4	4
Chemistry	3	3	3
Biology	2	3	3

1.2 Which sciences are to be taught

In primary education, integrated science (with an emphasis on biology and physics) is one of the 15 subjects to be taught. Some technological aspects are included. Like other subjects, science is taught by the class teacher.

In basic secondary education the curriculum contains the subjects physics/chemistry, biology, home economics (including health), information technology and technology. These subjects are taught by specialists, usually trained at college level.

In all senior secondary streams, physics, chemistry and biology are taught as optional courses. Technology is at present not a separate subject in senior general secondary streams. Subjects are taught by university-trained specialists.

1.3 Realistic data on the above

Recent evaluation studies have shown that primary schools in general do little on physics and focus mainly on biology content. For example, topics on the curriculum such as electricity and light & sound are dealt with in less than half of the schools; forces & movement in only 25% of the schools. The main reasons for this one-sided approach to science teaching in primary schools are: (i) teachers are not well trained to teach physics topics and therefore feel insecure, (ii) most primary textbooks have underdeveloped sections on physics, and (iii) hardly any external support is available for physics teaching, in contrast with support given by various external agencies (local school biological centres and environmental support services) for biology and environmental education.

Secondary schools tend to stick to the recommended number of lessons, but it strongly depends on the school administration (science minded or not) and the negotiating abilities of the science teachers. Large divergencies exist, especially in basic secondary education. It is expected that the number of science lessons of this type will decrease during the current introduction of the new National Curriculum, owing to the fact that 15 subjects have to be accommodated.

In basic secondary education, schools are allowed to offer the three sciences integrated but only a minority (13%, mainly pre-vocational schools (VBO)) do this in practice. In fact even the recently introduced subject physical science is often taught as two separate subjects - physics and chemistry. For example, of the general education schools (MAVO/HAVO/VWO) currently about 30% offer both subjects separately, about 50% as one subject in form 2, but separated in form 3, and only 20% fully as one subject. This is in line with the national tradition of teaching the sciences separately.

1.4 Recommended learning activities

In primary schools, observation, making drawings, discovery activities and investigations are recommended; but in practice the latter two are not very common.

In the basic secondary science curricula, practical work is strongly recommended; also recommended are: studying science in daily life contexts, making use of the computer, developing general skills (such as communication and decision making) and relating science to a variety of vocations.

In senior biology, physics and chemistry curricula, practical skills are required and examined in a school-based practical examination.

Field studies are not recommended as such in senior physics and chemistry curricula. In biology courses, field studies are more common. The need for such studies decreased owing to the fact that the taxonomy of plants and animals is no longer part of the curriculum, but increased because of the new topic of ecology. Field studies as a whole are under pressure as ecological studies in the field are more difficult than taxonomic activities (and not all teachers are familiar with the former) and because of the perception of many teachers that the biology curriculum is overloaded.

Attention to the history of science was recommended by the physics curriculum committee, but it is not part of any of the science syllabi.

The topic 'Science in Industry' is included in the senior chemistry syllabus, but is not mentioned in the physics syllabus. In the biology syllabus, agriculture and biotechnology are mentioned as two of the four context areas: this is an excellent opportunity to deal with industrial matters. The aspect 'controversy in scientific history' is not emphasised in any of the science syllabi.

1.5 Mandatory tests and examinations

In primary education, national progress and admissions tests are devised for mathematics and language by the Dutch Institute for Testing and Evaluation

(CITO). Schools are free to use those; many do, but some schools use their own tests. Secondary schools use the results of any of these tests, in combination with the advice of the primary school teacher and the wishes of the parents, to decide about the admission of the pupil. Science questions have been included in the national tests since 1996.

At the end of basic secondary education, national tests are obligatory, but the form in which they are given is left to the schools.

National written final examinations are obligatory for upper general secondary science courses. VWO-students have to sit exams in at least seven subjects. The only obligatory subjects are Dutch and one foreign language (students nearly always opt for English). Passing the exam leads to a general entrance qualification to all Dutch universities. Universities can only demand that one or two subjects have been part of the examination for entrance to specific studies, but a pass in these subjects is not required. The most demanded subjects are mathematics and physics, so by choosing both, a student keeps nearly all options open for university studies.

The exam papers at VWO-level consist mainly of open questions. Students' papers are marked by their teacher and monitored by a teacher from another school. Only the biology papers still have multiple-choice questions (50%). Multiple-choice questions are more common at VBO, MAVO and HAVO-levels. In the exam papers of all sciences there is a trend towards questions in experimental or daily life contexts.

In all subjects the results of the national written examinations count for 50% of the final mark; the other half of the mark is taken from school-based examinations. In all sciences practical work has to be part of the school-based examinations.

1.6 New trends and reforms underway

In the area of primary science, it is generally felt that teachers are not sufficiently trained for teaching science. Another topic of public debate is the many demands from outside on teachers in the primary school (see section 8). All kinds of specific interest groups produce materials for primary education in those fields.

Assessment by CITO has shown that the level of performance in primary science is too low, especially in physics. The Inspectorate fears that this is particularly harmful for girls. It also fears that political pressure to pay more attention to environmental education may result in an even more one-sided teaching of science in primary school.

A new government steering committee was established recently to promote technology teaching in primary schools.

In 1993, new primary and basic secondary curricula were introduced as part of a move towards national curricula for the compulsory school age.

In basic secondary education this led to 15 subjects to be taught in 32 lessons per week.

In the two science curricula (biology and physics/chemistry) emphasis is given to skills, applications (contexts), practical work, role of the computer (physics/chemistry), health education (biology), environmental aspects, science in jobs and the connections with other subjects (see appendices 6 and 7). This shift of emphasis is supported by many teachers and is reflected in nearly all new textbooks. At present it is a bit unclear how to prepare students well for senior secondary schools. The demands set by the National Curriculum are seen as too low for the more able students and some additions seem to be required to successfully enter senior science courses and senior secondary vocational schools. Most books solve this by offering more depth than required by the curriculum, with the assumption that there will be available at least 40 hours more than the recommended number. Another critique is of a more pragmatic nature: some schools (especially MAVO and VBO schools, see section 2.2) lack laboratory assistants and therefore have difficulties complying with the recommendations for practical work. The general feeling in schools seems to be that students have to work harder because of the number of subjects.

A problem raised in discussions on science teaching in upper secondary schools is that syllabi tend to become too full because of an increasing number of demands on the science curricula; practical work, applications, environmental aspects, technology, computers, modern developments of science, skills, etc. Another argument, put forward particularly by people from outside science education, is that science syllabi have become too difficult and too much oriented towards studying science at university level. As a result, too many students have no science in their diploma subjects, which means that educated citizens lack an acceptable level of scientific literacy.

2. How is science delivered?

2.1 Organisation and authority

The central government is responsible for monitoring the quality of education in all schools. Under the constitution, groups of citizens are free to start new primary and secondary schools if they bring together a minimum number of pupils and can guarantee sufficient quality of teaching. Schools are also free to decide how attainment targets are reached and are autonomous in all educational matters (within the boundaries of the laws).

Schools are governed by municipal authorities (public schools) or school boards (private schools). In the 1993/1994 school year, the 1,325 secondary schools could be classified as public (16.5%), Protestant (26.4%), Roman Catholic (35.8%) or non-Christian private (20.6%). In many of the Christian schools religion plays a minor role and parents' choice is more based on the general image of the school and its distance from home than on its religious identity.

Nearly all secondary schools have separate departments for physics, chemistry, biology and technology. A nominated teacher acts as coordinator of the department, but in general this person has no special status and receives no additional salary.

Textbooks are not approved by the government. It is up to the schools to decide which books to use.

2.2 Resources and funding

The central government finances all public and almost all private schools. Until recently financial matters were strongly regulated by the Ministry of Education and Science. During the last three years financial power has shifted towards the school authorities.

For the age range 4-16, education is free. Parents only pay the school a small, often voluntary, annual parental contribution which is low for public schools and slightly higher in private schools. For pupils over 16, parents have to pay a school fee of approximately HFL 1,400 to the government.

Each school has a budget for laboratory furnishings, apparatus and libraries. Budgets vary between schools. Chemistry departments tend to have the largest budgets, followed by physics and biology. In case of national innovations, additional money is provided: recently, for example, to equip technology classrooms or to buy computers and software.

In primary schools, books are owned by the school. In secondary schools, parents buy textbooks or rent those books from the school. Worksheets are provided by the schools, but sometimes additional money has to be paid for those by the parents.

By tradition only HAVO and VWO schools have laboratory assistants, on average one for 500 pupils. Presently, a large majority of science teachers are satisfied with the work of their laboratory assistants. However, there is a trend to extend the tasks of these laboratory assistants to more general school tasks, such as managing computers, audiovisual aids and textbooks, invigilation of written tests, and maintenance of the buildings. This is a result of the larger autonomy of schools to decide about the allocation of personnel responsibilities.

2.3 Methods of teaching

In 1989 a survey study (Kuiper, 1993) was carried out among 699 physics, chemistry and biology teachers in lower secondary schools. Kuiper concludes:

- textbooks play a predominant role;
- a context-based approach to subject-matter is rather uncommon;
- experimental work is practised in chemistry education mostly and much less in biology and physics;
- whole-class instruction (with and without questions to students) is the dominant mode of instruction.

Homework is very common in secondary schools, but it comes under pressure nowadays as many students in that age group are strongly involved in other activities, such as jobs, sports and entertainment. Many schools find it difficult to deal with this problem, partly because the concept of cooperative learning has not been implemented on a large scale. A growing number of lower secondary schools try to limit students' work to class time or organise preparation periods in the afternoon at school.

The use of computers has been emphasised during the last decade. All schools have computer rooms. In a number of curricula, notably mathematics and physics, working with computers is obligatory as it has been decided at the national level to integrate information technology as much as possible into the various subject curricula rather than have a special subject on this matter. In practice there is a wide variety in the manner, and the intensity, of computer use in the classroom.

In senior physics education, student-led investigations are now part of the curriculum; in biology too there is a strong trend towards open investigations.

Another strong trend in biology education is teaching students how to deal with textual and non-textual information. Factual recall becomes less important. Various types of biological data have to be used in problem solving (e.g. in examination questions).

Some years ago a new Working Conditions Law was introduced. Half of the science teachers are still not familiar with the consequences of this law for their science laboratories. Only one third are sure that their laboratories meet safety requirements. Physics and biology teachers are the most unsure in this matter.

Career guidance of students by science teachers is very rare, although it is promoted in the new National Curriculum for basic secondary education.

2.4 Sources of pedagogic innovation

Pedagogic innovation in science teaching is stimulated by several sources:

1) curriculum development projects, often based at universities or at the National Institute for Curriculum Development (SLO). During the last two decades some large projects have been financed by the government, especially in primary science (NOB, SLO), physics (PLON, University of Utrecht), chemistry (CMLS, SLO), biology (SPIN, Free University of Amsterdam; PBB, SLO), environmental science (NME-VO, University of Utrecht and SLO) and computer science (University of Amsterdam);

2) in-service training by college and university teacher training centres (see also section 6.3);

3) national implementation programmes, often carried out by pedagogical centres (APS, KPC and CPS). Such programmes are presently in operation for the implementation of the new national curricula for basic secondary education, e.g. for physics/chemistry in cooperation between APS, SLO, CITO and teacher training colleges;

4) school biology and environmental education support-centres. More than 60 of these exist, spread across the country. Their activities are mainly directed towards primary and lower secondary schools;

5) teachers organisations take initiatives for projects, publish materials and organise local and national meetings; the largest one is the Dutch Association for Science Education (NVON) with over 4000 members. Smaller ones focus on specific innovations, such as for physics the PLON-Association and the DBK-Association;

6) science education research. The largest research group is based at the University of Utrecht focusing on the key areas of curriculum structure and conceptual change in physics, chemistry and biology. Smaller research groups operate at some other universities (University of Amsterdam, Free University of Amsterdam, University of Groningen, Technical University of Eindhoven);

7) annual 24 hour conferences on physics, chemistry and biology education. The physics conference has a tradition of almost 30 years and attracts annually more than 400 participants. In general the annual conferences are becoming increasingly popular events in which to present and discuss ideas and experiences related to teaching methods and curriculum innovations;

8) the publishers by providing new textbooks (although the market for very innovative curriculum materials is limited).

3. Going beyond school

3.1 Use of out-of school resources

As part of science teaching, classes occasionally visit science museums, for instance NINT (Amsterdam), Museon (The Hague), Boerhaave (Leiden) and the Technology Museum (Delft). In 1996, a new National Centre for Science and Technology (IMPULS) was opened in Amsterdam with government and industry support. Special facilities for school classes were provided for.

Two 'technology discovery centres' have been set up (in Rotterdam and 's-Hertogenbosch) for children between 4 and 14 years old. These centres attract school classes and families, and organise special programmes for birthday parties and primary school teachers.

Some science programmes are broadcast by the NOT (School TV). In addition, each working day, a 15 minute programme (Klokhuis) is televised in which a scientific or technical topic is explained in an original way. For adults, a limited number of education programmes are devoted to science (TELEAC). In general, science programmes on TV are few in number and only some schools tape these programmes for use in lessons. Radio programmes on science do not exist.

Another use of out-of-school resources is generated by three magazines which publish exercises related to Dutch newspaper articles for use in physics (Exaktueel), chemistry (Chemie Aktueel) or biology lessons (Bio-aktueel) in upper secondary schools.

Several field centres offer day and week programmes for biology and geography classes. Field trips to nature reserves are common only in biology lessons (for one or more days), but this type of activity has recently come under some pressure due to changes in the senior secondary curriculum (see section 1.4). In primary education, the majority of teachers do not go on field trips as part of science lessons, but field trips are slowly becoming more popular as a result of the emphasis on environmental education.

In the Netherlands, the second week of October is traditionally 'Science Week'. This week has a specific theme each year, for instance 'Surviving' or 'Colour'. On the first Sunday of this week many laboratories open their doors to the public for visits, lectures and hands-on activities (especially for the young). During the week several universities organise events for students of primary and secondary schools; public lectures are given by scientists and special books are published related to the theme of that week. The activities of the Science Week are announced in the newspapers and a special newspaper with the programme is widely available.

3.2 Consideration of public science-based issues within lessons

The use of public science-based issues has become more common in science teaching since 1975. Popular topics are the energy problem (nuclear, renewable energy), environmental issues (greenhouse effect, ozone depletion, pollution), health and biotechnology.

In biology education, topics such as evolution, abortion and euthanasia are controversial. They are part of the senior biology curriculum but are not included in national examination papers; they are represented solely in school-level examinations to allow each school to teach these topics according to their educational philosophy.

Main attention to public science-based issues is given during the subject lessons, but these issues are sometimes dealt with in school projects, in which science teachers cooperate with colleagues from other subjects.

3.3 Science education and vocational training

Vocational training is a very large and diversified field and will not be dealt with extensively in this paper. Appendix 1 shows that the total number of students in pre-vocational streams is decreasing sharply. The main streams are technical (38%), home economic (22%), economic (11%) and agricultural (8%). Science is only part of the examinations in the technical and agricultural streams.

The number of students in senior secondary vocational education has increased in the eighties and is now stable. Most students (87%) are taking four-year courses.

The four main streams are:

1) economic (35%)

2) technical (32%)

3) personal and social services and health care (24%)

4) agricultural (5%).

Science is taught mainly in the technical courses, and to a lesser extent in the agricultural and health-care courses.

3.4 Science clubs and cultural associations

National Olympiads are organised annually for biology, chemistry, physics, mathematics and information technology. The first round is held at schools, with the second and final round usually at a university. The national winners participate in the International Olympiad Contests.

Only a few schools have science clubs and school-based science fairs are not common. Out of school, several clubs are active in the field of science and technology, among these:

- The Young Researchers Club (DJO) runs youth laboratories at eleven locations. The main event is a National Contest for boys and girls between the ages of 12 and 20;
- Technika 10 runs nearly 100 clubs all over the country on technology, for girls 10-14 years of age;
- Nature Friends Associations.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

In 1984 the country participated in the Second International Science Study (SISS) at the population 2 level (grade 9). The 5,025 students from 224 schools had an average age of 15.5 years.

Compared to the 22 other participating countries, achievement was among the highest with the exception of biology which was only average; the percentage of mean science achievement was 63.7 (only Hungary and Japan had higher results). However, the differences between the Dutch schools were quite substantial owing to the streamed educational system.

The study resulted in some other findings about science teaching in this country:

- on average the students had 6 hours of science homework per week;
- the average percentage of time spent on doing experiments is low (31%);
- only 4 countries spend less time on practical work;
- the percentage of male science teachers is high (87%);
- students score low on the attitude scale 'beneficial aspects of science': 2.18 (one of the lowest);
- students show low interest in science taught in the classroom: 1.94 (one of the lowest);
- the characteristic 'teaching style' showed less teacher-directed learning than in most other countries.

The results of IEA studies play a role if the scores are extreme. High results in SISS are seen by the Ministry of Education and Science as a justification of its own policy. They are used as an argument when people propose, for instance, US-based models for science teaching. In case the results are very low (such as reading in primary school), efforts are made to find the causes and improve the situation. Background information from IEA studies is seen as too concise and too unreliable to be used for policy purposes.

In general, the role of educational policy evaluation is increasing and politicians are becoming more sensitive to comparisons with other countries. IEA results are seen by the Ministry as an expensive but important tool.

4.2 Public or political concerns about educational standards

A recent evaluation report of the Inspectorate expresses concerns about the standards of primary education. It is suggested that too many subjects are dealt with in primary school and that more time should be spent on the main subjects, such as reading, writing and arithmetic. It is argued that several of the present subjects (such as art) could be left to out-of-school activities. Critics of this report argue that it is useless to spend more time on the three R's as long as more effective teaching strategies are not used, and that in almost all subjects language plays an important role in an integrated way: one should therefore not just count the official language lessons. Others claim that in compulsory education not just the cognitive aspects are essential and that a broad education is important for everyone. In this debate the freedom of the school also plays a prominent role: should the ministry decide on the full curriculum or only on a core of say 50%?

At the secondary level, concerns are expressed about the decreasing level of language competencies in French and German. It is argued that the Dutch should continue the tradition of mastering three foreign languages in view of a changing Europe.

In 1992 the government made some critical comments on science education in upper secondary school: these subjects lack sufficient attention for the social, cultural and historical context of science; are much too 'calculus' and selection oriented; pay insufficient attention to fundamental insights and are too masculine in character. It is proposed that the new reforms for upper secondary school (see section 4.3) should take this into account.

In higher education, there are complaints about the educational level of those entering higher education, especially in higher vocational education. It is claimed that many students lack proper study skills and attitudes, caused by the culture of senior secondary schools in which independent learning behaviour is not encouraged.

In the universities, there are also concerns about the lack of general literacy of those entering higher education: they are too specialised, for instance, with either too many mathematics and science subjects, or no science at all.

4.3 Suggested reforms

In the debate on the quality of primary education, several reforms are suggested, such as:

1) focusing on those subjects which cannot be properly learnt out of school;

2) giving schools more freedom to develop their own profile;

3) rewriting the attainment targets to make them more suitable for this age group and more comprehensible for teachers;

4) improving the basic training in all subjects in the teacher training colleges;

5) training specific teachers to become specialists in a particular subject, so that they are able to coach colleagues in arithmetic, reading, science, music or dance, for instance;

6) widening the expertise of the school biology and environmental centres in the field of physics and technology.

The changes in basic secondary education are too recent for discussions about reforms. Some teachers feel that 15 subjects are too much for the pupils. Evaluation of implementation activities in a few years time will probably result in reform proposals.

Owing to the problems students have in adapting to study at senior secondary vocational schools, vocational colleges and universities, a drastic reform has been successfully proposed for upper general secondary education. The main element of the reform is that in senior general secondary education (MAVO, HAVO and VWO) students should have less freedom in choosing subjects at examination level. For instance, in the new system for pre-university education (VWO), 50% of the time should be spent on the following obligatory subjects: Dutch, English, French, German, mathematics, general science, social science and economics, physical education, and art education. An additional 30% of study time should be reserved for one out of four streams with obligatory subjects (science and technology, science and health, economics and society, culture and society). The rest of the time is reserved for optional subjects. This new system will be in operation from 1998 onwards.

Another drastic change in the reform proposals is that study programmes are no longer expressed as the number of lessons taught, but in terms of study time for students. This makes it possible to use a larger variety of teaching methods and means a shift towards student responsibility for study progress.

The general feeling is that the new subject 'general science' (200 hours of study for VWO, 160 hours for HAVO) should be aimed at achieving scientific literacy and not at preparing for science studies in higher education. It should give a great deal of attention to the way scientists work, to technology and to the social implications of science.

In view of this review, the subject of technology is under discussion. Some argue that technology is very different from science and should be a key independent subject in upper secondary education. However, the dominant feeling is that aspects of technology should be integrated in all sciences and in mathematics.

5. Pupil interest and motivations

5.2 By type of science or topic by age/gender

No recent information on the general science interests of boys and girls is available. One way of looking at interest is the popularity of the optional science subjects in secondary schools, although it should be noted that not only interest but also career considerations play an important role (see section 5.4).

The following figures indicate how many students (girls and boys) participated in the 1993 science examinations at VWO-level:

physics	42% (girls 27%, boys 57%)
chemistry	36% (girls 27%, boys 45%)
biology	34% (girls 37%, boys 31%)

The total student figures for the HAVO- and MAVO-streams are for physics 26% and 34%, for chemistry 27% and 39%, and for biology 33% and 46%.

During the last few years, the physics and biology figures have been rather stable, but chemistry has tended to become less popular. This may have to do with the general poor image of chemistry in this country, as the subject is often associated with pollution problems. Several institutions (professional societies and the chemical industry) are trying to change this image but the success of these efforts is not yet clear.

Recent research about the interest in physics among pupils in lower secondary schools has shown that girls' initial interest in form 2 tends to decrease during year 3. No single factor explains this phenomenon; probably a complex set of factors is at work here.

At university level, the number of students in biology is increasing, in physics it is stable, and in mathematics, chemistry and many of the technological disciplines it is decreasing.

5.3 Options for choice within science

In primary education, teachers have a great deal of freedom to offer choices to the pupils, but for reasons mentioned above this freedom is not frequently used at present. However, new books are being published which tend to include more discovery-type activities.

The textbooks for science in basic secondary education offer opportunities for topics and exercises at a higher level than is required in the National Curriculum in order to facilitate the transition to science in senior secondary education. Some textbooks offer options for small project work which allow students to choose topics of their own interest.

In senior physics and biology syllabi, students are allowed to work on an open investigation as part of the school-based part of the final examination. In this type of investigation, students develop their own research questions, devise and perform experiments and write up a report. Open investigative work has only recently been introduced officially, but in some schools it has been a regular part of the curriculum for several years. It is rather popular with students, but some teachers object because of the large amount of supervision needed. Teachers tend to become less resistant when they gain more experience in supervising those activities.

5.4 Pupils' perspectives on the value of science

One of the reasons that mathematics and physics are often chosen in upper secondary school is that the student is thereby guaranteed the maximum range of choice in higher education courses. At present a maximum number of two subjects may be required as an entrance condition for some university studies; mathematics and physics are in this respect the most important. This probably explains in part why physics is a more popular examination subject than the other sciences.

Of the sciences, biology is the least required. Therefore the number of students taking biology probably better reflects true interest than the number of students opting for physics.

6. Training, status and morale of scientific teachers

6.1 Initial training

Primary teachers are educated in primary teacher training colleges and are usually not specialised in particular fields. Each college has its own broad curriculum in which not much time is reserved for science training. Recently a primary science teacher training book was published, which may draw a more appropriate level of attention to this subject.

Science teachers for basic secondary education and for some senior secondary schools (VBO, MAVO and MBO) are trained in secondary teacher training colleges. They have to specialise in one subject and are officially allowed to teach only that specific subject. This is strange in view of the fact that physics and chemistry are now combined in the new national curriculum for basic secondary education. There is a trend at some colleges to give students a broader base in the first two years, for instance, with courses in chemistry, biology and physics.

Science teachers for the senior secondary schools, HAVO and VWO, are trained through a postgraduate year at the universities. Half of the time is spent on teaching practice in one or two schools.

At present, the interest in becoming a junior physics/chemistry teacher is very low and decreasing, in contrast with biology. The initial teacher training at university level for the three sciences is becoming more popular, after a recession of about 6 years.

6.2 Decision-making authority for the above

There is no national curriculum for training science teachers; curricular decisions are taken at the institute level. The quality of the teacher training (at college and university level) is monitored by committees which periodically visit all institutions. The recommendations of these committees have policy implications at the national level.

Diplomas are issued by the college or university authorities.

6.3 Continuing training

Some colleges now offer courses for junior science teachers to qualify as senior science teachers. The government promotes cooperation between colleges and universities in this field, but so far it has not been very successful.

Participation in a very limited number of in-service activities is required for regular salary increments.

Most initial training institutes organise in-service courses for science teachers, dealing with new examination topics for example. However, the trend at present is that subject-bound in-service courses are less popular among teachers, in favour of more general courses (e.g. study skills, class management and pupil guidance). Increasingly popular are the annual one or two-day conferences for specific subject teachers - chemistry, biology and physics - which also count as in-service training (INSET).

Budgets for INSET are presently being transferred from colleges and universities to schools, which has resulted in more competition between institutions in the field of INSET, and less emphasis on subject-oriented INSET. Schools tend to use the money for INSET for more general educational issues, such as training for study skills and class management.

6.4 Number, teacher/pupil ratio, gender, age profile

Many science teachers are members of the Dutch Association for Science Education (NVON). The NVON is focused on general secondary education and publishes a monthly magazine. A number of the science teachers in upper secondary school are also members of the professional societies of biology, chemistry or physics (respectively NIBI, KNCV and NNV).

The average age of science teachers is increasing; physics teachers are on average the oldest (48 years) and biology teachers the youngest (average around 40 years). As a result, big shortages are to be expected towards the end of this century, especially in physics (see Appendix 4).

Science teachers have the same teaching loads as other teachers: 28 periods (50 minutes) per week, which is felt by many teachers to be too high. Class sizes vary, but can be up to 32 pupils.

6.5 Drop-out rates, late entries, maternal leave

There are 239,000 full-time jobs available in education (4.5% of total job volume); the absolute number is stable, but the proportional number is slowly decreasing (in 1985 the figure was 5.0%).

Annually about 7% of the teaching labour force leaves the teaching profession, with about 5% entering.

In general, the mobility of teachers is small: only 3% of all teachers change schools in a year (and these are mainly younger teachers). This is partly owing to an appointment system that favours those who have been working the longest in a particular school when teachers have to be dismissed due to a decline in student numbers.

No specific figures for science teachers are available.

An increasing number of older people (aged between 30 and 40, often Ph.D.-graduates) are interested in being retrained as science teachers, probably due to a decline in job opportunities for scientists in research and industry.

Maternal leave for teachers is 16 weeks with full salary; but often this period is extended for medical reasons.

6.6 Status and salary

The general status of teachers decreased in the eighties. This was partly owing to the relatively low salaries of starting teachers and publicity about the heavy working conditions in primary and secondary education. But also a general anti-authoritarian wave in the seventies has affected the position of those who had authority by tradition, such as parents, priests, doctors and teachers. The status of teachers has recently received a great deal of political attention, resulting in rather big increases in salaries for starting teachers and possibilities for sabbatical leave.

Salaries are paid according to function (type of school), with about 25 annual increments. Heads of departments earn the same as ordinary teachers.

Salary levels are lowest in primary and lower secondary education and higher in senior secondary general education (similar to university lecturers). Owing to a move towards a system of block grant funding (greater financial authority within the schools), there is a trend to offer new university trained teachers salaries only at the junior level. This may change in future if shortages arise in particular subjects.

7. Equality of opportunity?

7.1 Different status of the schools

Pre-vocational schools have the lowest status amongst secondary schools, but they are now often merged into larger schools with general streams. The gymnasia (VWO schools with Latin and/or Greek as examination subjects) have the highest status. Really prestigious secondary schools are not common in the country. Schools try to increase their status in the battle to get more students.

7.2 Regional differences

Secondary schools in large cities tend to have more problems with crime and social problems than rural schools. In the south of the country Catholic schools are dominant. In the more urbanised parts of the country, the levels of education seem to be lower than elsewhere.

7.3 Immigration and migrant populations

Schools in the cities have an increasing number of pupils with ethnic minority backgrounds, especially from Morocco, Turkey and Surinam (see Appendix 2). Their results are on average much lower than those of pupils with local backgrounds. Recently the number of children from refugee families is increasing, e.g. from the former Yugoslavia and Somalia.

Although not much thought was given in the past to adapting science education to the needs of immigrant pupils, some research in this field has now been undertaken.

7.4 Special education for handicapped children?

Attempts are made to take children who are not seriously handicapped into regular schools. Special schools for blind and deaf children exist. About 5% of the pupils are in schools for children with learning disabilities. No large scale programmes for teaching science to handicapped children exist.

8. The dynamics of change in science education

8.1 Tradition

In the Netherlands, there has been a long tradition of division with regard to secondary education:

1) a division between state schools, Roman Catholic schools and Protestant schools;

2) a division between vocational (VBO) and several types of general educational streams (MAVO, HAVO, VWO) for pupils from the age of 12 onwards;

3) a division between the cultures of primary and secondary school;

4) a division between the cultures of secondary schools and tertiary institutes;

5) a division between the sciences as taught in secondary schools.

Recent developments show that some of these boundaries are becoming less sharply defined. Many parents choose the school they consider to be the best for their children, irrespective of its religious identity. Larger secondary schools are being formed, sometimes from Catholic and Protestant schools (a); in the new national curriculum for basic secondary education, students now follow the same curriculum (b); some methods common to primary schools (group work, working in themes, differentiation) are being taken over by secondary schools (c); in the new plans for senior secondary schools, freedom to choose almost any group of examination subjects is reduced to four streams corresponding to particular types of further studies and in which credit schemes are taken over from tertiary education (d); physics and chemistry have been merged into one subject in basic secondary education and a general science subject will be compulsory in senior secondary education (e). However, it will take some time before the traditional divisions become less evident in common educational practice. For instance, interest in the connection between the curricula of primary and secondary schools is rather small, compared to the increasing interest in the connection between the curricula of upper secondary and higher education.

8.2 Autonomy of schools

A strong trend has emerged to offer more autonomy in decisions about budgets and personnel to primary and secondary schools. Such autonomy offers schools a large number of policy choices and opportunities to develop their own identities. However, in secondary schools this trend is not always favourable for science teaching. The emphasis is on the school as a whole and subjects tend to become less important. This is apparent in the trend to allow more (lower-paid) junior science teachers to teach senior science classes, the lower priority given to subject-bound in-service training, and the extension of the duties of science laboratory assistants. The influence of national bodies is decreasing. This raises questions about the quality of science teaching in the future. At the national level countermeasures should be considered, such as greater support to science teachers by universities and professional organisations and visits by experts to monitor the quality of teaching in schools.

8.3 Primary schools

In many primary schools the teaching of science is not satisfactory, although some good work has been done and is being done to improve the situation, especially in the production of teaching materials. Probably the most important reason is the poor training of teachers. Many of them had science education only in their first years in secondary school and the time available for science in teacher training colleges is small. Some educationalists strongly believe in the usefulness of heavily guided teaching materials which could be used by any teacher without much preparation; but it is doubtful that this approach will really lead to proper science teaching at this level. Another weak base for improvement is that no research on primary school science education in the Netherlands has been carried out. This is contrary to the situation in mathematics, where research has played a very important role in the innovation of arithmetic teaching at the primary level. Unless some teachers specialise in primary school science teaching, and unless science education research takes primary school teaching seriously, there is not much hope for real improvement.

8.4 General secondary schools

At secondary school level a rapid change in science teaching is taking place. In all science subjects more attention is given to relating science to the world outside school ('science in context'), to practical work, to the use of computers, to open investigations and to modern developments in the disciplines. This does not mean that all problems have been resolved: for instance, in teaching 'science in context', the role of preconceptions is underestimated, the importance of practical work by students as such is too often overemphasised, the real potential of computers has not been explored fully, the guidance of open investigation is not yet mastered by many teachers and it has been difficult to find satisfactory ways of teaching the new topics. But at least there have been moves supported by many teachers to make science teaching more attractive and educationally worthwhile for students.

There has been pressure from outside the educational system to do so, driven by the fear that science and technology studies will decrease in popularity and by the low number of girls taking physics and, to a lesser extent, chemistry. The sciences are seen as difficult subjects by many secondary students. This perception is supported by the difficulty of the examinations, the full syllabi, the academic nature of some textbooks and the teaching styles of some teachers, who were themselves educated in the past in an academic way and who had but little pre-service teacher training at universities.

8.5 External influences

In the last decade both primary and secondary education have been subjected to pressure from a variety of external forces to pay attention to elements that are not part of traditional subjects, such as environmental education, health education, traffic education, technology education, peace education, computer studies, multicultural education, third world studies, crime prevention, Dutch as a second language and gender equity. Teaching materials have been published with external financial support (from various ministries or non-profit organisations). In the primary school this has proved a burden to many teachers who have difficulty dealing with all those elements, being non-specialists and already largely occupied with the requirements of the formal curricula.

The influence on secondary education by academic circles has been smaller than in the past; recent curriculum committees were dominated by teachers and people from educational institutions with only a few members from the universities and other tertiary institutes. One reason may be that a number of changes in university research and educational programmes has occupied university professors so much that involvement in secondary education has received a lower priority. With the plans to reform senior secondary education, a revival of interest in secondary education by professional societies and institutes of higher education is clearly visible.

By local tradition, industry has not shown much interest in science teaching in general secondary schools. The involvement in vocational education is much higher. Recently, industry has been focusing more attention on secondary education. One sphere of interest is the promotion of a positive attitude towards technology and technology-related occupations. This is strongly encouraged by the Ministry of Economic Affairs. Other spheres of interest are chemistry education (Association of Chemical Industries) and biotechnology education (Association of Biotechnology Industries).

8.6 New general science subject

From the point of view of public understanding, it is interesting that in a year's time (from 1998 onwards), a general science subject must be taken by all those preparing themselves for higher education. The content and the teaching methods to be used in this new subject have not yet been decided. Claims on the curriculum have already been forthcoming from a variety of other disciplines, such as earth science, philosophy, environmental science, astronomy and technology. Most likely it will be a subject with emphasis on the public's understanding of some basic scientific knowledge, of the nature of science, of the methods scientists use and of the implications of science on society and vice versa.

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Table 1: Number of full-time pupils and students (in 1000)

	80/81	85/86	90/91	91/92	92/93*
Primary schools	1743	1469	1443	1408	1415
Special needs schools	92	100	109	110	111
General secondary schools	824	804	684	647	668
Pre-vocational schools	403	359	233	221	215
Senior vocational schools	168	276	289	284	283
Colleges	132	149	194	204	214
Universities	149	159	166	174	175
Total	**3511**	**3316**	**3118**	**3048**	**3081**

*): preliminary figures

Table 2: Number of foreign pupils and students (1991/92) (in 1000)

Primary & special needs schools	114	(7.5%)
General secondary schools	28	(4.3%)
Pre-vocational schools	18	(8.2%)
Senior vocational schools	7	(2.5%)
Colleges	3	(1.5%)
Universities	6	(3.4%)

Table 3: Age of the teachers in primary and general secondary schools (1990/91) (in percentage)

Age	Primary	Special needs	Secondary
≤ 34	35	40	20
35-44	42	39	42
45-54	19	19	31
55-64	3	2	7

Table 4: Expected shortages of teachers in general secondary schools (in absolute numbers)

		1996/97	**1999/2000**
mathematics	junior	93	390
	senior	67	192
physics	junior	128	349
	senior	38	114
chemistry	junior	-29	48
	senior	13	71
biology	junior	-6	120
	senior	26	96

Appendix 5:

Science syllabus for primary education

Five domains:

1) Human beings

- structure of the body
- primary needs
- differences between people
- illness

2) Plants and animals

- ways of reproduction
- adaptation
- classification
- competition
- human influences

3) Materials and phenomena in non-living nature

- materials
- relations between shape and function
- energy sources
- dangerous substances
- electrical circuits

4) Environment

- caring for the environment
- air pollution
- influence of human beings
- weather and climate

- earth, sun and moon

5) Basic skills

- measuring with instruments
- devising and carrying out experiments

Appendix 6:

Domains in the National Curriculum for biology

1) Skills

- responsible behaviour towards organisms, materials and instruments
- observing and experimenting
- selecting and judging information
- use of the computer
- thoughtful decision making

2) Health of human beings

- human development
- sexuality and reproduction
- fitness, posture and movement of the body
- metabolism
- diversity and unity

3) Plants and animals

- diversity and unity
- interdependency
- behaviour

4) Human beings and the environment

Appendix 7:

Domains in the National Curriculum for physical science

1) Skills

- processing information
- practical skills
- use of the computer
- thoughtful decision making

2) Substances and materials in the home:

- use of water
- cleaning products and cosmetics
- use of materials and products
- environmental consequences

3) Electrical energy in the home:

- circuits
- use of energy

4) Burning and heating:

- heating homes and extinguishing fires
- energy conservation
- health and environmental consequences of burning
- sources of energy

5) Light and image:

- seeing light
- formation of images

6) Hearing and producing sound:

- speech and music

- noise pollution
- recording and reproducing sound

7) Forces and safety:

- types of forces and their properties
- traffic and safety

8) Structure of matter

- molecules and atoms
- physical and chemical changes described in terms of molecules

Appendix 8:

Domains in the National Curriculum for technology

1) Technology in every day life

- industry
- profession
- the environment

2) Using products of technology

- technical systems
- control techniques
- use of technical products

3) Producing functional workpieces

- preparatory activities
- design, technical drawings
- processing materials
- inspection of workpiece

Appendix 9:

Pre-university syllabus biology

1) Practical part

- doing investigations, collecting and handling information
- dealing with biological information and formulating a viewpoint
- experiencing the role of biological information in vocations

2) Specific skills

[mainly related to the practical part]

3) Specific knowledge

- structures: ecosystems, population, organisms, cells
- life cycle: genetic information, human being, cells
- metabolism: energy and matter, plants, human being, cells
- stability and change: ecosystems, behaviour, human being: regulation and protection

Appendix 10:

Pre-university syllabus chemistry

1) Practical part

- formulating hypotheses
- designing and performing an experiment to test a hypothesis

2) Specific skills

- reading data, deducing relations
- reasoning and calculating
- experimental skills

3) Specific knowledge

- Analysis of chemical compounds (qualitative and quantitative)
- Atomic theory and chemical bonding
- Energy, entropy and equilibria
- Industrial chemistry, including environmental issues
- Chemistry of carbon compounds
- Acid/base and redox reactions, including calculations
- Reaction mechanisms and stereoisomerism

Appendix 11:

Pre-university syllabus physics

1) Practical part

- formulating hypotheses
- designing and performing an experiment to test a hypothesis

2) Specific skills

- handling data
- drawing graphs
- making calculations
- experimental skills
- dealing with physics information in social issues

3) Specific knowledge

- Mechanics
- Vibrations and waves
- Optics
- Liquids, gases and heat
- Electricity and magnetism
- Physics and informatics
- Atomic physics
- Nuclear physics
- Biophysics
- Astrophysics

Report from Norway

Svein Sjøberg

Introduction

Norway is currently undergoing a number of educational reforms, involving all ages and levels. The reforms range from including 6 year olds in the formal school system to a complete reorganisation of universities, tertiary education and research. Some of the reforms have just been introduced, some are in the process of implementation and some on the drawing board. The following description of science in the Norwegian school system will reflect that we are in a period of transition.

Here is a brief account of the main features of the current system and the major changes taking place[1].

1. The comprehensive, compulsory school

The Norwegian school is currently a 9-year compulsory school, where children start school the year they are 7 years old, and leave at the age of 16. These schools are owned by the 454 municipalities and run according to national laws and regulations.

The Parliament has recently decided to lower the age of entrance to 6 years, a reform that will gradually be introduced in the coming years. Today, some 90% of 6 year-olds have taken part in pre-school education, but not as a part of the regular school system. New curricula will be produced for the new 10-year compulsory school, a process that started in November 1994. The new curricula

1. More extensive information in English is available through the Ministry of Education, Research and Church Affairs. Of special value are the bi-annual national reports to the International Conference on Education, Geneva. Data for this review are mainly taken from the 1994 report, Oslo, October 1994 (KUF 1994c). Statistical data are taken from the latest available official Norwegian educational statistics (SSB 1994a, b and c).

will be in operation from 1997. These will build on the new core curriculum that was passed through Parliament in 1993. The core curriculum is a thoroughly illustrated document that avoids academic (and educational) jargon. It presents an analysis of current societal challenges and outlines the general philosophy of the education system. This core curriculum forms the basis of all Norwegian schooling from the primary stage through upper secondary school, including adult education. The more detailed curricula for various levels and school subjects has been constructed on the basis of this new foundation. The core curriculum is available in English translation (KUF 1994a).

The current 9-year school is divided into two parts, the primary stage (*barnetrinnet*) (grades 1-6) and the lower secondary stage (*ungdomstrinnet*) (grades 7, 8 and 9). The most usual organisation is to have the parts in separate schools, although some 660 of the total 3,352 schools are combined 1-9 schools.

With less than 4.3 million inhabitants living in an area of 324,000 square kilometres (mainland only), Norway has a very low population density (13 inhabitants per square kilometre). In the sparsely populated countryside many primary schools are rather small; about one half of the schools have less than 100 pupils, 12% less than 20 pupils. The maintenance of the many small schools in less populated areas has been a deliberate policy to protect the decentralised population structure (in contrast to Swedish policy for example). Only 3% of the schools have more than 400 pupils.

There is no streaming according to abilities, gender or other criteria in the Norwegian comprehensive school, and there is a deliberate policy of integrating pupils with special educational needs, for physical or mental reasons, into normal classes. Extra facilities and assistance are then introduced into these classrooms. The strong policy of 'integration' is one of the reasons for the low pupil/teacher ratio in Norwegian schools. The many small schools (and hence small classes) also contribute to this.

During the primary stage no grades are given to pupils. Twice a year parents are given a more informal progress report, and there are organised consultations between parents and teachers.

Very often the same teacher teaches across the curriculum in primary school, with the same class-teacher following the pupils through the first 6 years of schooling. Only in some subjects (music, physical education and arts and crafts) are there specially trained subject-matter teachers.

Grades are given at the lower secondary stage, and at the end of year 9 there is a public exam covering the main subjects; Norwegian, mathematics and English (but not science). There are no other public assessments or tests in regular use.

The school year is 38 weeks, or 190 days. The school week is five days long and each lesson lasts for 45 minutes. The number of lessons per week increases from rather few (starting at about 20) in the first years, to 30 in lower secondary school.

Most municipalities run after-school 'day-care centres' in connection with the school to provide extra opportunities for the child and enable parents to have full-time employment. (In Norway, the employment rate for men and women is nearly the same). In 1993 about 80% of municipalities had full day-care centres, and full national coverage for all school children up to 10 years of age was targeted for 1997.

2. Upper secondary schools

The public upper secondary schools are owned and run by the 19 counties, following national laws and regulations.

From 1976 all upper secondary schooling has been organised into one comprehensive system. Schools have often included vocational as well as academic lines of study. About 95% of the young people continue schooling after the school leaving age. The direct transition rate from compulsory school to upper secondary school increased from 81.3% in 1980 to 95.3% in 1992.

From 1994 an even more comprehensive system was introduced, lowering the number of possible first-choice study subjects from more than 100 to 13. This was part of 'Reform 94', a reform that reorganised the whole upper secondary school. The structural reform is accompanied by 'a legal statutory right' for all young people to have access to 3 years of free upper secondary education.

As can be seen from the above, from the mid 1990s Norway will have in effect a 13-year school for all.

3. Tertiary education

There are 4 universities in Norway and 6 tertiary institutions with university status. In addition there are a large number of other tertiary institutions. More than 100 of the institutions in this category are currently undergoing dramatic organisational changes, where institutions in the same region (county) are merging to become 26 regional institutions. This reform has been in operation since 1994. The objectives of this reform are many; among them is the notion that larger units make the system more efficient, enhance cooperation and also improve the quality of both teaching and research. The reforms are, of course, also motivated by the possibilities of economic gain through higher efficiency. This reform, as well as most of the others, is controversial and rather turbulent, mainly because the people involved feel that heavy reforms have been introduced without the necessary advanced planning and without extra resources. In some cases, institutions have experienced financial cut-backs at the same time as the new structure is implemented. The whole system is currently shaken by unrest, and some of the elected leaders have resigned in protest against cuts in budget.

A common law covering all public tertiary education is currently being prepared. This will replace the many separate laws for the different kinds of higher institutions. This law is an integral part of the complete reorganisation of the Norwegian education system.

Some 10% of the students in tertiary education attend private institutions. These institutions cover a wide range of studies, among them engineering, business and religion. Most of these institutions are financially supported by the state, but students also pay additional fees - in contrast to other tertiary institutions, which are free of charge.

The number of students in tertiary education has increased by 60% in 5 years, from about 100,000 in 1988 to 160,000 in 1993. The direct transition rate from upper secondary to higher education has increased from 16% in 1981 to 34% in 1992. The annual student intake has in recent years been larger than the total age cohort, meaning that a lot of 'older' people start studies after some years out of school. Part of the reason for this is the current level of unemployment (about 6%). When stabilised, it is expected that some 40% of the age cohort will continue through tertiary education after completing upper secondary school.

4. General information

a) Gender equity

For about two decades there has been a clear nationally-agreed policy to bridge the gender gap in all realms of society, and the success has been most marked in the education sector. Girls outnumber boys in upper secondary and tertiary education, where 54% of all students are female (SSB 1994c). In research and higher academic positions there is, however, a strong imbalance in favour of men. This gap has been narrowing in recent years. Although the general pattern of development is positive for equality between the sexes in education, in some areas the differences remain high and are even increasing.

Here are some numbers to illustrate female participation in various science-related studies (data from SSB 1994c). For enrolment at the highest university level (or *hovedfag*, comparable to Master's level), females have become the majority in such science-related areas as:

1) biology (54%)

2) medicine (51%, falling to 31% at Ph.D. level)

3) veterinary medicine (69%)

4) dentistry (57%)

5) agricultural science (52%).

In other areas of study, female participation is rather low:

1) mathematics (22%) and

2) physics (22%).

In civil engineering, the numbers vary from one field to another:

1) architecture 57%

2) chemistry 46%

3) machines 16%

4) electronics 10%

After a period of increase in female participation in science and technology-related studies, there are now signs of a reversal. There is also a tendency for females to educate themselves for occupations in the public sector, while more men go to the private sector where salaries, as well as competition, are higher.

The teaching profession is becoming more and more female-dominated. In teacher training through the regional system (previously called colleges of education), the proportion of male students is only 25%, and it has decreased over the last 10-15 years. Many of these male students do not go into teaching, but continue to qualify further after completing their teacher education. The real input of male teachers into schools is therefore, in effect, even lower.

b) Public spending on education

The proportion of the gross domestic product (GDP) spent on education has increased along with the growth in the number of students, and was, according to the Norwegian IBE report, 7.3% in 1991 (KUF 1994c). (UNESCO statistics indicate a public expenditure on education of 6.8% of GDP in 1991, and a total expenditure of 7.6% - the difference owing to private spending. The reason for the discrepancy is unknown).

5. A recent review of science education in Norwegian schools

The Ministry appointed a review committee early in 1994 to review the state of science and technology education in Norwegian education. The first report was delivered to the Ministry in November 1994. This report covers science and technology in compulsory education, and the training of teachers for this level through the regional system (the former colleges of education). An English translation of some findings and recommendations is given in Appendix 1, and the following report draws heavily on material in the report.

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

Teaching in the compulsory school has its legal foundations in the laws passed by Parliament and the Curriculum Guidelines of 1987 (*Mønsterplanen: M87*) drawn up by the Ministry of Education and passed by the Parliament. The plan was introduced in 1987, replacing the Curriculum Guidelines of 1974. M87 is a 'frame curriculum', giving considerable freedom to the local school (and also teacher) in translating the principles into practice.

The contents are described for periods of three years, leaving considerable freedom to schools to organise the content in a school-based working plan. The content is described in rather broad and general terms.

M87 describes the minimum number of lessons for each subject, also given for the three-year periods. The allocation of teaching periods in the compulsory school can be seen in Appendix 2. A lesson in Norwegian schools is 45 minutes, and in the first years there are about 20 fixed lessons per week, increasing to 30 in the lower secondary school. For grades 1-3 there is in total 7 'year-lessons' (out of 60) for orienteering (see next section), and for grades 4-6 it is 15 out of 82.

Part of the new school reform is, as mentioned, to make a new national curriculum. The signals are clearly in the direction of more national control over the contents of schooling.

1.2 Which sciences are to be taught

For the primary stage, the natural sciences are part of a broad subject called *orienteering-fag* or just: *o-fag*. A commonly used translation, seen in the IBE reports, is 'civics'. The science part of *o-fag* is meant to include biology, physics and chemistry. *O-fag* also includes the social sciences (history, geography and social studies).

Orienteering is allocated two hours each week for grades 1-3 and five hours each week for grades 4-6. The main topics are as follows:

Orienteering Topics, Grades 1-6

1) Investigating the environment (methods)

2) Everyday life (neighbourhood, school, home)

3) Relationships between people

4) People and society in olden days

5) The Saami Culture

6) Norway and the Nordic countries

7) Europe and the other parts of the world

8) The human body and health

9) Life forms and relationships in nature

10)Natural resources

11)The world around us (physics, weather, earth, solar system)

12)Materials, tools and technique

13)Communication, drama, pictures and the media

The intention of the *o-fag* is to 'integrate' knowledge about the surrounding world into one subject. It is argued that this will present a view of the world that does not follow artificial subject matter boundaries. (Other Nordic countries have similar *o-fag*-constructions, but they do, interestingly enough, include different subjects from the Norwegian version). Nothing in the curriculum guidelines suggests that one *o-fag* subject should dominate over the others. The reality, however, is quite different, as is manifest in both textbooks and actual classroom practice. Although the plans for *o-fag* are clearly child-centred and well-intended, the result is, as we shall see later, that the science component is neglected.

For the lower secondary level, *o-fag* is split in two: the social sciences (history, geography and civics) and the natural sciences (biology, chemistry and physics). Hence, from grades 7-9, science is a separate subject, but not divided into components like physics, chemistry and biology. This means that all science in the comprehensive school is integrated to a large extent, and that labels like 'physics', 'chemistry' or 'biology' do not appear on the timetable. The curriculum is organised under broad themes. The themes are as follows:

Science Topics, Grades 7-9

1) Observation and experimentation

2) Data presentation

3) Our physical world view

4) Weather

5) Life, heredity and development

6) Animals and plants - environment

7) The human body and health

8) Our senses

9) Energy and natural resources

10)Electricity in our daily lives

11)Information and data technology

12)Technology and society

13)Materials and their characteristics

14)Scientific knowledge, technology and quality of life

Science in the comprehensive compulsory school is organised as outlined in the preceding paragraph, and there are no options within this system. There are, however, also some elements of science in other school subjects, such as home economics. Some earth science is included in the social sciences under its geography-component. There may also be science or technology-related subjects among the electives (Optional subjects, see timetable, Appendix 2). The variety of electives offered is wide, and is to a large degree a matter of freedom for the local schools. There is a tendency to reduce the time allocated for electives. The number of lessons for electives is in practice lower than indicated in the timetable, since a second foreign language (in addition to English) is a 'choice' that must be taken in grade 8 and 9 in order to proceed to most of the options of upper secondary schools. In grade 8, some 67% take a second foreign language, in grade 9 the proportion is 52%. The percentage is higher for girls than for boys. The most usual choice is German (about 80%), the remainder is mainly French (SSB, 1994a).

Earth sciences (such as geology, geophysics, meteorology, astrophysics, limnology, glaciology, hydrology) have a weak position in the Norwegian curriculum. This may be seen as surprising in light of the fact that Norway relies so heavily on resources like hydro-power, oil on the continental shelf and other natural resources, and also has a strong scientific heritage in areas such as oceanography, meteorology, polar research and the study of phenomena like the northern lights (aurora borealis).[2]

2 In fact, the study of the northern lights was a basic activity that formed part of the impetus for the establishment of Tromsø University, the northernmost in the world, at nearly 70° North, far north of the polar circle.

Technology does not exist as a separate subject in the comprehensive school, but some elements may be found in subjects like arts and crafts, drawing, woodwork, textiles, etc. The possible introduction of technology is currently debated, mainly because of the broad emphasis on technology in the new core curriculum (KUF 1994a).

In upper secondary school the pattern is of course more diversified, but it is interesting to note that in grade 1 (i.e. age 16) of upper secondary school, science is compulsory for most of the lines of study (reaching more the 60% of the age cohort). Science is also taught as one integrated subject at this level.

It is only in the last two years of the academic lines of study at the upper secondary school that the different sciences are studied as distinct subjects. It is probably true that few countries have taken the integration of subjects so far and to such a late stage as Norway has done.

1.3 Realistic data on the above

a) Primary level

At the primary level (grades 1-6, or ages 7-12), science is part of the above-mentioned *o-fag* (civics). In the curriculum guidelines, natural science and social science are well balanced in the official curriculum. In practice, however, the time allocated for science is considerably less than half as much as should be expected from the official curriculum.

The analysis of the actual role played by science in the *o-fag* (following the interpretation of the curriculum guidelines) may be based on two sources:

1) an analysis of subject-matter coverage in textbooks;

2) evidence obtained from interviews with teachers and observation of classrooms.

The textbook analysis is important, since textbooks have a strong position in Norwegian schools, and we also know that teachers without subject-matter knowledge (like teachers of primary science) rely heavily on textbooks. The result of several investigations give similar results for the various textbooks in use, and is summarised as follows in the national science review Report 1 (see Appendix 1). Regarding the textbook coverage, a recent investigation (Nergård 1994) shows that the proportion allocated to science in the most widely used textbooks is less than 30%, while the curriculum guidelines suggest an equal distribution between social science and natural science. Looking at details, the situation is even worse, as practically all the science in the textbooks is descriptive biology (flowers and animals in the neighbourhood and some human biology).

Only 5-8% of the total coverage of textbooks is for chemistry and physics taken together. Moreover, studies of the science presented in the textbooks have revealed numerous errors, among them several of the 'misconceptions' that science education research has identified as wide-spread among young people. Many textbooks at this level also convey a negative image of science and technology. The national review concludes:

> *Very little place is given to science topics in orienteering at the primary level. The little science that is taught is 'nature studies' and little chemistry or physics.*
> *Science review (see Appendix 1)*

> *The little science that has been written into 'orienteering' books contains many errors. The philosophy behind science and technology is one of 'the bad guys'.*
> *Science review (see Appendix 1)*

When extending the analysis to observations of classroom practice, one notes that the proportion of science is even further reduced than in the textbooks. The review concludes:

> *Science is practically not taught at the primary level, and there is a particular absence of chemistry and physics.*
> *Science review (see Appendix 1)*

b) Secondary level

At the secondary stage (grades 7-9, ages 13-15) and later, the time allocated to science follows the curriculum guidelines, and this is adhered to by all schools.

1.4 Recommended learning activities

In principle, the learning activities are very much up to the teacher to choose according to their professional judgment. Some guiding principles may, however, be read from the curriculum guidelines, and both the *o-fag* (1-6) and the science (7-9) curriculum have chapters on 'teaching methods'.

For both levels, active teaching and learning are stressed strongly. Project work is recommended, experimental work is stressed, excursions are mentioned, etc.

The following quote is typical:

Experiments and tests are the most important ways of working in Natural Science. For both pedagogical and safety reasons, this work should be done in small groups.
Science 7-9, M87

The first 'main area of study' in the *o-fag* curriculum is 'Exploring our surroundings', which begins like this:

Exploring our surroundings

In civics, the methods used to obtain, record, consider and present information are more than teaching methods. They are part of the subject matter.
Civics (o-fag) 1-6, M87

The science (7-9) curriculum stresses the experimental nature of science, and argues strongly that this should be reflected in the actual teaching and learning activities.

The science (7-9) curriculum has even advanced as the first two (of 14) 'main areas of study' the following: 'Observations and experimentations' and 'Data presentation'. These aspects are given a high priority in the guidelines and are delineated in some detail.

In conclusion, the curriculum guidelines suggest active learning activities, basing the argument both on the experimental nature of the subject and the fact that they provide good educational activities for learning.

1.5 Mandatory tests and examinations

At the primary stage, there are no grades in any subject in Norwegian schools, and there are no national tests or evaluations of learning in any subject. In lower secondary schools, grades are given, but there are no national tests or exams (neither mandatory nor optional) in science. At grade 9, pupils may, however, be drawn out for an oral, school-based exam in any subject, including science.

The absence of any kind of national testing has been a matter of public debate for a long time. The Norwegian tradition has been to put all the trust in the teacher and the schools. With more decentralisation of control, and with a looser curriculum framework, there is a growing concern that central national authorities should have more knowledge about what is really going on in Norwegian schools. This critique was also raised in an OECD-report on Norwegian education in 1988 (OECD 1988).

> *[...] consensus and newly-found wealth have made it perhaps too easy for rational and purposeful planning to remain in the background. Instead, the state has been able to justify itself that all is going reasonably well [...]*
>
> *OECD, 1988 p.50*

Some pilot projects are taking place, but the issue of a national testing or monitoring system is still very controversial and there have not yet been initiatives from the ministry to establish such a system.

1.6 New trends and reforms underway

For a long time, there has been criticism of science education in Norway, voiced mainly from a growing field of science education research. A survey of Norwegian and other Nordic research in science education is given in Sjøberg 1993.

There are no science teachers' associations or other potent interest groups for science or technology in Norwegian schools. The above-mentioned national science review looks into details concerning the state of science and technology education in Norway. This review has given its report and summarises a lot of the criticism voiced in earlier critiques. (See Appendix 1)

The first report (on science in compulsory education and teacher training) has been well received by the Minister of Education, and some of the suggested reforms and research initiatives are likely to be followed up in practice in the coming years.

2. How is science delivered?

2.1 Organisation and authority

The national authorities (i.e. the Parliament and the Government) decide on the overall policies, and the responsibility to run the schools according to these regulations resides with the local authorities: The 454 municipalities own and run the compulsory part of the school system, while the 19 counties own and run the upper secondary schools, including the vocational parts of that school system. After the recent educational reforms, which in general implies a decentralisation of decision making and power, the state has established a National Education Office in each of the 19 counties as a link between the national and the local levels. Part of these national education offices' remit is to supply the central authorities with information, and exert some control and influence locally to monitor how national policies are implemented. The background for this may be found in documents such as the OECD-report, which stated:

> *We were surprised by the absence of material that could be useful to the Norwegian authorities for their own planning system.*
> *OECD, 1988 p.50*

Many steps have recently been taken to establish better reporting systems and better national statistics as an information basis for a national policy.

2.2 Resources and funding

a) Funding

Changes in the economic relationships between the state and the municipalities (from 1986) has involved a new grants system. The former earmarking of grants to primary and secondary education has been replaced by a system where the local and regional authorities receive a lump sum covering all government subsidies for education, culture and health. The result is greater local autonomy as well as possibilities for differences in priorities between regions.

It should also be noted that the economy of the municipalities vary greatly, which also may contribute to larger differences in resources for education than was previously the case. The picture shortly after the introduction of the new grant system was rather confusing, as is noted by the OECD examiners:

> *The examiners did not find it easy to comment on the use of educational resources because data about them was almost completely absent.*
> *OECD, 1988, p.52*

Better statistical reporting is now being established to ensure more national control - or at least more national knowledge on how the system operates. The concern about growing inequalities has been expressed from many different groups, ranging from the teachers unions to the Union of National Employers.

Some recent figures are as follows for the comprehensive school:

The national mean number of pupils per class is 19 (the maximum allowed is 28 for primary and 30 for lower secondary), ranging from 24 in some cities (23 in Oslo) to 8 in some municipalities in rural areas.

The number of pupils per teacher-year is 10 in the comprehensive school, a ratio that has fallen during the last 10 years, partly (but only partly) owing to the policy of integrating pupils with special educational needs.

In the upper secondary school, the number of pupils per teacher-year is 8.9, but that also includes the labour-intensive vocational teaching.

The national mean for current expense per pupil is NKR 37,000[3] in the comprehensive school, of which the expense of wages per pupil is NKR 30,000.

The national mean for current expense per class is NKR 717,000, of which the expense of wages is NKR 581,000.

b) Resources for science teaching

There has previously been more or less obligatory lists of equipment for school science at different levels, and these lists were used by schools and teachers to keep their schools, rooms and equipment updated. Such lists do not exist any more, or they have no formal status within the system.

There are some data on the status of science equipment from the IEA/SISS-study, with data collected in 1984. (Sjøberg 1986).

At the primary level, very few schools have special rooms for science; none of the schools have technicians; most of the teaching is done with the whole class without extra teacher resources or splitting of the class. Nearly all teachers use a textbook and stick to that one. There are rather limited experimental resources, and running costs for expenditure is very low.

At the lower secondary level the situation is better. The great majority (92%) of the schools have special rooms for science, and conduct most of the science

3. Typical rates of exchange:
1 ECU = 8.3 NKR, 1 GBP = 10.7 NKR, 1 DEM = 4.35 NKR, 1 USD = 6.85 NKR.

teaching in these rooms. Only 5% say that they never use special science rooms. About half of the schools spend between NKR 1,000 and 5,000 (1984 money) per year on running costs for science equipment. One should bear in mind that many schools are rather small, so this sum is difficult to interpret.

Upper secondary schools are much better equipped and most often have separate rooms for the three sciences (plus frequently one room for the integrated science taught in grade 1 - see above).

For all schools it may be stated that access to equipment and running expenditures to a large extent is dependent on teachers' demands. This demand is not very often voiced, since experimental science has weak traditions in Norwegian schools. The lack of equipment is therefore only partially due to neglect from the political level.

c) Information technology (IT)

IT is not a separate subject in Norwegian schools, but should be integrated in all subjects. Norway has seen several 'waves' of centrally-initiated introductions of computers in education. Special task forces have been established, and large sums have been spent on the development of educational software and in-service courses for teachers. The area has been a subject of debate and conflict - even of scandals in Parliament threatening the chair of the Minister of Education. Bureaucrats at high levels have been replaced.

Science teachers (especially in the upper secondary schools) have probably been at the forefront in using IT. Computers have not, to a large extent, entered the schools lower down the grades, and in many cases pupils know more about the use of computers than their teachers.

International surveys show that Norway is among the countries with the highest relative numbers of computers in the home, higher than in most other industrialised countries. However, computers are very much a boy's activity, as found in most other countries.

It is probably true to claim that computers are not in very frequent use in the science classroom, and that they are probably more in use in other subjects. There are some special science-oriented instructional materials, but it is only in science in the upper secondary schools that computers are used as on-line measuring and monitoring devices in experiments.

d) Textbooks

Textbooks have a strong standing in Norwegian schools. All textbooks in use must pass through a process of official approval. In this process, they are scrutinised according to several criteria, including adherence to the national curriculum guidelines and possible gender discrimination. A special feature of the Norwegian school system is that all textbooks must be available in both of the two official languages, called *Bokmål*, 'book language' and *Nynorsk*, 'new Norwegian'. *Bokmål* is the language used by some 85% of the school children. For a population of 4 million, and with 5-8 competing private publishers, this of course makes textbook production a costly process! State subsidies cover part of the additional costs of producing all books in two (rather similar) versions.

The approval system has been under constant debate for both political and professional reasons, but has survived all attempts to abandon it. In the case of science, the national review committee has recently voiced a strong criticism of the textbooks by showing that they contain factual mistakes - despite the approval process. This is particularly the case for primary science, largely owing to the fact that the science component is only part of the larger *o-fag*. The rather wide integration of many disciplines has probably resulted in publishers using authors with backgrounds in only a limited part of *o-fag* - with the result that none of the authors for *o-fag* books for the first grades have a science background. The same seems to be true of the official textbook reviewers.

2.3 Methods of teaching

At the primary level, science is most often taught as a theoretical subject (or rather, only as a text to be read and 'learnt') - if taught at all. The exceptions are excursions and outdoor activities such as collecting leaves, etc. This kind of activity-based teaching has a strong position in Norwegian schools. Teaching methods at the primary level are in general often activity-based and project-oriented. But experimental science is the exception, and the national science review committee concludes:

Primary and junior secondary science is, for the most part, theory and textbook-based with chalkboard teaching methods. The experimental and experiential base of science teaching is not well developed.

At the upper secondary level more experimental work and field work is taking place, and there are statutory requirements for this in the official curricula for these levels.

2.4 Sources of pedagogic innovation

Most of the municipalities run a kind of teacher's resource centre, but science does not play a key role in this context. In the mid-1970s, Norway had a curriculum development project on environmental science which was also internationally a pioneer project. Since then, Norway has not had any curriculum development project in science, although such a project is being planned now.

Norway also has no organised science teacher's association (or journal), but an initiative has recently been taken to establish one.

Both the above-mentioned initiatives stem from the national science review committee. (See Appendix 1)

In 1992, as part of the reorganisation of the Ministry of Education, a National Centre for Educational Resources was established. Its role is, among other things, to develop, produce and disseminate teaching and learning material. In connection with the introduction of new curricula, its role is to develop supplementary teaching guides as a bridge between the curriculum and classroom teaching.

The universities of Oslo and Bergen have centres for science education where teachers can get help and support, and which also organises in-service courses. The centre attached to Oslo University has been particularly active since it started around 1970. In addition to the support for teachers, they have also established degrees in science education up to Ph.D. level. This is now a joint effort of the Faculty of Science and Mathematics and the Centre for Teacher Education, the unit responsible for the practical-pedagogical training of university-educated teachers. A survey of science education research in the Nordic countries is provided in Sjøberg 1993.

3. Going beyond school

3.1 Use of out-of school resources

Teaching outside the classroom has a rather strong tradition in Norwegian schools, a fact that may be explained by demographic factors and a traditionally strong relationship with nature. A strong feature of Norwegian life is to use nature as a recreational resource: walking and cycling in the woods, boating on rivers, lakes and fjords, hiking in the mountains, skiing and skating in the winter. These activities are often linked with certain science-related activities, such as nature studies, and a general interest for biology, wildlife and nature conservation. Picking berries and mushrooms, fishing and hunting are widespread leisure activities.

The school links up to this tradition in many ways, by spending some teaching time in the neighbourhood of the school; the local forest, pond, etc. Norway also has the tradition of camp-school (*leirskole*, outdoor pursuits centre), specially organised school-like institutions where classes spend a whole week once or twice during their schooling. These camp-schools are often situated in nice surroundings, most often in the mountains. The teaching content of these schools is cross-curricular, but always includes science and nature studies of some sort, often combined with an introduction to ways of outdoor survival with limited resources.

Until recently, Norway has not had any science centres on the 'exploratorium' model like the ones so frequently seen in many countries, including the other Nordic countries. The National Technical Museum in Oslo has a small, simple and 'home-made', but very popular science centre, and there are ongoing plans to established a larger centre in Oslo, modelled on the other Nordic experiences and in cooperation with them. There are, however, several museums that have science-based contents, like forestry and hunting, mining, geology, (even glaciology), etc., in addition to the more 'official' museums that belong to the universities. In total, there are nearly 700 museums and collections in Norway. Norway has a long-standing tradition of Natural History museums throughout the country. Some of these are innovative in their educational thinking and have large numbers of school children passing through every year.

The link between industry and school is weaker, but this varies a lot from region to region.

3.2 Consideration of public science-based issues within lessons

a) Environmental science

Concern for the environment and nature conservation play key roles in the public debate in Norway, and this is also reflected in the schools. A special task force for environmental science has been established within the Ministry of Education. For many years, environmental science has been a priority area of Norwegian education, and a large proportion of the teachers have taken specially designed in-service courses in this domain. The catalogue of local school projects in environmental science includes hundreds of local initiatives. It is assumed that environmental aspects should be a cross-curricular theme, but the links to science are of course strong. There is, however, growing criticism and concern that too much environmental science is 'action-oriented' and about having 'correct attitudes', and that the actual scientific-knowledge base is neglected in favour of these more overt and visible aspects.

b) Health and sex education

Health and sex education also have a strong position in Norwegian schools. Food and nutrition play a particularly strong role in the compulsory subject home economics; and human biology and health are key aspects of science in schools.

Sex education is quite widespread, and children are taught at a rather early age about reproduction, contraceptives and sexually-transmitted diseases, although there are large variations from school to school on some of these issues.

3.3 Science education and vocational training

The world of work plays a minor role in the official science curriculum, and textbook analysis in fact reveals an implicit ideology of nature-romanticism. Notions of untouched nature and the old-fashioned (non-existent) farm are presented in textbooks as a kind of ideal. Modern industry and technology are not treated in depth, and the ideology is often hostile to these kinds of activities. Modern human production is in many textbooks related only to pollution, depletion of resources, etc. Even great events in the history of Norwegian industrial development, such as the introduction of hydro-power and the energy-intensive industries based upon it, are given little coverage.

The ordinary curriculum for compulsory school contains rather few vocational elements and the links between schools and industry are generally weak.

Work placement

In the last grades of compulsory education, work placement is used to a certain degree, but most often for non-academically oriented pupils.

3.4 Science clubs and cultural associations

Many leisure-time activities are science-oriented. The various scout movements used to have a strong standing among children.

The 4-H movement (Head, Hand, Heart and Health) has a strong position in the countryside, and they have many science-related activities, mainly with an orientation towards agriculture.

The Norwegian Association for Nature Conservation has a youth club (*Blekkulf*) with a very high membership among young children.

Norway participates in the annual 'young researchers' competition, based at the national museum for technology.

Many widespread outdoor sports activities (like orienteering: running in the forest with maps and compasses to find control-posts) seek to combine the physical activity with creating awareness and respect for nature.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

As mentioned, achievement testing has a bad reputation in Norway, and there is broad political agreement that tests, competition and exams should be kept at a minimum, particularly in the comprehensive school. Hence, there are rather few data on scholastic achievement on the national level or for international comparisons. There are no tests, and there is no inspectorate or similar system for reporting on quality or achievement.

Norway did, however, take part in the IEA/SISS (International Association for the Evaluation of Educational Achievement/Second International Science Study). The overall national results are published in Sjøberg, 1986, and more details are given in other books.

When the international results were published some years later, Norwegian results did not compare very well internationally. In fact, the international report commented on this:

> *This is the first time Norway has participated in an international study. The fact that its grade 9 scores are lower than Sweden's Grade 8 scores may give it food for thought.*
> *Postlethwaite and Wiley, 1992, p 70*

These results should, however, be interpreted with some care, since methods of sampling, translation, etc. are open for criticism and debate. (see Sjøberg 1992 for examples.) Norway is now taking part in the IEA TIMSS (Third International Mathematics and Science Study). The rather large Norwegian group sees as its major task to 'soften' the purely psychometric nature of these kinds of projects by introducing better science items and by introducing more open-ended items and more qualitative aspects.

Norway participates in the International Olympiads in physics, chemistry and mathematics, but this involves only a rather small elite in the upper secondary school, and provides a poor measure of the quality of Norwegian education.

4.2 Public or political concerns about educational standards

As in most industrialised countries, there is growing political concern and public debate about educational standards. This critique has traditionally been voiced by the more conservative political parties and by industry and employers. Recently, however, criticism has emanated from a wider political spectrum. Some critics link their worries about quality with a concern for the equality of Norwegian education as a consequence of the decentralisation of control described earlier. Also teachers' unions and more radical political parties have recently expressed fears of falling standards and unequal opportunities as a consequence of decentralisation and lack of national control. The OECD report noted the lack of information about quality at the national level. As noted in a preceding paragraph, a national system for testing has not yet been introduced, but the Ministry is likely to decide on moves in this direction in the near future.

4.3 Suggested reforms

There are, as mentioned, several reforms going on at all levels of the education system. Some of these have direct relevance for science. Some of the recommendations from the national science review have already been put into operation (see Appendix 1). A general trend that can be read from the new core curriculum (KUF, 1994a) is that the Ministry of Education wants stronger national control over the curriculum. This may be seen as a move to counteract the decentralisation that is the trend in other respects.

A move away from the high degree of subject integration in the official curriculum seems rather likely. It is probable that 'science' will appear on the curriculum as a subject in its own right at an early stage. It is, however, rather unlikely that science will be split up into its various components, despite the fact that other Scandinavian countries doing exactly that. 'Integrated science' in Norwegian schools is likely to continue up to the age of 16-17 for all pupils for the foreseeable future.

5. Pupil interest and motivations

5.1 Generally by age and gender

In general, both girls and boys enter school with an intrinsic interest in science and nature. It is a saddening fact that several investigations show a decline of interest and motivation with age (and exposure to school science?) (Sjøberg and Imsen 1988). This observation is, however, so common to many western industrialised countries that it may be unfair to construe it as an effect of a typical bad Norwegian school science.

5.2 By type of science or topic by age/gender

Again, the observed pattern seems to follow lines that are well-known from research; physics seems to be more favoured by boys than girls, whereas biology (and especially human biology and health) are more favoured by girls. The same pattern is visible in achievement testing - and in later career choices.

5.3 Options for choice within science

During the compulsory school, there are no options within the science offered at school.

5.4 Pupils' perspectives on the value of science

The Norwegian version of the IEA/SISS study included several items on attitudinal aspects of science. There have also been some studies directly addressing the image of science and scientists (Kjærnsli 1989, Sjøberg and Imsen 1988)

Most scientists are seen to have the following traits: logical, intelligent, hard-working, and accurate. For other traits, students tend to distinguish between two groups of scientists: physical scientists or engineers on the one hand, and biologists or medical doctors on the other. The biologist is seen as 'caring,' the physicist as 'selfish.' The biologist is seen as 'open,' the physicist as 'closed.' Furthermore, the physicist is seen as boring, inartistic and tasteless, while the perception of the biologist is more neutral in these respects.

Other research results portray the typical scientist as male with traits similar to the 'mad scientist' caricatured in cartoons and movies, who is absent-minded and deeply entrenched in his own strange world, sealed off from the real world as life passes him by. It is interesting to note that both girls and boys tend to share these stereotypical images. They develop at an early age, and only become more refined and elaborated as the child grows older.

6. Training, status and morale of scientific teachers

6.1 Initial training

There are two main ways of becoming a teacher in Norway:

- through colleges of education now integrated in the regional colleges, as described earlier; and
- through universities with add-on pedagogical training.

1) The (21) colleges of education offer a general teacher training programme of three years duration, extended to 4 years since 1993. The teachers from these institutions have general teaching credentials which allow them to teach across the curriculum for the whole compulsory 1-9 school. Science is very weak in the colleges of education, and most students do not have a science background from their own schooling.

2) Subject matter studies at the 4 universities are generally not oriented towards the teaching profession, but rather to an initiation in each academic discipline. With a degree from a university, one could until recently take a year of practical pedagogical training to get a teaching licence. The duration of the practical pedagogical training was extended in 1993 to one full year. If your basic degree is the first university degree (*cand. mag.*, some 3 years), then you become an *adjunkt*; if you have the highest university degree (approximately 5 years), then you become a *lektor*. In both cases, you are licensed to teach from grade 7 in compulsory school and upwards through upper secondary school.

As can be seen from the above, there are two kinds of teachers 'competing' at the lower secondary (grade 7-9) stage. These two kinds of teachers represent different 'cultures', one strongly oriented towards pedagogy and psychology, the other towards the subjects. There is some competition of hegemony between these two cultures, while in general the cities are dominated by the university-trained, and the countryside by the college-trained teachers.

The recent educational reforms in teacher training have attempted to bridge the gap by strengthening the subject matter components in the colleges and the pedagogy in the university teacher training.

Surveys show that very few teachers at the primary level have any training in science. At the lower secondary level, the situation is somewhat confusing since there are no reliable statistics. A recent survey indicates that some 47% of the teachers at this level have at least half a year of science training. But this may well be in only *one* of the three sciences, and the teacher will have to teach the whole integrated course. Indeed, very few teachers at this level have a background that covers all three science components in the curriculum.

6.2 Decision-making authority for the above

The Ministry of Education determines the overall national regulations for teacher qualifications, and is also responsible for the structure and contents of teacher training at both colleges and universities. In practice, however, the whole system has become more and more deregulated. The colleges are in reality rather autonomous and follow their own policies, and the local school owners decide on teacher appointments.

There are suggestions that the state should impose stricter rules for teacher qualifications to guarantee that teachers are educated with a more balanced background than is now the case. The Ministry of Education is now seriously discussing measures to counteract the obvious lack of science in initial teacher training for the primary level.

6.3 Continuing training

The general principle is that innovation, development work and in-service training should be school-based and initiated at the local level. For teachers in the 1-9 compulsory school, there is a built-in system of study and planning days corresponding to one week of work per year. It is up to local (school or municipality) initiative to prioritise the use of this week. Science is not very high on the priority list, although there is great local variation. There is a national institution (*Statens Lærerkurs*) organising (and financing) in-service courses.

They have developed a module-based course in science, but have problems filling the places in these courses. The most plausible explanation is that there is no incentive to take science, and that teachers (like most people) prefer to develop competencies in areas where they already have some knowledge and interest. It is the expressed intention of the Ministry of Education to channel in-service education to areas where teachers' competencies are low.

The major responsibility for upgrading the teachers' qualifications through courses and other measures reside with the municipalities. This fact introduces marked local variations in priorities and possibilities for teachers. The possibilities for sabbatical leave or other forms of secondment are rather poor. In such cases, finance must be found outside the school system (or be financed privately).

6.4 Number, teacher/pupil ratio, gender, age profile

The maximum number of pupils allowed is 28 in the comprehensive school and 30 in the (academic part of) upper secondary schools. In primary schools, very few teachers have more than 100% of full-time hours. Indeed, a large proportion have much less.

A full teaching post includes 25 teaching hours for primary teachers, less for teachers higher up in the system. In the academic branch of upper secondary school, a system of converting teaching in 'heavy-duty' subjects is negotiated between the state and the teachers' unions. For science and mathematics, a typical number of teaching lessons per week is 18. In the upper secondary school, there are quite a number of teachers who carry a teaching load of 120% and more of full-time hours.

6.5 Drop-out rates, late entries, maternal leave

The teaching profession is rather stable, and has not been hit by unemployment. It is relatively easy to get a job at all levels in the school system, but not in the tertiary sector. Part-time teaching is rather common, especially in compulsory schools. In fact, many teachers go in and out of full-time employment as determined by the needs of their family (and their economy). Many women with small children have reduced posts, and many teachers scale down their teaching burden when they pass 60 years of age. The retirement age is 67 years of age, with the right to continue until 70.

The teaching profession follows the general national rules for maternity leave. In connection with a birth, there are now 42 weeks of leave with full pay (alternatively 52 weeks with 80% of full pay). Of the 42 weeks, 4 must be taken by the father, otherwise they are 'lost' for the family. In addition, the father gets 2 weeks of paid leave in direct connection with the birth. Parents with small children have the right to a maximum of 10 days absence from the job in connection with their children's health problems.

6.6 Status and salary

a) High (but declining?) status

Traditionally, teachers for all levels in the Norwegian schools enjoyed a rather high social status. In a sparsely populated country, teachers were often (with the doctor and the pastor) the most educated persons, and they had a high social prestige. Future teachers were recruited from among the most academically gifted children in the community. They were educated in one of the, relatively speaking, many colleges of education, where stress was put on a general and well-rounded education. The aim was a balance of academic and aesthetic, artistic, musical and literary tradition, the weight being more on the latter than the theoretical and academic. (The so-called seminary tradition.)

Today the situation is rather different, although local teachers in Norway still enjoy a great deal of social respect in comparison with other countries. The social status is not matched, however, by a correspondingly high income, and in recent years there have been many disputes over salary and working conditions for teachers.

The teaching profession is still considered attractive by many young people. In times of relative unemployment, the teaching profession offers rather safe jobs; and it is easier to combine teaching with part-time work where family obligations or other factors make this desirable. Many women see teaching as a chance to combine a job with family life, since it offers part-time work with adaptable hours. (In the countryside, many combine small-scale farming or other locally-based occupations with teaching.) After a small setback in the mid-1980s, colleges of education still attract some of the most able students, while, for example, engineering colleges have many vacant places. When one has a tenured job as a teacher, there is practically nothing that can take that job away (although in recent years it has sometimes been necessary to accept moves to other schools in the same area).

The professional status of teachers has recently been under attack - that at least is how teachers see it. Teachers used to enjoy a great deal of freedom to organise their work outside of timetabled lessons; but recent moves have introduced stricter regulations of attendance within ordinary working hours. Teachers argue that this involves a de-professionalisation of their work, and they also argue (rightly so) that they are not given sufficient office facilities to do their preparations at school. The move towards fixed working hours is one of many that are interpreted by teachers as converting their profession into that of a clerk or technician. There are also attempts to impose quality judgements and other control measures on teachers and schools, although these have until now been resisted by teachers' unions. These ongoing conflicts are likely to continue, but so far Norwegian teachers have rebuffed some of the similar international trends towards control and efficiency. The negative side of this, of course, is that the teachers may still do whatever they like inside their own classroom, without the possibility of public interference.

b) Moderate and flat pay scales

The pay scales for teachers are centrally determined, with the State as counterpart for the teachers' unions. This is under serious debate, since it is the municipalities who actually run the schools and pay the salaries. They find it hard to accept that teachers' salaries are determined without their intervention. The maintenance of a national pay-scale and other nationally determined conditions of work are seen by teachers (and many others) as a safeguard to guarantee a national school system with equal standards.

The pay scales reflect a characteristic of Norwegian society in general - a rather equal distribution with small differentials in payment, according to age, responsibilities and education. The pay-scales follow a rather flat ladder, where the education of the teacher and the number of years in service are the only determining factors. This means that, with a given age and education, one's salary does not depend on where one teaches, be it a primary, secondary or upper secondary school. The main groups of teachers, by level of education, are the following:

1) ***Lærer*** (ordinary teacher) (until 1993 a three-year college education), usually the class teacher in primary school.

2) ***Adjunkt*** (either an ordinary teacher with an extra year of academic training, or a university-trained teacher with the first university exam, called *cand. mag.)* Both these types of teachers usually teach in lower secondary school.

3) ***Adjunkts*** may add a year to their qualification, making them *Adjunkt med opprykk*

4) ***Lektor*** (teachers with highest university degree plus teacher training, in total approximately 7 years of tertiary education) Most teachers in (the academic part of) upper secondary schools are of this type.

In Appendix 3 the pay scales are shown for the 'ordinary teacher', the *adjunkt*, *adjunkt med opprykk* (i.e. with an extra year of education) and the *lektor*. As one can see, the difference between the highest and lowest ends of the pay-scale is rather slight. There are also few additional possibilities for increasing one's salary by taking on special duties, such as being a department head, etc. It should be added that salaries at university are not much higher than in schools. The salary of a full professor is only some 20% higher than the salary of a teacher at top of the ladder (and without any 'extras'). The pay scales are the same for teachers of all subjects, irrespective of other circumstances, such as the demand in the labour market. Higher pay for teachers where the supply is low and the demand is high has been discussed from time to time, but has been forcefully rejected.

Teaching duties for full-time employment vary from level to level (and in upper secondary school from subject to subject). In general, the teaching load is highest for primary school, diminishing higher up in the system. The basic teaching load is typically 25 lessons per week in primary, 22 in lower secondary and 18 in upper secondary schools, figures which are in practice reduced for subjects with high work loads according to rather specific regulations negotiated between the State and the teachers' unions.

In the compulsory school, the heavy teaching load prohibits extra earnings for teachers, but some teachers in upper secondary schools carry a workload of up to 150% of full-time hours. These teachers of course earn relatively high salaries, but this may be at the expense of the quality of instruction.

A positive feature of the Norwegian pay system is that it stresses the importance of equality and job safety. On the other hand, there are rather few incentives to improve quality of teaching or to advance by merit. (One may even say that those who teach more than 100% at the expense of quality of preparation are economically better off than those who spend all their time in preparing for a 100% job of high quality.) The prime driving force is the job satisfaction that comes with doing a better job, but in the pay- or award-system there are few incentives. Neither schools nor teachers are in any way ranked, and there is strong resentment even against publishing exam results for separate schools.

7. Equality of opportunity?

7.1 Different status of the schools

The private sector in Norwegian education is small - but growing. According to a new Act on state grants to private schools from 1986, private schools have the right to exist alongside the public system and to receive state support. Today, about 98.5% of the pupils in compulsory schools attend state schools, and about 96% in upper secondary schools. Recognised private schools receive state grants that cover 85% of running costs for compulsory schools and 75% for upper secondary schools. The private schools are often based on special religious creeds or alternative pedagogic ideas (like the Steiner schools). The official state religion is Lutheran, and the school laws state that schools shall be based on the state religion. It is also interesting that the Minister of Education is also the minister of church affairs. (Official name: Royal Norwegian Ministry of Education, Research and Church Affairs.)

It is hard to relate any measure of status to the different types of schools. Some of the private schools at the upper secondary level obtain better results than many public schools, but it is hardly possible to relate this to differences in pedagogy or educational philosophies.

7.2 Regional differences

a) The Saami minority

The Saami people have lived for thousands of years in the Northern regions of the Nordic countries. Out a total of approximately 40,000 Saami, some 20,000 live in Norway, with the other half in the northern regions of Sweden, Finland and Russia. Saami language, culture and ethnic background is quite different from Norwegian, and the Norwegian society has for a long time treated the Saami population as a second-rate culture. Their religion, rites, language, etc. have been severely discriminated against both in schools and in society. However, there is now a strong recognition of this historical fact, and many measures are being taken to give Saami children equal rights to education and other social benefits. The right to education in their own language is a key issue, complicated by the fact that there are two different Saami languages. Saami children may today choose between having Saami or Norwegian as their main language of instruction. Only 1,400 children in the school system have Saami as their main language of instruction. There are rather few textbooks in Saami, but issues relating to education for the Saami population are now taken very seriously in all official policy on education. Saami textbooks are subsidised.

A council for Saami education as well as an institution for tertiary education (mainly teacher training) where Saami is the language of instruction have recently been established. There is also a Saami Parliament dealing with Saami affairs.

b) Urban - rural differences

Urban - rural differences are rather large in Norway, and this is manifested in many realms of life. In the November 1994 referendum on Norwegian membership of the European Union, this divide was highlighted in the voting results. There was a majority for joining the EU only in the urban areas, mainly around the Oslo fiord - and a correspondingly very strong no-vote in the rural parts of the country. In the northern regions (nearly a half of the land area), about 75% voted no. This is only one of many manifestations of regional divides. Educational statistics reveal the same pattern, especially in recruitment to tertiary education. Education is seen, however, as the best instrument to counteract social and regional imbalances, and several institutions for higher education have been established to serve the interests of the local communities. Although imbalances are still large, educational differences in general have diminished.

There is a growing concern that the decentralisation of finance and responsibility for school might increase inequalities. The differences in costs per pupil may be an indication of this; the costs per pupil in the comprehensive school range from NKR 25,000 in one municipality to 106,000 in other (with a national mean of NKR 37,000). Some of this may be explained by regional differences in population density, etc., but differences may vary by a factor of 2 between comparable municipalities - and the variations are not necessarily a function of the overall economy of the municipality.

In spite of the above-mentioned differences, Norway is, compared to many other countries, a culturally homogeneous country.

7.3 Immigration and migrant populations

The official policy on immigration has recently become much stricter, and legal immigration is mainly limited to quotas on a political and humanitarian basis. There is, however, a rather large and growing immigrant population, mainly living in the Oslo region. In 1992, there were some 21,000 pupils with a non-Norwegian language in Norwegian primary schools. This is 4.5% of the total number of pupils. In Oslo, however, the percentage of new school children with a non-Norwegian background is about 24%. In some inner urban areas of Oslo the percentage is much higher; in some places they are in the majority.

Pupils with a non-Norwegian mother tongue receive extra teaching in Norwegian. They are to a certain extent also given education in their own mother-tongue, although it has become a controversial issue whether this should be a public responsibility for the Norwegian authorities. Non-Norwegian adults are given free lessons in Norwegian language and society. The cultural isolation of some of the immigrant groups has recently become a growing concern. Even children born in Norway are found to have insufficient skills in Norwegian to deal with demands at school.

7.4 Special education for handicapped children?

Special education has a very strong tradition in Norway. Many schools for pupils with special educational needs were established in the decades after the war. Towards the end of the 1980s, there was a shift in policy on issues relating to special education, leading to the adoption of a policy of integration. Many schools and other institutions for special education were closed down, and both pupils and teachers transferred to ordinary schools in a policy of 'integration'. (This fact may explain part of the apparent high teacher-pupil ratio in Norwegian schools.) The current philosophy is that, whenever possible, all children of the same age should go into mixed-ability classes catering for all children, including those with physical as well as mental handicaps. Many blind and deaf children go to ordinary schools, and so do many children with Down's syndrome.

8. Recent developments and debate

In a period of rapid change, it is evident that many of the reforms are controversial and are met with opposition. Some of these are mentioned in the above text. In addition, new areas of conflict are about to emerge. Some of these are connected to the dramatic reform of upper secondary education, a reform that started in the autumn of 1994 (Reform 94, see section 0.2) A consequence of this reform is that a much larger proportion of the age cohort follow the same courses up to age 17 (and even higher). There is a growing critique that the theoretical and conceptual demands of academic subjects (especially mathematics and science) are too high for the large group of pupils that in previous years went on to vocational training after comprehensive school. It is contended that the new system creates school losers by keeping pupils too long in ordinary, theory-oriented studies. On the other hand, there are also complaints from the previously academically-oriented branch of upper secondary school that they have to lower the level in order to cater for the new groups of unmotivated pupils. The ministry (and in particular, the minister) is accused of overestimating the proportion of pupils that are theoretically inclined and motivated.

New school reforms will soon follow also in the compulsory comprehensive school, which from 1997 will be a 10-year school (see section 0.1). This reform of the whole comprehensive school (with the acronym GR97), will be implemented from 1997. Today, new national plans and curricula are being prepared. They will be based on the new core curriculum (KUF 1994a) already passed by Parliament. There are signals that science will be a subject in its own right from an earlier stage instead of being integrated in the *o-fag* as it is today (see section 1.2). It is also evident that national control over the contents of schooling will be 'taken back' after a period when national control has diminished. A more prominent place for science in the curriculum is expected. This will also have consequences for teacher education and for in-service courses for teachers. Many of the recommendations from the National Science Review are likely to be implemented (see Appendix 1). The role of technology as a school subject in the comprehensive school is also being debated, but the outcome remains uncertain.

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Mededelingen Kl. 64.06, 1994.

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Appendix 1

National report, Norway

Science review, abridged translation of main findings and recommendations for comprehensive school and teacher education, 1994.
(Translation by Doris Jorde)

Science Evaluation Committee

Svein Sjøberg, chair

Doris Jorde

Anne Lea

Knut Haldorsen

Notes: This report deals with grades 1-9 and teacher education. We define primary as 1-6 and junior secondary as 7-9.

Findings

Science is practically not taught at the primary level, and there is a particular absence of chemistry and physics.

The number of hours of science at the junior secondary level is lower than in other countries.

Primary and junior secondary science is for the most part theory and textbook-based with chalkboard teaching methods. The experimental and experiential base of science teaching is not well developed.

There is often little equipment for practising a good science program. Split classes are not used enough in science teaching (only half of the class at a time).

Primary teachers are poorly qualified to teach science. Student teachers tend to be those who have not studied the sciences at senior secondary and are able to choose other subjects in their teacher education.

The number of teacher education students concentrating on the sciences is low. Generally science is thought of as negative.

The negative picture of science is also found in pedagogical textbooks used in teacher education.

We lack a formal degree program which would qualify teachers with a teacher education school background to concentrate on the 'hard' subjects taught in school. The present situation allows them to only take degrees in pedagogy after they have completed teacher training.

Teachers and schools do not recognise the need they have for in-service science courses. Those teachers with the least education in the sciences also have the least need to take such a course. We have integrated science away from the primary level by integrating it with the social sciences.

Experimental or experience-based in-service science courses show that teachers can enjoy teaching science.

We teach integrated science in grades junior secondary (physics, chemistry and biology). Very few teachers are formally qualified in all of these subjects.

The little we do know about the level of science knowledge of Norwegian pupils indicates that they are not doing very well.

Pupils show a negative attitude to science when they finally meet it as a course.

Girls especially become negative towards science and tend to choose other subjects when the possibility arises.

At the departmental level, we do not have statistics which show teachers' subject competency. We have increased teacher education from 3 to 4 years and have fewer statistics about these teachers than we had before. Student choice in education is without national steering.

At the school level, there is no formal initiative which would require administrators to hire new teachers with science competency when it is lacking in a school.

The number of men working in day care and the early school years has decreased, meaning that male role models are not in children's lives in education. This also means that young children are not being exposed to activities dealing with work tools, science and technology.

Very little place is given to science topics in 'orienteering' at the primary level. The little science that is taught is 'nature studies' and little chemistry or physics.

The little science that has been written into orienteering books has many errors. The philosophy behind science and technology is one of 'the bad guys'.

Technology is not presently found in schools.

Earth science is also lacking in science courses.

Science teachers and educators do not have an interest organisation, whereas many other subjects do.

Despite the fact that many reports have described the poor situation that science has in schools, the situation has been steadily declining.

Based on these findings we have recommended the following for ***national science curriculum guidelines:***

Science should be made a subject by itself, separated from orienteering.

New ideas and models for science textbooks are needed.

A curriculum development project is recommended which could be supported by the department.

We continue to teach science as an integrated subject (chemistry, physics and biology) at the junior secondary level.

The number of hours science is taught must be increased from the present level.

The experimental nature of science must be stressed at all levels. To accomplish this schools will need more equipment and the possibility to teach smaller classes.

School structures and plans must be made to accommodate science teachers who will work away from the classroom. This is especially important for the lower grades.

The following recommendations are made concerning ***teacher education***:

Development of statistics which can show which subjects teachers are taking and the competency teachers have at each school.

The establishment of guidelines for subject competency for junior secondary science teachers.

In-service courses for primary teachers who lack a science background.

National steering of teacher education.

Establishment of courses such that teachers from 4-year teacher education schools have possibilities to take advanced degrees in subject areas.

The following ***projects*** have been recommended:

The establishment of an interest organisation for science teachers and educators.

Initiation of a national science curriculum development project.

Establishment of science evaluation in schools.

Establishment of a project in scientific literacy.

Appendix 2

Country report, Norway

Compulsory education.
Allocation of teaching periods. (From KUF 1994c)

Compulsory education. Allocation of teaching periods.

Subject	Primary stage			Lower sec.stage
	Years 1-3	Years 4-6	Total years 1-6	Years 7-9
Religious instruction	6	6	12	6
Norwegian	20	16	36	14
Mathematics	13	11	24	11
English	2	7	9	9
Civics	7	15	22	
Social Studies				9
Natural Science				8
Music	3	6	9	3
Arts & Crafts	5	12	17	5
Physical Education	4	6	10	8
Home Economics		3	3	4
Optional subjects				11
Pupil and class council	30**)	60**)	90**)	2
PSCW *)	50**)	75**)	125**)	150**)
Total	60	82	142	90
At local disposal			5	
Total			147	90

*) Practical, social and cultural work.
**) Total number of lessons in the three year period. The activities are integrated into all subjects.

Appendix 3

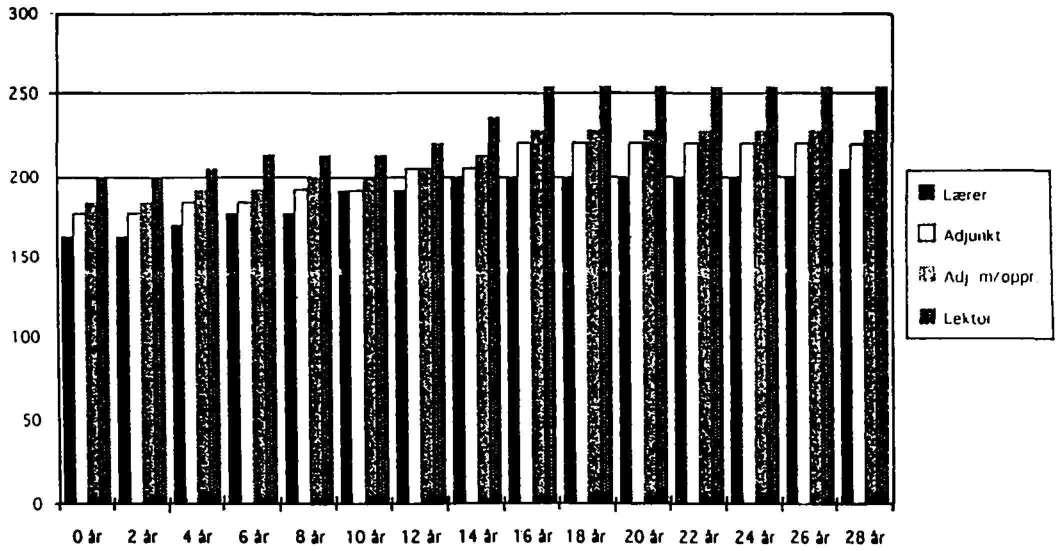
National report, Norway

Teacher's salary scales (In NKR 1000 per year before tax)

Conversion rates:

1 ECU	=	8.3 NKR	1 DM	=	4.35 NKR
1 UKL	=	10.7 NKR	1 USD	=	6.85 NKR

Pay scales are nationally decided, and payment is according to level of education, regardless of where you teach and which subjects you teach.



Graphs show salary development with years in service. No increase after 16 years.

Teacher categories in graphs:

Lærer: Teacher, usually with a three year education from college of education, teaching mainly at primary level.

Adjunkt: Teacher from college or university, with about 4 years education

Adjunkt m/ opprykk: *Adjunkt* with one year extra education (in total some 5 years)

Lektor: Teacher with highest degree, mainly from university, approximately 7 years

Report from Portugal

Teresa Ambrósio

Introduction

This report is focused on Portuguese compulsory education, which encompasses the first nine years of schooling. The choice was based on the diversity of viewpoints - pedagogical, curricular, scientific, social and cultural - that lends special interest to compulsory education in Portugal, which has been experiencing a process of reform since 1986. Moreover, compulsory education constitutes the basis for fostering science education for all.

This does not mean, however, that the team does not consider as equally relevant the comparative and prospective study, on a European dimension, of science teaching at a post-compulsory and pre-university level. At such levels, the problem of the continuous updating of both curricula and teaching methods has been caused by the impressive evolution that scientific knowledge has undergone and by the increasing demand of basic and updated scientific knowledge for the practice of science-based jobs.

This report was based on a wide range of documentation from existing laws to official texts that contain theoretical and political foundations of the curricula, general recommendations for teaching and science programmes. The team also included critical analyses based on each member's personal experiences as a result of the work they have been developing with science teachers and schools.

The process of developing this report involved a continuous exchange of ideas and discussions between those people who participated in it: the members of the Portuguese team, the European partners who were producing their own country reports, and the Portuguese specialists from different domains related to education - science educators, psychologists, sociologists, policy makers and philosophers of education.

The Portuguese educators were asked to read a preliminary version of the report in order to generate criticisms, suggestions for improvement, and more general recommendations concerning science education in Portugal. A workshop was organised with the purpose of opposing participants' reactions as triggered by the reading of the report.

Several working meetings were organised with the European partners. These meetings enabled the exchange of ideas and culminated in a conference that was opened to an enlarged invited international audience (see in Appendix 2 a summary of the Portuguese communication).

The team believes that this is not a totally comprehensive report in that it only reflects a fraction of the reality of Portuguese education. In fact, what this report shows is mainly a factual perspective of a centralised system and its educational view of the school as an entity without flexibility, expression and autonomy.

In order to solve that problem, the team considers that in-depth, in-context analyses about everyday classroom practices could bring out other data that would enhance the understanding of both the teaching process and the development of scientific literacy of the Portuguese citizen. Such a goal is a relevant issue to compare at an international level.

Therefore, we advocate a future addition to this report consisting of in-depth descriptions of what has been done in order to promote change in educational practices, based on questions such as: in which schools, with which teachers, for what reasons, integrated through which innovations and with the support of whom? According to this analytical approach, it would be better to study fewer questions related to the teaching of science (involving, for example, contents and teaching methods, and teachers) and more questions related to science education in general, involving, for example, concepts, cognitive development, logical issues related to scientific reasoning, problem solving capacities, experimental reasoning capacities, technological competencies, interdisciplinary approaches, and availability and use of information resources.

In conclusion, we suggest an analytical study of the present situation framed on a political-scientific-cultural and global perspective instead of a technical and administrative point of view, that is, basic science education approached through a multiplicity of education processes with the purpose of improving the Portuguese people's basic scientific literacy.

Despite not expressing an objective opinion which has been completely justified, the team would like, at this stage, to point out some of the more relevant problems that have conditioned change and innovation in the quality of teaching and the success of science education in Portugal. We would like to emphasise the following:

1) Lack of efficient dialogue among the influential members of the educational community, namely, scientists, researchers in education, teachers, and political and administrative authorities. The few cases of dialogue that have occurred have failed to provide the public with an explanation or to lead to a change in public opinion. Scientific debate on educational topics is practically absent, with the exception of some occasional lectures and symposia. Public debate is strongly supported by interest groups, such as trade unions, private schools, political lobbies, and also by funding strategies with no pre-established criteria appropriate to the promotion of the present educational reform.

2) As a consequence, public opinion changes cyclically, from the demand for changes which involve educational processes and the quality of both technological and science education, to the support of conservative opinions which are detrimental to the development of the population's scientific literacy.

3) Frequent changes in educational authorities. Due to the tenacious centralisation by the Ministry of Education, political authorities have accumulated enormous control over different processes, including careers counselling and school budgeting. When a change occurs in the government, simultaneous alterations in political orientation occur which have an impact in school management and which disturb the experimental implementation of innovative programmes. Changes according to such orientations have been made quite often on the basis of budget decisions, many of them depending on EC funding, with no respect for scientific or pedagogical criteria. Economic efficiency has taken priority in spite of being non-coincident with the objectives of the reform. As a result, serious damage has been done to the implementation of educational programmes such as in-service training and the expansion of the school network.

4) Lack of cooperation within projects, which fail to have clear and coherent objectives, between the agents of formal science education and those involved in the dissemination of information to the public. Such limitations do not allow the integration of students' knowledge, acquired through the media and informal education agencies, with the formal teaching-learning process of science.

5) Lack of educational resource centres which are able to compensate the limitations in experimental work and technological education, for example, in a

saturated school system which has poor conditions for promoting good quality teaching.

One can add to these considerations the lack of determinant stimuli for teachers to update their teaching abilities, lack of support to those teams of teachers and educators who, having demonstrated a particular dynamism in their schools, are developing innovative programmes under difficult conditions, lack of effective attempts to decentralise the system with the concomitant lack of appreciation regarding the diversity and pluralism of educational projects, overall lack of participation on both national and international collaborative projects involving, in some instances, the use of EC funds.

The deep changes that the Portuguese educational system has been experiencing, which involve a multiplicity of perspectives, have not yet stabilised. Present dynamics of change lead to new trends which concern science education objectives, methodologies, contents, teaching aids, the role of the teacher and the school, and the role of the students, to name just a few. These are in some cases radically different from those previously reformed. One may comment that this report lacks an historical perspective and we would agree with that. However, facing the nature of this report and the complexity of the present situation, we decided to concentrate our analysis on present reform issues as a starting point for future contributions about scientific literacy in Portugal and in Europe.

Within the context of Portuguese educational reform and within the context of our analysis, we realised that, for a complete understanding of the nature of science education and scientific literacy in Portugal, we needed to expand our analysis to other areas that traditionally do not integrate science. As a result of one main trend within the present national curriculum, which is the establishment of multiple interactions between the school and the environment, all the disciplines are oriented towards integration. We do not mean that such integration is visible in both schools' and teachers' practices. However; curriculum recommendations show, for instance, that not only the contents of geography and history overlap the contents and methodologies of science subjects, but that there is also a general consistency between the objectives of the different disciplines and the general trends of curriculum organisation. Therefore, we decided to include geography and history in this analysis in order to widen perspectives which include different contributions to science education and scientific literacy.

1. Science in the National Curriculum

This section contains information about the Portuguese national science curriculum extracted from documentation published by various departments of the Ministry of Education involved in the Educational Reform. Data selected are the basis for a comparison with similar descriptions from other countries. Data from both research and systematic sources covering most of the topics of this report either do not exist or are not available in Portugal. Therefore, data provided in subsections 1.3. and 1.6. are mostly based on the personal experiences of the authors of this report as a result of the work they have been developing with science teachers and schools.

1.1 Recommended number and duration of lessons

According to the present educational reform, compulsory education consists of 9 years grouped into three cycles. This subsection contains a description of both the number and the duration of each scientific area formally taught in each cycle (cycles 1 to 3; levels 1 to 9).

The reform considers three major school situations in which science is approached according to: (1) the conventional science curriculum subjects either integrated or separated by discipline as explained later in this report; (2) the School Area that is a compulsory curriculum issue not taught in conventional lessons; (3) the Complementary Curriculum Activities which are not compulsory or included in formal science subjects (DGEBS, 1990).

a) First cycle

The first cycle includes 4 schooling years (levels 1 to 4) for children starting at 6-7 years old. Science topics are integrated in one discipline called Study of the Environment. Mathematics is taught separately. All the subjects are taught by the same teacher.

Elementary teachers and the respective school's senior management decide how much time to dedicate to each subject within the minimum of 25 hours per week. First cycle classes function in special schools belonging either to the public, private, or cooperative system. There is a great diversity of elementary schools, from schools with only one teacher and few students (minimum 15) generally found in inner regions of the country, to schools with many teachers and many students in urban centres. Small schools are becoming progressively extinct. Integrated basic schools in which the three cycles are taught started in 1990/91.

b) Second cycle

The second cycle includes 2 schooling years (levels 5 and 6) for children 10-11 years old. The allocated time for each schooling year is 31 hours per week distributed by school periods of 50 minutes each. Ten periods per week are dedicated to science subjects as follows:

History and Geography of Portugal	3 periods
Mathematics	4 periods
The Science of Nature	3 periods

c) Third cycle

The third cycle includes 3 schooling years (levels 7 to 9) for children 12 to 14 years old. The time allocation for each schooling year is 31 hours per week distributed by school periods of 50 minutes each. Fourteen periods per week are dedicated to science subjects plus 3 periods for an optional discipline. Table 1 shows the distribution of the time periods according to each discipline and the schooling year.

Table 1: Distribution of science time periods per week in the third cycle

Discipline	**Level 7**	**Level 8**	**Level 9**
History	3	3	3
Geography	3	-	4
Mathematics	4	4	4
Physics and Chemistry	-	4	3
Natural Sciences	4	3	-
Technological Education[1]	3	3	3

[1]Optional

Both the School Area and the Complementary Curriculum Activities are subject areas taught in the three cycles, according to the decisions taken by teachers and students involved.

1.2 Which sciences are to be taught

This subsection provides an overview of how science subjects are organised in the present Portuguese curriculum. It starts with a description of selected curriculum guiding principles, followed by a description of how science subjects are organised in each cycle and which content is taught in each discipline or subject area.

a) Science curriculum guiding principles

The curriculum guiding principles for science curricula are as follows:

Science education should enable students (a) to develop an understanding about themselves and the natural world; (b) to develop an understanding of science as a human activity for solving real life problems; and (c) to develop positive attitudes towards knowledge and discovery.

Science teaching should question the value of solutions provided by science, enhancing these as social-cultural conditions change and research technologies improve. Well established hypotheses and theories can be challenged, modified and even substituted.

Schools should be able to face a new challenge, that is, to prepare citizens, (a) aware of the deep and strong relationships that exist between humans as well as between humans and nature; and (b) able to critically reconstruct their own knowledge in response to the continuous interactions they establish with the environment.

Disciplines in each level should have their content articulated in such a way as to enable students to understand that there is an integrated approach to knowledge that goes beyond the conventional disciplines. This should be done without forgetting the importance of development of both factual knowledge and process skills related to the operational concepts of each discipline (content's horizontal articulation).

Disciplines that are part of sequential levels should have their content articulated in such a way as to enable students to expand both their knowledge and their competencies throughout the various teaching cycles (content's vertical articulation).

Knowing how should be valued over knowing what:

Alternative knowledge, which does not always match knowledge traditionally conveyed by the school, should be valued. Such knowledge is built upon students' personal experiences and expectations leading to a personal cognitive grasp of the reality.

Active, student-centred teaching methodologies should be implemented in order to: (a) enable students to direct personal experiences and interests towards their own learning; and (b) promote relationships between the school and the environment.

In and out-of-classroom conditions should be created in order to engage students in searching for information, observing, hypothesising, making decisions, and developing projects either individually or in groups.

Students should access information using computer based technologies. The potentialities of these technologies for graphical analysis and simulation can give rise to various activities involving exploration, research, recovery and development.

b) Science curriculum disciplines

How science subjects are organised, and which content is taught:

1. First Cycle

The *Study of the Environment* includes "concepts and methods of various sciences such as history, geography, natural sciences, anthropology and sociology in order to promote a progressive understanding of the relationships between nature and society" (DGEBS, 1990, pp. 67).

The *Study of the Environment* includes "concepts and methods of various sciences such as history, geography, natural sciences, anthropology and sociology in order to promote a progressive understanding of the relationships between nature and society" (DGEBS, 1990, pp. 67).

1) *Discovering oneself.* The purpose of this group is to enable children to construct knowledge about themselves as well as to develop attitudes of self-esteem and self-confidence, valuing their own identity and origins. The following topics are common to the four levels of the first cycle: the body, the body's health, the body's safety (DGEBS, 1990, pp. 70).

2) *Discovering the others and the institutions.* Children become aware of the functions and roles of social groups, developing attitudes and values related to

responsibility, tolerance, solidarity, cooperation, respect for difference, and non-sexist behaviour. (DGEBS., 1990, pp. 75).

3) *Discovering the natural environment.* Contents of this group relate to the environment's basic elements (air, water, rocks, soil), the living beings that live there, the climate, the landscape, and stellar space. The following topics are taught in different levels: living beings and the environment (levels 1, 2), physical aspects of the local environment (levels 1, 2, 3), physical aspects of the environment in general (level 4), the stellar space (levels 3, 4), physical aspects of Portugal (level 4).

4) *Discovering relations between spaces.* It is assumed that the notion of space is constructed from practical experiences related to motions, locations, and distances. The following topics are taught: communication (level 3), how to locate spaces in relation to a referential (levels 1, 3); the motions of living things (level 3), connections between continents and oceans.

5) *Discovering materials and objects.* Students explore everyday objects through observation and experimentation (DGEBS, 1990, pp. 87). Such activities involve manipulation of objects (levels 1 to 4) and experimentation with everyday objects (level 1), water (levels 1, 4), sound (levels 1, 4), light (level 3), magnets (level 3), electricity (level 4), and air (levels 2, 4).

6) *Discovering relationships between nature and society.* This group is taught only in levels 3 and 4 with the following goals: to promote positive attitudes towards the conservation and the improvement of environmental conditions and the rational use of natural resources, and to promote active and unambiguous participation in solving natural problems (DGEBS, 1990, pp. 91). Essentially, topics are related to local human activities, such as, agriculture, mineral exploitation, industry, tourism, cattle raising, and fishing. Level 4 is dedicated to the main Portuguese industrial and commercial enterprises and the quality of the environment.

A major emphasis is put in the first cycle on the development of positive attitudes towards mathematics as a way of allowing children to remain active, questioning, and imaginative human beings. This cycle focuses specifically on Numbers and Operations (natural numbers, and their operations, mental computation), Quantities and Measurements (estimation, units, measurement devices), Space and Shape (spatial orientation, solids, plane figures, transformations, and drawing devices). These topics should be taught using a problem solving approach. Special care is given to the use of adequate learning environments, namely through the use of materials, recurrent activities, language and representation (DGEBS, 1990, pp. 127).

2. Second Cycle

Science subjects are grouped according to two major areas, (a) *History and Geography of Portugal*, in which history and geography are put together in one single discipline; and (b) *Exact and Natural Sciences*, which includes mathematics and natural sciences as two independent disciplines. Issues about technology are not included. Technology is approached within the area of 'visual education' and is limited to the utilisation of tools in order to build different kinds of objects and devices.

a. History and Geography of Portugal

The topics of history taught in this discipline are organised according to the following themes: (1) The Iberian Peninsula as a place of passage and as a place of settlement; (2) Portugal in the past; (3) Portugal today.

Geography starts with the theme *Looking at the Earth* with the purpose of remembering and deepening basic knowledge acquired in the first cycle.

Throughout the second cycle, geography is approached according to country, as a unit of analysis. Within the theme *Portugal in the Past*, geography is approached with the purpose of allowing students to perceive space as something whose components are in constant change. The theme *Portugal of Today* enables students to understand that the national space is the result of interdependent spaces with different dimensions. Students construct an elementary picture of the contrasts inherent to space organisation, leading to an understanding of economical, social, and cultural differences.

b. Mathematics

The content of the second cycle is organised according to the following topics: Geometry (solids, perimeter, area and volume, geometric figures, symmetry), Numbers and Computations (integers and their operations, divisibility, fractions, numerical expressions), Statistics (data collection, organisation, and interpretation, tables and graphs; mode and mean), and Proportionality (direct proportionality, percentage, pie charts, scales) (DGEBS, 1991a, pp. 148).

c. Natural Sciences

The content of this discipline in both levels 5 and 6 is organised according to the unifying theme - *Earth: The Environment for Life*. Level 5 is dedicated to both biological and geological diversity. It includes the following units: (1) Diversity of life, Interactions of living beings with the environment; (2) Unity within biological diversity; (3) Earth materials - water, air, rocks, and soil.

Level 6 is centred on life processes and the ways these processes interact in a balanced organism. It contains the following units: (1) Biological processes; (2) Assaults on both the environment and the integrity of organisms.

d. School Area

The School Area is present in all levels and cycles of both basic and secondary school. It is a curriculum area and not a discipline. The main goals are: (a) to make knowledge operational through interdisciplinary activities and projects; (b) to encourage interactions between the school and the community; and (c) to promote students' personal and social preparation.

At the beginning of the school year each school selects several themes as potential School Area projects. Each project involves the students of one class (or more) and respective teachers. In general, people from outside school, other than students and teachers, are asked to participate, such as school employees, parents, members of the community's government and local representatives. The school becomes, hence, a generative nucleus for the cultural development of the community.

"To sum up, the traditional disciplines are not explicitly present in the first phases of the Portuguese educational system. Up to *secundário*,[...] the programmes do not set out to study the science disciplines for their own sake. The science is identifiable by its characteristic knowledge" (Bárrios & Daudin, 1994, pp. 45).

3. Third Cycle

In the third cycle, disciplines are separated as follows: history, geography, mathematics, physics and chemistry, natural sciences. Technological education is an optional subject.

a. Geography

Throughout the third cycle, geography is approached according to the following units of analysis: Europe - level 7; the World - level 9.

Subject matter is organised according to a common structure: (1) study of the population, including the definition and application of basic concepts of demography, and the analysis of the factors for population distribution and evolution; (2) analysis of three dimensions related to space organisation - rural, urban, and industrial dimensions; (3) exploration of the concepts of interaction and interdependence in which the study of demographic, commercial and information flows are associated with the analysis of the networks that support them; (4) study of the new dimensions and variables that characterise human development; and (5) framed on economic models, study of questions about the need to preserve the environment and the country's heritage.

b. History

According to the curriculum, the thematic areas for this discipline are organised in order to give a general approach to history.

c. Mathematics

The third cycle includes the following topics: Geometry (plane and space, geometric figures, constructions, transformations, trigonometry); Numbers and Computations (divisibility, rational and real numbers, equations, inequalities); Statistics and Functions (direct and inverse proportionality, graphs, tables, data collection, mean, mode, median, probability) (DGEBS, 1991b, pp. 172).

d. Natural Sciences

Earth and Life Dynamics is the underlying theme of this discipline. It is divided in two sub-themes: *Earth, the Living Planet* (level 7) and *Life: Regulation and Conservation* (level 8). The first sub-theme contains the following units: (1) Geological activity; (2) Earth history; (3) Dynamics of the ecosystems. The second sub-theme contains the following units: (4) Energy and life; (5) Coordination of the organism - neural and hormonal system; (6) Transmission of life.

e. Physics and Chemistry

The development of the curriculum of physics and chemistry has been both a difficult and a controversial process. As a consequence, the experimental implementation of this discipline has been continually postponed. The texts presenting the curriculum structure, recommendations, objectives and contents have been published (DGEBS, 1994). Level 8 started implementation in 1994/95 and level 9 in 1995/96.

Despite being put together in a single discipline, physics and chemistry are taught sequentially. The school year is divided in two equal parts. The first part, in general, is devoted to physics and the second part to chemistry. Textbooks support this situation since most of them have the teaching units related to each science in separate volumes.

The text with the recommendations for physics and chemistry refers to the lecture method as the one most widely used by the teachers of this discipline. Pointing out the need to move towards experimental work and a closer relationship with students' everyday lives, the following principles are presented: (a) provide students with the sound scientific information necessary for the comprehension of what is happening in Portugal, Europe and the world; (b) such scientific preparation is important for all students and not only for those who want to follow a career in science; (c) given the characteristics of today's world, students need to develop competencies enabling them to act in the future as educated consumers and as involved citizens. They should be able to solve real-life problems using both their scientific and their technological knowledge.

The programme of physics and chemistry is structured around three basic dimensions:

1) *Relationships with everyday phenomena.* The teaching-learning process of physics and chemistry should emphasise not only scientific explanations about everyday phenomena but also the acquisition of knowledge and the development of competencies enabling the student to assess the impact of these sciences on the well-being of humanity and understand the need for educated decision-making (DGEBS, pp. 5).

2) *Scientific dimension.* The discipline of physics and chemistry should stimulate the acquisition of concepts, laws, theories, and models as well as engage students in experiencing the processes inherent to these sciences.

3) *Structure as school knowledge.* The scope of physics and chemistry goes beyond the study of the principles of physics and chemistry. It encompasses other scientific domains such as astronomy, meteorology, biochemistry, and electronics. As a curriculum discipline, it should use elements different in nature (technological, social, cultural and ethical), contributing to the development of a multiplicity of competencies and attitudes.

Both sciences are structured according to thematic areas which do not correspond to the traditional divisions of physics and chemistry. The thematic areas are centred on contemporary issues and related to everyday activities.

The thematic areas for physics are the following: (1) Man and the universe, (2) Production, distribution and utilisation of electricity, (3) Sound and audition, (4) Light and vision, (5) Production and energy consumption, (6) Transports and safety, (7) Radiation and environment, (8) To control and to regulate, (9) Atmosphere and climate changes.

The thematic areas for chemistry are the following: (1) The material world and ourselves, (2) Chemical substances: What are they? What can we do with them? (3) Chemical transformation and the world around us.

f. Technological Education

Technological education is an autonomous and optional discipline of the third cycle which continues the artistic and technological education of the second cycle. In order to promote an understanding of the technological world and the scientific mind, the goals of this discipline are to develop: communication skills, technical and manual aptitudes, problem-solving skills, critical thinking, and a social sense. These goals can be attained through the following areas of intervention: nutrition, environment, home, recreation, resources, and clothing.

A distinction between the terms *technique* and *technology* is presented in the curriculum guiding principles. Technique is limited to the utilisation of tools and specific methodologies in order to obtain reliable results (DGEBS, 1991, pp. 338). Technology implies the search for a solution in which multiple data from several domains (physics, mathematics, history, fine arts, economics) are used. The end product of such a project is a solution considered the most appropriate for a certain problem (DGEBS, 1991, pp. 338). Students should have an understanding of the meanings of both terms through the use of a diversity of tools and devices as well as through the development of projects focused on well defined practical problems in which they have to apply the scientific knowledge they have learned in various disciplines. Consequently, technological education should be an integrative nucleus appropriate for the development of a technological attitude. The science programmes contain several situations in which students, adequately oriented by the teacher, can integrate the issue of technology and its interactions with science and society.

Complementary issues related to technology are included in the programmes of the different science disciplines of the third cycle. Many suggestions are made in order to integrate scientific knowledge, technological development and their effects on society. It seems to us (although we recognise that this is a controversial issue) that 'on the paper' conditions are created in order to provide a broad and deep perspective of the relationships between science, technology and society, along the lines expressed by such contemporary authors as Solomon (1993) and Ziman (1980).

1.3 Realistic data on the above

With the purpose of giving an overview of how realistically the specifications of the national curriculum seem to be carried out, this section is organised according to the disciplines taught in the three cycles.

Systematic data about the level and quality of accomplishment of the Portuguese curriculum specifications are scarce. We do not have a supervision system similar to those that exist in other countries which would constitute a reliable source of data. Besides, we are living in the experimental phase of a curriculum reform. Therefore, information given in this section is mostly based on data informally obtained from a diversity of sources directly related to the schools and to the teachers.

Given the centralised Portuguese educational system, curriculum recommendations should be expected to coincide with the national implementation of each discipline. In addition, the number and duration of hours taught in Portuguese schools as well as the disciplines taught should coincide. However, opportunities for variability are offered regarding the emphasis given to the content, objectives, and activities. The programmes are presented with substantial flexibility giving teachers the opportunity to organise the teaching-learning process according to their convictions, their preparation, the students and the resources available.

a) Study of the Environment

Research in several countries has shown that elementary teachers tend to devote less time to science subjects compared to the time devoted to basic subjects such as reading, writing and arithmetic. These teachers evoke a lack of scientific preparation to teach most of the science topics. In Portugal, according to the recommendations of the new programmes for the first cycle, an identical situation is expected unless adequate programmes for the scientific and pedagogical preparation of teachers are offered. In fact, the new programmes recommend that teachers should organise the classes in order to correspond to: (a) the population of students with different preparation, learning styles, interests and needs; and (b) the specific characteristics of each school's environment. Therefore, teachers are free to change the sequence of topics, to associate the content of the programme with other contents they consider relevant, to decide how far to go regarding each topic, and to add new content (DGEBS, 1990, pp. 68). Such flexibility enables one to assume that the Study of the Environment has been and will be approached in many different ways, according to the teacher, and the resources of the school and the community. It would be interesting to know what effectively has been done in Portuguese schools and what has been the intervening role of the teacher, as well as of the school, in this process.

Three brief case studies of Portuguese elementary schools revealed teachers' dynamism in order to get their students involved and to obtain resources. These studies also show a tendency for collaborative team work among teachers, and for the development of cooperative teaching methodologies involving project work. Strategies for getting parents involved were also observed (Bárrios & Daudin, 1994; Bárrios & Cremin, 1994; Ryan & Barbosa, 1994).

b) Mathematics

Excessive emphasis has been put upon teacher-centred activities and, consequently, students do not have enough opportunity to experience mathematics. Some results suggest that students have to face a kind of mathematics characterised by the mere manipulation of formal symbols, specially at the more advanced grades. At lower grades excessive emphasis on the computational aspects of mathematics has been weakening children's comprehension of more complex mathematical reasoning processes. The Association of Teachers of Mathematics has argued that the recommended activities proposed by the Reform have not been put into practice, namely problem-solving approaches, the use of technology, the applications of mathematics and the development of projects.

There are no data available about the degree of accomplishment of the new curriculum in the various cycles. However, there are indicators pointing out difficulties in their teaching. Experimental implementation of the new programmes has shown excessive content coverage. In spite of this, no alterations were prescribed by the Ministry of Education. Presently, teachers in general agree that there is not enough time to teach the entire curriculum and simultaneously promote successful learning in most of the students. The Ministry of Education has implicitly recognised this problem through documents sent to the schools, but no measures have been taken to resolve it.

c) Science of Nature

The curriculum of this discipline is structured around unifying themes according to a systemic approach. However, experimental implementation has shown that the themes have been forgotten and have been substituted by a sequential and not a systemic structure.

Other aspects related to the way the new programmes have actually been applied throughout the country are shared with the discipline of natural sciences.

d) Natural Sciences

Several teachers and scientists have pointed out that the curriculum of natural sciences is too ambitious, as if one "would want to teach all the biology and geology in two years" (comment from a professor of geology from FCUL). Besides, recommended practices involving time-consuming experimental components are not compatible with the number of topics to be learnt. One may assume that the content of natural sciences is not, or will not be, accomplished by the majority of schools. It is not clear what the capacity of the Ministry of Education is to respond to this kind of reaction from the schools. Neither is it clear whether, in the event of such a response, it would fit teachers' expectations.

Non-coverage of content relates to teachers' practices of content management. Two extreme situations that limit a *continuum* of teachers' intermediary actions may be considered: to assume the leadership over the process of content organisation, or to follow passively and non-critically a pre-established sequence of content topics. Concerning the first case, the teacher plans realistically what can be done with the students in his or her charge and the resources available in and out of school. He or she then organises the content to be taught, and selects more general concepts upon which to centre the teaching-learning process, thus building something that becomes intelligible for students and gives them the cognitive tools for further knowledge.

Concerning the second case, the teacher is limited to teaching classes following a pre-established sequence of topics provided either by the prescribed programme or by a selected textbook. This provides no sense of the whole and hence the possibility of establishing relationships between concepts is lost, promoting students' acquisition of factual knowledge and hindering significant learning.

In conclusion, in order to understand how realistically this curriculum has been implemented, among other aspects, it is important to question teachers' common practices, understand which factors lead to decision-making as regards content management, understand how such decisions are reflected on the teaching-learning process, and clarify what the students are really learning.

e) Technological Education

Teacher preparation is a necessary condition for the development of a technological attitude among students. Presently, institutions of higher education that have teacher preparation programmes have been developing both research and curriculum development projects centred on science-technology-society themes. However, its systematic integration into current programmes of initial teacher training has not yet been observed. Teachers enrolled in graduate programmes have developed interesting projects, containing good activities, in collaboration with school teachers who are aware of the issues involving science, technology and society (Santos, 1994). However, these are isolated cases that do not reflect teachers' common practices. According to the guiding principles, the success of technological education depends on the establishment of close relationships between the school and the community, providing resources for students to observe *in situ* human activity and its effects on the environment. Consequently, the school should have an active role in both curriculum development and continuous teacher training.

In summary, present curricula enable a wide and up-to-date approach to technology and its relationships with the various disciplines taught. Lack of resources and lack of appropriate teacher preparation programmes hinder its implementation.

f) School Area

The School Area has generated controversy among teachers, educators, students, parents, and other community members. On one hand, there is a growing number of descriptions of successful interdisciplinary projects (Abrantes, 1994; Santos, 1994). On the other hand, teachers and parents show a tendency to demonstrate suspicion towards most of the activities developed in the School Area. According to them, such activities are no more than simple games and playful field trips with no educational value.

Teachers who have participated in School Area activities have commented how students genuinely get involved in the projects, producing high quality work. Collaborative teachers show great enthusiasm and report a set of advantages concerning the development of interdisciplinary projects. However, they regret their colleagues' low participation and the continuous everyday difficulties that must be overcome. In consequence, they ask for more aggressive support from the school.

It is interesting to notice that many projects have been initiated by natural science teachers. Projects such as building a lake in the school yard, planting a garden with Mediterranean species and producing a video describing the lichens of the region, involved the entire school and stimulated students to relate concepts, integrate knowledge, solve problems and discover authentically.

Because this is a new experience, it is fundamental to analyse, reflect, compare projects, exchange experiences and show what can be done. Such interventions that lead to an assessment of what has been done facilitate the implementation of new projects. Moreover, one may rethink the role played by schools based on the experiences that have been developed within the School Area (Praia, 1994).

Methodological curriculum recommendations in general are considered clear, useful, and appropriate regarding the objectives. However, teachers refer to "specific characteristics of the students, number of students per class, a lack of both human resources and instructional materials, and a lack of appropriate funding as conditioning factors for the attainment of the recommendations" (I.I.E., 1992, pp. 4).

1.4 Recommended learning activities

The Portuguese curriculum recommended activities relate to the attainment of several objectives grouped in the following domains: (1) personal preparation and social integration, (2) acquisition of knowledge and competencies, (3) preparation for citizenship. A sample of these objectives is presented as follows:

- To develop the concepts of space, time and quantity, establishing logical relationships, evaluating and drawing hierarchies;
- To develop thinking, problem-solving and communication skills;
- To develop memory, accuracy, critical thinking and creativity;
- To develop an experimental methodology in approaching problems which enables the comprehension of both the natural and the technological world;
- To develop concerns about accuracy regarding the physical and social reality in order to enable the acquisition of basic methods and techniques of inquiry and data processing;
- To develop an open mind and the willingness to become a responsible citizen, specially regarding future decision-making about the preservation of both the natural and the cultural heritage;
- To become aware that science has limits, particularly with regard to the solution of human problems;
- To stimulate and sustain students' motivation towards learning in general and towards the learning of scientific processes;
- To encourage the application of both scientific principles and methodologies in order to solve problems.

"The official programmes specify [...] a general orientation towards differentiated teaching, but without giving preference to one particular approach. [...] There are not specific connections between teaching strategies and content, even when the guidelines are in the same chapter that specifies the contents, regardless of the age range" (Bárrios & Daudin, 1994, pp. 48).

a) Study of the Environment

Aimed at stimulating accuracy when approaching the natural world, the programme of this discipline recommends learning activities in which students should make contact directly with sources of information using techniques for data collection such as direct observation, questionnaires and interviews. Students should organise collected information in brief reports or monographs, organise albums, pictures, posters, tables and graphs.

Concerning the student's personal history, the construction of time lines is recommended. This enables students to develop a better sense of time, which is important for further studies in science. Similarly, the construction and the study of maps in order to develop a better sense of space is recommended.

Other activities are recommended in the programme such as: to develop simple experiments and inquiries in order to encourage students to ask questions and look for answers; to observe natural phenomena directly, using as many senses as possible; to collect samples (without disturbing the environment); to use observation and measurement devices in concrete situations; to write down the observations and data collected in the appropriate manner; to develop experimental work centred on common materials and encompassing the following operations - observation, introducing changes, appreciation of the effects and results, inferring conclusions; to observe events and people in the community directly through the use of interviews, pictures, etc. (DGEBS, 1990).

b) History and Geography of Portugal (Second Cycle), History and Geography (Third Cycle)

Recommendations do not relate to specific activities with the exception of the production of the *Atlas of the Class* and the *Chronological Ribbon*, which are considered to be indispensable tasks for the articulation, in terms of space and time, of the various sub-themes.

Within history, besides the activities recommended in general for the three cycles, the programme suggests field trips to monuments and museums as well as an introduction to the study of various kinds of documents: texts, maps, and pictures.

For the purpose of engaging students in the first and second cycles in research techniques involving, among other activities, the selection and organisation of materials, the organisation of thematic portfolios is recommended with the support, whenever possible, of new information technologies. Students should therefore use the computer in order to process information and communicate the results of their research.

In the field of geography, the recommendations in general match the principles of active pedagogy, promoting interdependency between the school and the community, and stimulating students' motivation and participation. Students should therefore have the opportunity to search for information, observe, formulate hypotheses, make decisions, develop a critical attitude, work either individually or in groups, develop projects, engage in games and simulations, and go on field trips.

The use of the media is also recommended, including television, radio, newspapers, films, literature, advertisements, and legal documentation, to cite just a few. Other sources of information about the region where the student lives and about Portugal, such as statistical data from surveys, are also indicated. Information obtained from such sources leads to the production of written reports as well as to the construction of maps, charts, and graphs. Cartography, hence, is a relevant resource, engaging students in activities in which they will develop competencies of graphical expression. Whenever possible students should use maps with symbols and scales.

Activities which bring together the school and the sources of informal education are recommended, such as field trips, attendance at conferences, seminars and similar initiatives, the consultation of bulletins, local newspapers, and cultural agendas.

The programme does not contain any reference to the history of geographical thought. Epistemological issues are essentially approached at the secondary level.

c) Mathematics

First cycle mathematics should stimulate children to collect and organise data, to make measurements using appropriate devices, to estimate, explore, construct and transform geometric models, explain and confront ideas with their colleagues and solve everyday problems. Problem solving, and the use of appropriate learning environments is recommended, particularly the use of materials, recurrent activities, language and representation (DGEBS, 1990, pp. 128).

The curricula of mathematics for the second and third cycles claim that they are adapted to student diversity. Therefore, the programmes are adapted to the student's level of development and to his/her progression. Proposed curriculum methodologies assume that students are the agents of their own learning. Concepts are built from individual experience, and can be approached from different perspectives, according to progressive levels of normalisation. It is suggested that student methodologies should follow five strands: problem solving, the development of thinking, mathematics as a communication vehicle, the learning of specific content, knowledge of the history of mathematics, and the use of specific resources. In the second cycle specific learning activities include: drawing designs and figures, the use measurement and drawing devices, the use of computer software, the use of the calculator to solve problems without forgetting estimation and mental computation, and data interpretation and representation (DGEBS, 1991a, pp. 148-149). In the third cycle the programme recommends learning activities centred on manipulation, observation, comparison, discovery, construction, making conjectures, discussion of relationships and properties, data collection, organisation and representation, and analysis of real life situations (DGEBS, 1991b, pp. 155-162).

d) Physics and Natural Sciences

This subsection refers to the following disciplines: sciences of nature, natural sciences, physics and chemistry. In general, the curricula of these disciplines refer to teaching methods in which the learner engages in the discovery of scientific facts. Science is perceived as a body of specific knowledge as well as a set of processes leading to knowledge. Both dimensions must be present in learning activities. Therefore, it is recommended that students read and analyse different kinds of written materials. Experimental activities in which students have the opportunity to ask questions, suggest possible solutions, design experimental devices, analyse data, infer conclusions and communicate both their own ideas and the results of their research are considered as relevant. Activities that go beyond the school are recommended, such as field trips, field work and various kinds of projects.

e) Sciences of the Nature (Second Cycle), Natural Sciences (Third Cycle)

Similar activities are recommended for both disciplines. Teachers should plan discussion periods involving student-student and student-teacher interactions in order to formulate questions and problems interesting enough to generate research projects. Therefore, experimental work "involving activities that characterise science" (DGEBS, 1991b, pp. 218) is considered very important.

The computer is viewed as something that works both as a source of information and as a medium for students to communicate their work. Emphasis is placed on the use of particular kinds of software such as word processors, spreadsheets, and databases.

f) Physics and Chemistry (Third Cycle)

Within physics and chemistry the activities recommended are centred on both experimental and practical work. A distinction is made in relation to both approaches. Experimental work, in and out of the laboratory, engages students in observations, explanations, and inferring conclusions based on theoretical knowledge.

Practical work is designed in order to attain three major objectives: (a) to develop specific techniques and practical competencies, (b) to provide contact with different physical phenomena, (c) to develop scientific processes using both the student's knowledge and experience in order to solve problems, undertake research, and develop project work (DGEBS, 1994, pp. 32).

Students should develop a 'scientific language' taking written notes of the observed phenomena, describing experiments and results, and using appropriate terminology.

1.5 Mandatory tests and examinations

Presently, there are no national tests or exams for basic schooling. Teachers are responsible for the production of evaluation instruments for each discipline. There is an emphasis on formative evaluation in which criterion-referenced testing methodologies are developed in order to obtain individual information on students. Self-evaluation is considered an indispensable source for the formative component. Classroom activities as a whole provide a source for evaluation, for example, individual and group work, discussion, exhibits, interviews, and the student's exercise book. Regarding experimental work, suggestions emphasise direct and individual observation.

Normally all schools organise autonomous examinations every tri- or semester. Pupils have to take exams on all subjects in the curriculum. During the year, there are tests that are also taken into account in the final assesment.

Various evaluation techniques with specific characteristics and various time periods are considered:

1) *Formative Evaluation.* This occurs during the school year with the following aims: to collect data related to the different learning domains; to inform students, parents and teachers about the state of development of the teaching-learning process; to establish intermediary goals.

2) *Cumulative Evaluation.* Basically, this occurs at the end of each school trimester, and at the end of the school year with the following purposes: to integrate all the aspects related to the teaching-learning process - progression or non-progression - showed by the formative evaluation; to compare the student's development with the objectives formulated for each evaluation period, level and cycle.

3) *Standardised Evaluation.* This makes it possible to: measure to what degree educational objectives defined as essential have been attained; control the quality of the educational system; reinforce the school system's social credibility.

4) *Specialised Evaluation.* This is developed in order to collect elements for the production of a teaching-learning process appropriate for each student.

The new evaluation system assumes that all pupils can achieve the objectives specified for the school year in which they are enrolled. In order to ensure that students are successful the teacher has to find different strategies and should encourage parents' involvement.

1.6 New trends and reforms underway

Besides current criticisms on the discrepancy between content requirements and the time available to achieve them, and on the poor horizontal structure of the curricula, the following criticisms are considered:

1) Excessive number of students per class;

2) Lack of resources regarding equipment, instructional materials, and funding;

3) Lack of teacher training programmes suited to the new demands of the new curricula;

4) Inconsistency between the evaluation paradigm proposed in the new curricula and the norms ruling the process of evaluation from the Ministry of Education.

a) Study of the Environment

There is the general comment from the education community that the programme for the Study of the Environment is excessive because it covers a wide range of content topics. Two issues can be extracted from it: first, such a programme has not been and will not be accomplished and should be revised; second, teachers' practices, which are in general centred on the content, are not appropriate to either the scope or the nature of the new discipline. Descriptions of successful implementation cases reinforce this point of view (Abrantes, 1994). Facing the diversity of content, skills and competencies that this discipline is intended to promote, a new kind of teacher is needed with a sound scientific preparation that enables him/her to generate relations between concepts and create bridges between scientific knowledge and everyday life events. Such a teacher should be able to implement intellectually challenging activities that engage students in authentic learning. What are the initiatives necessary for promoting adequate teacher preparation? Given the recommended relationship between the school and the environment/community, what roles should the school play regarding its teachers' preparation?

b) History and Geography

Regarding the disciplines of history and geography, the main general criticisms concern the following points: 1) conceptual contents not matched to the student's cognitive development, 2) absence of an integrated approach between historical and geographical subjects, 3) insufficient resources in schools to support the methodological proposals recommended in the curricula, 4) an excessive amount of content. In the particular case of history, there are also criticisms concerning the excessive value apparently placed on a Euro-centric approach to the detriment of a world-wide discussion of problems.

Due to the gap in level 8, geography is the only subject that students do not study on a continual basis. Apart from the pedagogical difficulties this situation will impose, it constitutes a long-term and a serious bias regarding the development of the student's geographical knowledge.

The previous definition of the scale of analysis for both levels 7 and 9 imposes serious constraints in curricula design. It also confronts level 7 students with a spatial framework far beyond their most common geographical experiences, a fact that may disturb the development of problem solving competencies.

The objectives defined for the elementary and middle school level are in accordance with updated proposals made by several international organisations, such as UNESCO and the International Geographical Union. In this respect we would like to emphasise the need to develop decision-making skills throughout all classroom activities.

Nevertheless, the geography curriculum shows several discrepancies regarding the requirements that are proposed either vertically and horizontally: 1) the main objectives defined for levels 7 and 9 seem to over-evaluate the basic geographical skills that students develop in previous levels of teaching. On the other hand, the appropriateness of the content for levels 5 and 6 for promoting the development of the conceptual skills considered is questionable; 2) both the history and geography curricula are structured in a way that does not allow horizontal articulation.

Faced the limitations we described above, we suggest for the third cycle a curriculum structured around geographical key concepts (for instance, scale, space, distance, localisation, orientation) that should generate discussions according to different scales of analysis not determined by teaching levels.

c) Mathematics

Most of the new programmes of mathematics correspond to the aspirations of the majority of educators, researchers and mathematics teachers. In particular these include: (1) the vertical requirements for the different levels, (2) the fact that contents are updated, and (3) the appropriateness of the suggested methodologies. The programme's extension, however, has been forcing teachers to focus on the teaching of procedures instead of mathematical processes. The Ministry of Education has not been willing to discuss this issue. In consequence many teachers do not believe that the present curricula's underlying philosophy can be implemented.

Research has been developed with the purpose of fulfilling issues scarcely approached in the new curricula, such as: the integration of calculators and computers in mathematics lessons, greater emphasis on mathematical processes, and achieving better connections between the affective components of learning. Experiments in the domain of curriculum development have been implemented in order to promote the integration of mathematics with other knowledge domains and with real life events, enabling students to actively engage in learning.

d) Sciences of the Nature

At a first glance, this programme does not offer special problems given its similarities with previous ones. Moreover, teachers of the second cycle are probably those who are best prepared to teach science according to updated pedagogical principles. In previous years, the antecedent of the second cycle - the preparatory cycle - had been the centre of intense pedagogical innovation in which new practices based on recent models of teaching (such as discovery learning) were implemented.

One difference of the new programme in relation to the old one concerns the study of the concepts of biological taxonomy. Teachers have reported complementary efforts in order to devise adequate methodologies for approaching these topics and to create activities and strategies appropriate to students' age.

e) Natural Sciences

Major criticisms have been levelled at programmes with excessive content load, showing inadequacies between the extension of the content and suggested teaching-learning methodologies. This is particularly serious. When the structuring principles of the curriculum lead to an updated perspective of what science education could be, content demands impede its implementation. Those who developed the programmes generated an illusion of advancement, updating and innovation without providing the means to accomplish it. It is the teachers' responsibility! These factors raise an ethical problem that should be clarified:

- The time needed for the student to receive the new information and assimilate it according to processes that involve a multiplicity of both cognitive and affective mechanisms is a factor that seems to be completely forgotten by curriculum developers.

- Curriculum conceptual demand does not match students' level of intellectual development. For instance, the programme for the level 7 includes the theory of plate tectonics. This theory involves the comprehension of phenomena that are difficult, if not impossible, to make concrete (according to Piagetian terminology) and, consequently, it is far from students' ability to understand. One may predict that these students will develop negative attitudes towards this topic which constitutes one of the most interesting theoretical frameworks of geology, and in consequence will refuse to learn it.

The lack of natural sciences in level 9 has raised many criticisms from educators (Rosa, 1993):

- Lack of resources regarding equipment, instructional materials, and funding;

- Inconsistency between the evaluation paradigm proposed in the new curricula and the norms ruling the process of evaluation from the Ministry of Education. Present curriculum evaluation criteria have led some teachers to conceive alternative forms of evaluation in which qualitative assessment is included in the student's cumulative report. Some parents reacted against this practice and the Ministry of Education, without recognising the innovative attributes of the curriculum, penalised these teachers..

We predict that the errors of this programme will generate youngsters with a low level of scientific preparation, contributing to the scientific illiteracy of our population.

f) Physics and Chemistry

The implementation of the new programme has been implemented. Although aware of some teachers' reactions, the team considers it premature to include any information about this issue in the present report.

2. How is science delivered?

2.1 Organisation and authority

Portugal has a centralised educational system. The nation-wide curriculum is 'prescribed' by the central government and it is developed by teachers who are selected by the Ministry of Education. The school and its teachers are responsible for curriculum implementation. Regarding curriculum development, a certain tension between schools and the central government has been observed. Recently, some schools have initiated collaborative projects with local industry and other organisations in order to promote curriculum implementation and develop educational activities. In general, the participation of local industry provides extra resources. The regional dimension of the curriculum has been limited to activities and methodologies that involve both the environment and the community as a pedagogical resource. However, certain disciplines of the new curriculum and recent requirements for continuous teacher preparation demand the more active participation of the school, which not only concerns the implementation of the new subjects but also decision-making on the nature of the subjects taught.

The authority of the Ministry of Education extends to the control of the funding processes regarding all school needs and the control of nation-wide teacher recruitment. The percentage of GPD spent by Portugal on all three levels of public education is 5.5% (OECD, 1993).

2.2 Resources and funding

Available resources differ greatly from school to school. In general, there are no classrooms especially devoted to scientific disciplines. The science teacher does not 'own' a classroom. However, there is a tendency to concentrate science classes in a small set of classrooms in which other subjects are not taught. Traditionally, schools in which second and third cycles are taught have laboratories for physics and chemistry and for biology and geology. Sometimes, there are no laboratories at all but just a small store room. A small number of schools have a small room dedicated to geography where different teaching aids may be kept. In general, schools built recently have one or two classrooms connected to a single laboratory. Several schools (a small number on a national scale) have computer rooms that are mostly used for mathematics and computer science. Some schools have organised various kinds of clubs, many of them involving science-related activities.

Resource Centres are facilities located in school areas with the purpose of providing a variety of instructional materials that teachers may request. Educators devoted much attention to the creation of some of these centres and some of them constitute dynamic locations for accessing information. However, a lack of continuous support may lead to a general lack of interest.

There are remarkable differences between schools that affect the availability of resources, from schools that lack the minimum needed in order to provide a serious learning environment, to well-equipped schools. Teachers usually complain about the lack of resources, but a growing number admit that they are teaching in well-equipped schools. There are cases of schools with a substantial amount of material available that is going unused. This issue raises questions about the quality of teacher preparation.

Every year the Ministry of Education determines how much money to distribute among schools. In each subject area, teachers responsible for the laboratories and subject area delegates submit to the school's administration proposals for the acquisition of materials. Presently, teachers - either individually or in groups with the involvement of the school's administration - may initiate a search for alternative forms of funding. Some of these funding strategies constitute interesting methods for acquiring material. Teachers may submit both curriculum development and research projects to funding agencies such as the Institute of Educational Innovation. The clubs which are part of the Complementary Curriculum Activities and the School Area also have been fruitful sources for funding.

In some cases, teachers create and implement class materials such as work sheets, informative handouts, and laboratory protocols, for various purposes. In general, students do not have to pay for these materials, but the school establishes limitations on the number of working sheets delivered.

A lack of resources and a lack of appropriate continuous teacher preparation result in having the textbook as the main, sometimes the only, resource available. In addition to the textbook, several handbooks (for the student, for the teacher) have recently started to be used. Textbooks are authored by groups of teachers or individuals who have contracts with private educational publishers. Among the existing textbooks for each discipline, the school has to select one which becomes the 'approved textbook' for a period of three years. Textbooks (even the approved one) and handouts are not free. In fact, the price of the textbook is a relevant criteria considered by teachers in selecting the 'approved textbook'.

2.3 Methods of teaching

There are discrepancies between the curriculum recommendations summarised in section 1.4 of this report and the teaching methods actually applied in the classroom. This subsection contains a description, organised by discipline, of the methods predominantly used by teachers.

a) History and Geography

The textbook is the major instructional material used by teachers; therefore, teaching methods are basically limited by the textbook's suggestions.

Most teachers use expositive methodologies. However, in recent years a growing interest has been directed towards group work, research work, discussions and round tables, project work, role playing, games and simulations, and field trips.

b) Mathematics

In the first cycle it is recommended that mathematics should be taught through exploratory and discovery situations using the manipulation of materials (the children's own body, structured and non-structured material, computers, calculators). Second and third cycle mathematics should be taught manipulating several materials as a basis for exploration activities aimed at the formulation of conjectures. Teaching methodologies should allow students to construct concepts from their experience and from concrete situations. These concepts should also be taught from various points of view and using increasingly more advanced levels of formalisation and rigour. Some individual and group activities together with the use of play are also suggested.

In the second cycle, curricula recommend that teachers base their lessons on the following presuppositions: mathematics is indispensable both as a means of interpreting reality, and as a factor in the development of a dynamic structure of thought; the student as a person is at the centre of the teaching and learning process; mathematics is learned by building living experiences, connecting the concrete and the abstract, and making learning a personal adventure associated with a broader reality.

However, several findings indicate that methodologies recommended by the new curricula are not used in our classrooms. Teachers in general have difficulties in relating mathematics to other sciences, the real world, and the use of computer-based technologies. Expositive methodologies are used more often as one advances in the programmes. For several reasons, students have few opportunities to engage in hands-on activities or activities in which they have to explore mathematical ideas. Some indicators point out that in the first cycle an excessive emphasis is given to computation procedures. The third cycle is predominantly centred on language aspects to the detriment of the conceptual domain.

c) Physics and Chemistry and Natural Sciences

In this subsection physics and chemistry and the natural sciences are approached as a whole since we have detected no relevant differences between the methodologies followed by the teachers of either discipline. Once again, the information provided is based on opinions expressed by the majority of the people with whom we have interacted throughout our years of professional experience.

The textbook is the resource used most frequently. Consequently, teaching methods, other than the expositive one, are limited to the suggestions included in the textbook. In general teachers justify this situation by saying that the textbook is the only resource it is possible to share with most of the students and that they should learn how to use it.

Expositive teaching is the methodology most commonly used in our schools. A great number of teachers recognise that this is not the most appropriate teaching method in order to promote students' science learning but advocate that, faced withthe excessive programmes, they have no other solution. In research on teachers' practices, only 17 of the 48 teachers questioned professed to using more than 20% of their class time in doing experimental work. Eight respondents said that they never implement experimental work in their classes (Valente, Sequeira, Abreu, Teixeira, & Tojal, 1989). Another study carried out in the district of Portalegre involving 80% of the science teachers teaching in middle schools, showed that most of the teachers spend less than 40% of teaching time on experimental work (Miguéns, 1991).

Teachers' lectures are usually supported by audiovisual aids. The most common medium is the image - diagrams, pictures, charts, drawings - projected by overhead projector; this is the teaching aid that received overwhelming approval from teachers. Video images are also frequently used, especially in biology and geology, because of the wide range of high-quality films available today. Teachers also cite student interest as a reason for their decision to use videos in the classroom. This issue raises questions about how effectively teachers use audiovisual aids.

The computer is not commonly used by science teachers. The most significant reason is, obviously, lack of both hardware and good quality software. Teachers regret that most of the quality software available is not issued in Portuguese versions. Consequently, they feel inhibited in using them in the classroom. The number of teachers who go beyond the use of quizzes, tutorials and simulations of dubious quality is very small. In fact, cases of teachers using, for example, spreadsheets, data bases, sensors with graphical analysis programmes, are few.

2.4 Sources of pedagogic innovation

Despite being a prescribed curriculum, there are opportunities for innovation, namely in the School Area and in the Complementary Curriculum Activities. At the disciplinary level, in spite of the compulsory contents and the extensive recommendations for curriculum implementation, the teacher is responsible for content management as well as for the selection of both methodologies and activities.

There are nation-wide projects that allow curriculum innovation. For instance, the *Minerva Project* for introducing computers in the classrooms and the project *Innovate through Education*, supported by the Institute of Educational Innovation. Protocols established between schools and institutions of higher education also enable pedagogical experimentation and innovation.

Teachers' spontaneous team work is occasional. The prescribed meetings that bring together teachers from the same subject areas are generally bureaucratic. However, there are teachers who associate, forming working groups, integrated or not into wider pedagogical movements, with the purpose of innovating respective practices. These groups may apply for funding to either public or private agencies.

Despite the unstable situation resource centres presently experience, they have the potential to contribute to the following: the diversification of teaching-learning resources, a better relationship between the school and the environment, and school change (Bento, 1992).

The results of educational research scarcely reach teachers in the schools. Teachers are known to be eager for this kind of information, as is reflected in their impressive participation levels at conferences, seminars and other forms of public discussion and presentation. However, it is unclear if they are capable of introducing the new teaching approaches within their classrooms.

Various teacher training methods generally emphasise innovation in science teaching; but it is frequently observed that teachers go back to conventional practices when integrated into the teaching system. We suggest that this is due to the weight of the institution over the individual teacher, and the burden of everyday working routines that impede innovative work.

3. Going beyond school

3.1 Use of out-of school resources

Informal science teaching delivered by several institutions such as museums, natural parks, sanctuaries, and television, have earned the attention of educators

(Chagas, 1993). Since the beginning of the 80s, modern museums have been created, especially at the local level. These museums are developing interesting educational programmes that are becoming good resources for science teachers. Recognising their own educational role, museums have been making efforts to attract the youngsters through the organisation of temporary exhibits.

The museums connected with the University of Lisbon - the Museum of Natural History and the Science Museum - are examples of the present tendency of linking museums to schools. The instructional materials they are developing and the teacher training courses they are promoting have met with substantial interest (Carvalho, 1993; Gil e Almaça, 1992; Gil, 1989, Gil, 1994).

Other institutions, such as the Museum of Electricity and the Water Museum, to cite just a few in Lisbon, are organising exhibits of great interest from a scientific point of view. The Portuguese public, which in general still views the museum as a boring and an uninviting place, has reacted remarkably well.

The National Service of Natural Parks and Sanctuaries organises field studies and presentations by specialised people, and promotes several activities for the youngsters. Some sanctuaries organise camping meetings which last a few days in ecologically important areas.

At the local level, the Eco-museums are at present becoming important educational resources. Their objective is to use the "tangible and intangible aspects of the cultural legacy that help in understanding, explaining and experiencing the economic and the historic reality that the different cultures have shaped" (Nabais, 1985, pp 211). These institutions are special promoters for partnerships between the school and the community, in particular regarding school projects on environmental issues.

Institutions such as libraries, media centres and resource centres could play an important role in the diffusion of scientific knowledge. However, updated information conveyed in a recent weekly magazine shows that, despite the increasing number of libraries that are opening their doors to the community, attendance is decreasing.

3.2 Consideration of public science-based issues within lessons

Although we would argue that the concept of public science needs clarification, we consider that 'citizen's science', approached as the integration of science into daily life, is not a major concern of present science programmes. However, curriculum-proposed activities refer to the environment as a pedagogical resource enabling the linkage between the teaching-learning process and the concrete aspects of students' daily lives.

3.3 Science education and vocational training

The formal system of education offers, in level 9, optional disciplines connected to scientific/technological training, such as: agriculture-veterinary, mechanics, electronics, health, chemistry and economics. However, such offers are limited because these options work only in a small number of schools.

Former professional and technical-professional courses created in 1983 have been, according to the present reform, gradually replaced by: (a) technological courses (level 3) taught in secondary schools; and (b) courses taught in professional schools (levels 2 and 3). Professional levels 1 and 2 correspond to the basic schooling. Technological courses have a national curriculum, and professional schools have a local curriculum.

The new technological courses are tailored for active lives (the employment market). Their curricula include an area of general knowledge, a scientific area and a technological area. Both the scientific and the technological components are substantially demanding.

In 1993, the scientific areas taught in the technological courses were electronics, mechanics, chemistry and information technology. The courses taught in professional schools were electricity, electronics, food production, aquatic exploitation, environment and natural resources, mechanics, chemistry and information technology. These areas correspond to 33% of all the courses taught in these schools.

Besides the professional training programmes that are integrated into the regular educational system, there are also professional training programmes integrated in the employment market (levels 1, 2 and 3). These programmes, known as 'apprenticeship programmes', have a local curriculum which alternates classes in a school with real work practices in the work place.

In 1992, the courses offered by this system were: electronics, agriculture-veterinary, food production, fishing, mechanics, refrigeration, chemistry and information technology. These courses correspond to 44% of all the courses taught. This kind of professional training inside the work place is offered by the companies and the centres of the Institute of Employment and Professional Training.

3.4 Science clubs and cultural associations

Cultural associations, in general, do not pay attention to scientific issues. Besides, the few scientifically oriented activities that exist are mostly frequented by a small number of individuals who are highly motivated towards science.

The area of Complementary Curriculum Activities has generated the implementation of science clubs in schools. In fact, it is possible for a group of teachers and students sharing the same interests to create a club where they can do research either in groups or individually. Various research projects are developed according to the amount and diversity of the resources available. Presently, there are several science-related clubs working in schools all over the country (science clubs, information technology clubs, ecology clubs, mathematics clubs, etc.).

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

The evolution of European society - its values, structures, degree of economic progress, and level of human development - and the progress of education, training, and pedagogy allow us to formulate objectives for science education that are quite different from those formulated 20 or 30 years ago. It is not our task in this report to explain the process of evolution of the objectives that are formulated today by a wide range of organisations involved in education, but it is possible to understand the reasoning and inherent behaviour that have led various groups - parents, teachers, employers, scientists - to formulate educational objectives in accordance with their knowledge, opinions and social context. For those in charge of the school system, it is difficult to reconcile some of those objectives within the system because they are contradictory. Inevitably, there will be clashes and strains, generating many of the so-called 'crises'. Therefore, it is important to create groups, as has been done in other areas of political decision, that can undertake social and educational negotiation, generate the consensus needed to render operational the education policies, and share responsibilities regarding execution and evaluation.

The systematic and public debate about the advancement of evaluation, critical reflection and educational research, as has been the practice of both international and national bodies such as the OECD-CERI and UNESCO-IIPE since the sixties, is unquestionably indispensable. It is at this level that decision-makers of European programmes operate, providing the basis for preparing professionally active, culturally and politically intervening human resources for the next decades. Examples of educational blockage such as we find in Japan, which come about when educational systems that have been rigid for decades are confronted with the necessity of curricular and pedagogical innovation and social change, should alert us to the dangers and risks inherent in such a lack of debate. Educational reform should be considered as an ongoing process, in which the advancement of knowledge about how individuals interact with scientific information, and compose thought and scientific operational competencies, is coupled with a continuous study of the social demands of the system. It should be stated at this stage that although Portugal is a small peripheral European country, educational reform, in its objectives, contents and methods, translates many of today's demands of a modern society and is the result of intense study and research in education. Deviations from previous orientations have occurred in the implementation phase.

Results of the *International Association for the Evaluation of Educational Achievement* (IEA) survey place Portugal behind most of the European countries in terms of students' scientific achievements. However, we claim that it would be important to obtain more details about the tests used in this survey - their validity and reliability - and the methodologies followed: for instance, procedures for the selection of the study's sample (OECD, 1993).

Portuguese students aged 9 and 13 were evaluated by the *Second International Assessment of Educational Progress* in mathematics. Results were below average in both groups. Portuguese students aged 13 obtained their worst result in measurement and their best in probabilities, statistics and data analysis. Nine-year-old students achieved their best score in knowledge of processes and their worst in problem solving (OECD, 1993).

4.2 Public or political concerns about educational standards

Evaluation of both school results and educational achievement obviously depends on a set of criteria defined *a priori*. These criteria do not always correspond with the objectives of education and generate tests with numerous limitations, giving place to an evaluation reflecting at best: (a) a blurred perspective of 'acquired' knowledge, without rendering explicit pedagogical processes and contexts; (b) a teaching paradigm - information transmission (acquisition of concepts and theories) - which has been questioned by innovative educational approaches and replaced by another teaching paradigm - development of cognitive abilities and scientific logical reasoning (knowledge building, problem-solving and development of scientific competencies); and (c) a traditional evaluation model of teachers' performance. Within this context, teachers are viewed as information-transmitters and not as mentors of scientific learning processes.

In a recent survey conducted in Portugal, 35.9% of respondents consider mathematics teaching excellent or good, 35.2% find it reasonable and only 15% consider it mediocre or bad. 56.6% say that mathematics teachers are competent or very competent, whereas 29.8% consider them incompetent. 47% of those queried think that youngsters nowadays leave school knowing more than in the past, while 37.2% believe that youngsters learn less. The use of calculators in the classroom is supported by 46% of those taking part in the study, against 50% who oppose it (OECD, 1993).

Limited research on Portuguese public opinion regarding the way science is taught in schools showed that 55% of respondents consider that the amount of science taught in schools is not enough, 18% consider it enough, and 27% did not answer. About 58% of the respondents consider that it is possible to learn more about science through the conventional media (TV, radio, journals, and magazines) than in school. However, youngsters (15 to 24 years old) refer more often to school as the major source of science learning (35%), as do subjects with higher education (39%) (Dias, Gonçalves, Oliveira, Ramos, 1987).

4.3 Suggested reforms

It is interesting to note that the social demands upon those who need qualifications and training do not correspond to the criteria used in IEA. No employer asks how much you have scored in mathematics, geography, etc. except when pursuing an academic or teaching career. What is actually assessed is scientific competence and skills such as scientific ability, initiative, communication and motivation skills. What society asks of individuals is a developed personality, self-confidence, a civic and concerned attitude and the ability to learn through experience. It is our belief that the criteria currently used in evaluation and assessment contribute to the shattering of the individual's self-image, blocking any educational progress (see comparison between American and European education).

Curriculum reform, as part of a wider educational reform of both compulsory and secondary levels, introduces new orientations that schools and teachers of various subjects should follow. Some of these new guidelines are substantiated by the creation of new subjects such as the newly introduced Personal and Social Development. This subject, which has generated much controversy, aims to provide students with a proper identity that they will develop through the analysis of their own school career, and the analysis of the great challenges that today's world offers regarding knowledge, action and cooperation. It is an area of coherence in which each student integrates scientific knowledge, values, social demands and citizenship. The reform also foresees new curriculum areas organised in the school by teachers and other educational agents aimed at intensifying environmental education, health education, multi-cultural education, education through art, etc. These activities are integrated into the School Area project, where much initiative is left to teachers.

It has been difficult for teachers, owing to their working conditions and social status, to fully understand these new guidelines. Moreover, school administration in general is not receptive to the development and practice of such guidelines. Much remains to be done involving changing attitudes and educational intervention. This is the objective of science education as it is embedded in the spirit of the Reform, and not in traditional science teaching. Present teaching practices and assessment models oppose what is recommended.

5. Pupil interest and motivation

No reliable data from systematic sources are available to answer the main questions of this section. We suggest filling this wide gap with information from research projects developed by present graduate students in education.

Useful data may, however, exist, but remain inaccessible because they are not part of the usual sources of information. This raises an issue that has strong implications for the development of scientific literacy and a scientific culture - there is a lack of comprehensive data bases about research developed in Portugal.

6. Training, status and morale of scientific teachers

When someone wants to become a certified teacher he or she must obtain a diploma from one of the teaching training programmes recognised by the Ministry of Education. Then the qualified teacher has to stand as a candidate for a place as a teacher in a school. There are periodical recruitments organised by the

Ministry of Education which provide professional qualifications for the candidate. For instance, young teachers who have just finished their teacher training programmes (in general this happens in mid-June) may submit a proposal for a position in the nation-wide recruitment that generally occurs in July. Candidates may apply for a place as a *profissionalizado* (professional) teacher in any school in the country, or in a small number of school regions, or in a specific school, knowing that by reducing the range of school options, they are reducing their chances of being awarded a position. A candidate awarded a position is classified as an *agregado*. An *agregado* teacher must work for one school year; after which, he or she may enrol in nation-wide recruitment in order to obtain a tenured position, thereby becoming a *professor efectivo*. Given the situation of certain teaching subjects where there is a surplus of teachers for the number of tenured positions available, it may sometimes take years for a teacher to secure a position in a school located in a preferential region. The advantages of being a *professor efectivo* are multiple; the teacher gains not only the assurance of keeping the position awarded, but also the prerequisites necessary for career advancement.

In a given school it is possible to find teachers with a variety of qualifications: from non-*professionalizado* teachers (those who have not finished a teacher training programme but who have some academic qualification such as a *licenciatura* degree from a programme other than teacher training) - who may or may not have *habilitação própria* (academic preparation appropriate to teach certain subjects) - to *efectivos* with any number of years of professional experience. Non-*professionalizado* teachers may enrol in in-service teacher training programmes in order to gain teacher certification. Schools may recruit teachers directly with the purpose of filling available positions. There are three kinds of teacher training: initial, in-service (to consider it as initial or continuous training is a polemic issue), and continuous.

6.1 Initial training

a) First cycle

First cycle teachers receive their initial preparation in Superior Schools of Education - *Escolas Superiores de Educação (ESEs)* - or in Integrated Centres for Teacher Training - *Centros Integrados de Formação de Professores (CIFOPs)* where they obtain a degree, the *Bacharelato*. There are eighteen *Escolas Superiores de Educação* and five *Centros Integrados de Formação de Professores* spread throughout the country.

The *Bacharelato* programme lasts three years, including pedagogical practice. Each ESE and CIFOP has its own curriculum, which means that both the programme's duration and science contents vary from school to school. Pedagogical practice is integrated within the theoretical component of the programme. Student teachers become more responsible as the pedagogical practice progresses throughout the programme.

b) Second cycle

Teachers of the second cycle may have either a *Bacharelato* or a *Licenciatura* degree. *Licenciatura* programmes last either 4 or 5 years, depending on the institution that offers it. The first 3 or 4 years are dedicated to both scientific and pedagogical preparation, which can be either integrated or sequential depending on the programme. *Bacharelato* programmes are offered by the ESEs and *licenciatura* programmes are offered by CIFOPs or by those universities which, regarding teacher preparation, have an organisation other than the CIFOP.

c) Third cycle

Third cycle teachers are required to hold a *licenciatura* degree, which is offered by the universities.

1. Critical Remarks

Teacher training programmes available show a diversity of approaches regarding the coordination between scientific preparation and pedagogical preparation. Certain institutions emphasise the scientific component over the pedagogic one; others emphasise the pedagogic component over the scientific one. This issue extends to other sensitive areas such as the coordination between theoretical knowledge and pedagogical practice. Usually, teachers complain about the high theoretical load of teacher training programmes in general. This issue also reflects an inadequate relationship between the institutions of higher education and schools.

The question of the diversity of the training models also needs discussion because such models are different in terms of academic requirements, demand, and duration. This situation, which is a consequence of local dynamics and university autonomy, may lead to remarkable differences among teachers in the quality of their initial preparation.

New teachers (*agregados*, for instance) need support from the school. There are no programmes for counselling and there is no supervision of teachers' activities.

d) Special education

There are no programmes available which are specifically dedicated to science teachers. Most of the initial preparation programmes lack a component on special education. Student teachers used to complain about this deficiency. Some of them display anxiety when faced with the possibility of having a special needs student in their future classes.

e) In-service training

1. Profissionalização em Serviço

Teachers of the second and third cycles and of the secondary level who have been teaching up to three years without a specific teaching diploma are asked to apply for the *Profissionalização em Serviço* programme in order to receive appropriate pedagogical preparation and a teaching certificate. This is a two year programme. The first year is taught by an institution of higher education - ESE, CIFOP, university - the second year corresponds to pedagogical practice in the school where the teacher has been teaching, supervised by a colleague (in general the delegate of the group of disciplines in a certain area), and a professor of the institution of higher education. This model of teacher training develops around the individual plan prepared by the teacher who is receiving preparation. Teachers who have been teaching for more than six years are entitled to omit the second year. The ratio of student teachers to university professors is 10:1, and there are generally 1 to 3 student teachers for each delegate in the school.

2. Critical Remarks

There is a lack of experienced teachers who apply to be delegates. The lack of delegates is a serious problem that leads to the acceptation of teachers with no experience and poor pedagogical preparation. One may ask why this happens. In fact, being a delegate does not bring any advantage to the teacher. It is well known that there is a lack of both financial and pedagogical support for the delegate.

Universities centralise the whole process. This results in a general lack of motivation on the part of schools which do not actively and seriously engage in the preparation of their own teachers. Other problems are expected to result from this situation.

Time dedicated to the programme is compulsory for the in-service teacher. This means that it does not contribute to his or her professional qualification. One result of this is that, whenever they can, in-service teachers do not apply for the second year of the programme. In many cases, these teachers remain poorly prepared despite having accomplished the programme - experience does not necessarily mean knowledge.

6.2 Decision-making authority for the above

The Portuguese teacher training system is centralised. Programmes have a nation-wide general organisation that is similar to all subject areas taught in schools. Science teachers are selected according to criteria based on: initial academic preparation, pedagogical qualifications, and years of teaching practice. Teacher training programmes are regulated by a set of legal documents published by the Ministry of Education.

6.3 Continuing training

A new regime of continuing training was created in 1992/93. It is a national programme promoted by local school associations, universities, and teacher associations. This programme is coordinated by a central council belonging to the Ministry of Education and is funded by the European Commission. It includes different modes of training - courses, seminars, training modules, study circles, projects - which may be approached at three different levels: initiation, improvement, and specialisation. In order to obtain a professional qualification, and hence progress in their career, teachers need to obtain a certain number of credits earned by taking courses that are part of a continuing training programme. Presently, programmes dealing with experimental approaches to science have priority over others with regard to funding.

a) Critical Remarks

The entire process of continuing training is excessively bureaucratic and the central council that coordinates it is too powerful.

There are serious inconsistencies between what these programmes offer in general in terms of scientific and pedagogic updating and new curricular demands on the one hand, and teachers' demands concerning their personal and professional development on the other. Moreover, the majority of courses included in the programmes are not structured according to an adult population. Some teachers dislike the 'schooling conditions' and feel little motivation.

There is no appropriate training for teachers' trainers and the numbers of qualified trainers are insufficient to meet the needs.

Nevertheless, we can point out some positive aspects regarding this model: 1) the implementation of school associations injecting a new dynamism at local level, 2) cooperation among various levels of schooling and various institutions is made possible, 3) the school becomes involved in training activities because its teachers may be trainers, 4) it provides a space for teachers to obtain preparation in order to progress in their career.

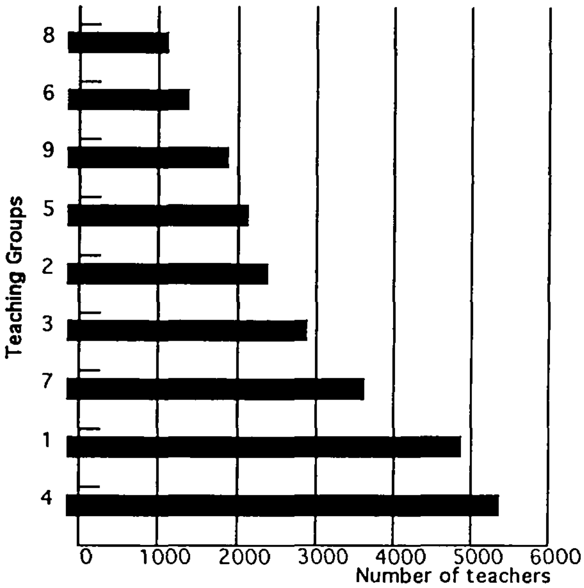
b) Sabbatical leave

During their professional careers, teachers have the right to apply for two one-year sabbaticals. The teacher applies for the sabbatical leave in order to develop a project of scientific and/or pedagogical nature. The development of such a project is supervised by someone designated by the Ministry of Education. Only a very small amount of teachers are awarded this kind of leave because of the scarcity of places available.

6.4 Number, teacher/pupil ratio, gender, age profile

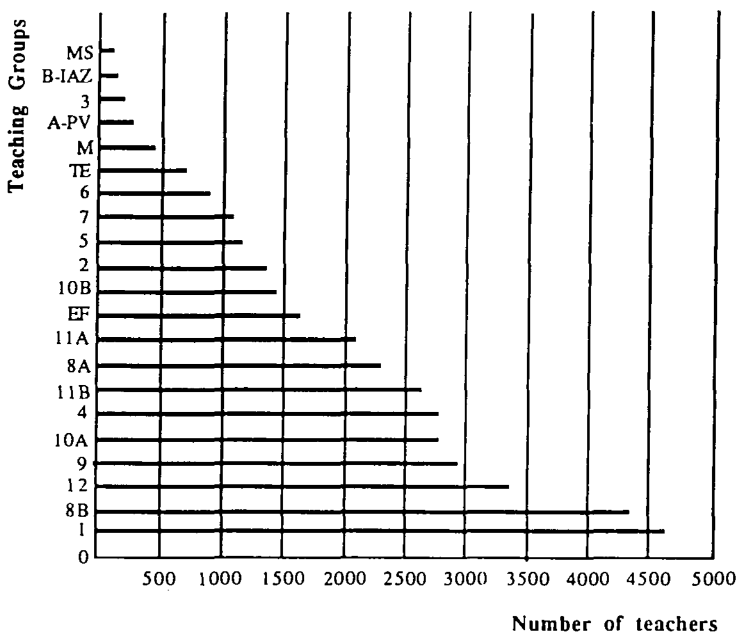
Graphics in figure 1 show a wide variation in the number of teachers according to the teaching group. As regards the second cycle, we suggest that the differences observed are mainly due to the time loads of each discipline. In the third cycle and secondary level, the differences observed may result not only from the time loads of each discipline but also from the students' options. The group which has a higher percentage of teachers is the second cycle, the 4th group (mathematics and sciences of nature) and in the second cycle, the 1st group (mathematics) (GEP, 1993, DEPGEF, 1993).

Table 1: Teacher distribution according to teaching group: second cycle, third cycle and secondary level



Legend:
1 - Portuguese, Social Studies, History
2 - Portuguese, French
3 - Portuguese, English, German
4 - Mathematics, Sciences of the Nature
5 - Visual arts
6 - Music
7 - Arts and Crafts
8 - Religion and Moral
9 - Physical Education

Figure 1 - A



Legend:

1	Mathematics	10B	Philosophy
2	Mechanics and electronics	11A	Geography
3	Construction	11B	Biology and Geology
4	Physics and Chemistry	12	Arts and Crafts
5	Visual arts	EF	Physical Education
6	Accounting and Management	TE	Special Techniques
7	Economics	M	Moral
8A	Portuguese, Latin and Greek	A-PV	Plant production
9	English and German	B-IAZ	Food Industry and Zootechnics
10A	History	MS	Music

Recent reports show that the number of pupils in the first and second cycles will decline or stabilise owing to demographic trends. Such a tendency may imply that there will be a surplus of teachers in the near future. Miguéns (1994) comments that "the output of teacher education institutions (universities and schools of education) will probably exceed the need of the basic educational system" (pp. 261). As one possible solution he points out the need for the development of different and flexible programmes by teacher training institutions, responding to new client groups such as museum educators, specialists on educational resources, curriculum developers, etc.

a) Pupil/teacher ratio

Figure 2 shows that the pupil/teacher ratio does not present variations according to the cycles, and the regions considered. Data available do not allow us to make inferences about the quality of the relationship in the classroom, since it does not consider teachers' academic and professional qualifications. The number of students taught by each teacher is determined by the number of classes that he or she has to teach. Each class is formed, on average, by 25-30 students in the second and third cycles and by 20-25 students in the first cycle (GEP, 1993).

Table 2: Pupil/teacher ratio for the school year 1991/92

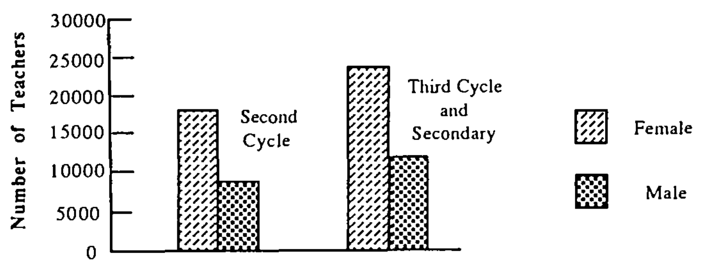
Second cycle					
North	Centre	Lisbon	Alenjo	Algarve	Contine
12.2	11.7	12.6	11.9	12.9	12.2

Third cycle and secondary					
North	Centre	Lisbon	Alenjeto	Algarv	Contine
12.2	11.7	12.6	11.9	12.9	12.3

b) Gender

Female teachers represent more than 60% of all existing teachers. The feminisation of the teaching staff is much more relevant in the lower levels of schooling. There are no available data regarding science teachers (GEP, 1993; DEPGEF, 1993).

Table 3: Teacher distribution according to gender



c) Age

Graphs in figure 4 show that, in the second cycle, about 20% of mathematics and sciences of nature teachers fall into the 20-29 age group. In relation to the other groups, this percentage is one of the lowest, showing that teachers of these disciplines are relatively older than the others. The trend in the third cycle is a little different. About 35% of mathematics teachers, and about 40% of biology and geology teachers, belong to the 20-29 age group. The percentage of young teachers is lower in the physics and chemistry group.

d) Profile

Figure 5 shows the percentage of teachers according to their professional qualifications (GEP, 1993).

6.5 Drop-out rates, late entries, maternal leave

Teachers of mathematics show higher drop-out rates, because the job opportunities outside the school system are better for them. There are cases in which teachers ask for a leave of absence, meaning that they maintain bonds with the public service but receive no salary. In general, these teachers are 30-45 years old, with more than 11 years of service. On the contrary, those who drop out without any bonds to the system are generally young teachers, under 34 years of age, who have been teaching for less than two years. Regarding the figures for teachers who leave the public service, grouped according to their discipline, a marked increase in the number of broken contracts has been observed, particularly in those groups related to mathematics.

Maternal leave has been extended recently. It lasts up to 14 weeks and is integrated into the general system of the public service.

6.6 Status and salary

The status of science teachers is no different from the status of the other teachers in general. In Portugal teachers are considered as belonging to the middle classes. This classification is based both on teachers' perceptions of their social prestige and on living conditions. The teaching profession has been an important factor for social mobility (Teodoro, 1992).

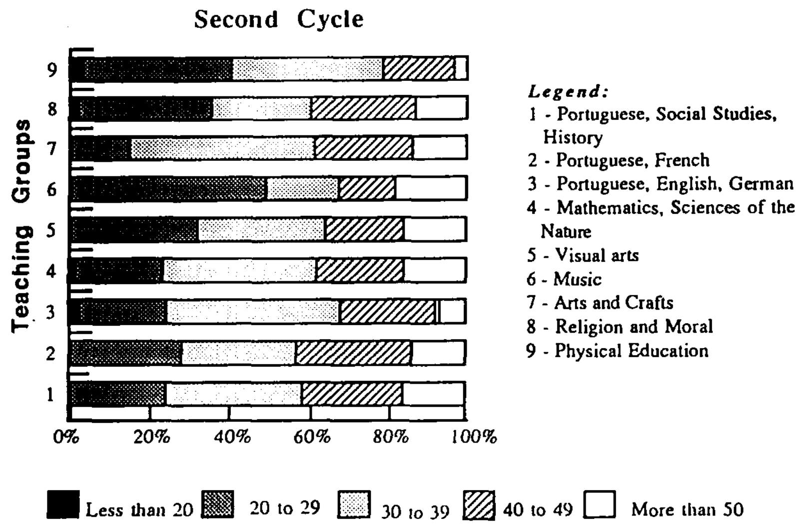
Within the public service system teachers are usually integrated into the same group as the office staff, and, among the intellectual professions, constitute the largest group. There are about 150 thousand teachers, which represents 3.7% of this particular labour force (Teodoro, 1992).

According to a 1989 survey, teachers are not happy with their profession. This sentiment is independent of age, gender and qualifications. As a matter of fact, 35% of the respondents claimed that they would leave the profession if possible. The willingness to leave the profession is higher among males (46.5%) than among females (41.3%) and is lower among those older than 56 years old (16.3%). These percentages are higher among teachers of the second and third cycles (42 and 45%) than among those of the first cycle (19%). This situation is essentially due to the low salaries (32.6%), poor working conditions (21.7%) and lack of motivation (19.8%).

Teachers at the same career level and having the same academic qualifications earn the same salary. There are no distinctions among disciplines. In 1993-1994 a teacher with a *licenciatura* degree, at the beginning of his or her career and with a bond to the public system, earned 145,000 escudos (ECU 725). Upon completing ten years of service, a teacher earns ESC 217,400 (ECU 1,087). In the upper level of the profession, teachers earn ESC 374,000 (ECU 1,870) — [1 ECU = 200 escudos].

Teachers work 35 hours per week, 20 hours of which are spent in classroom activities. As the career progresses, classroom time is progressively reduced. This reduction may be up to 8 hours.

Table 4: Teacher distribution by teaching group according to age



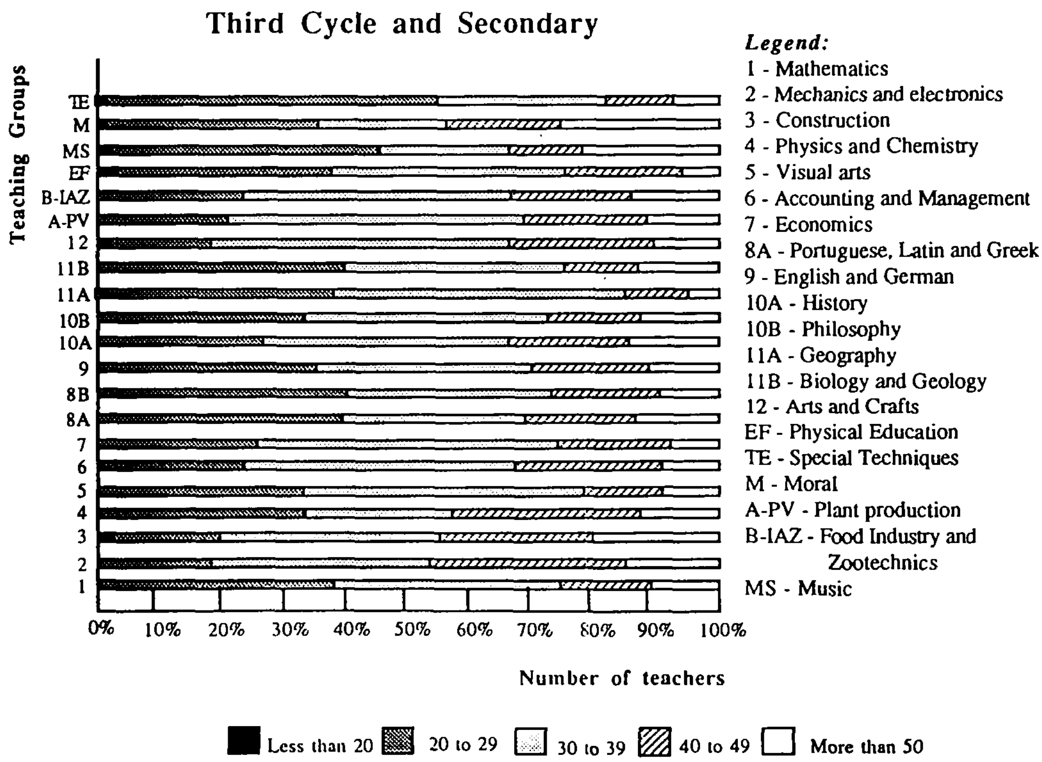
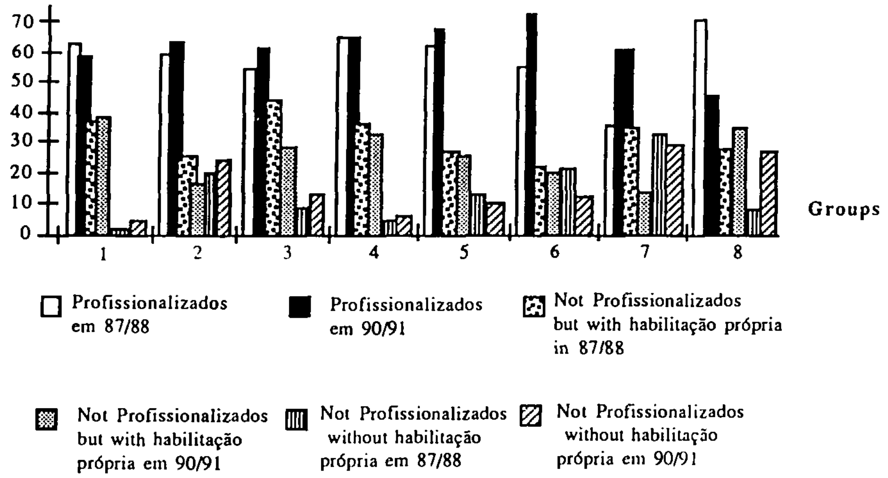
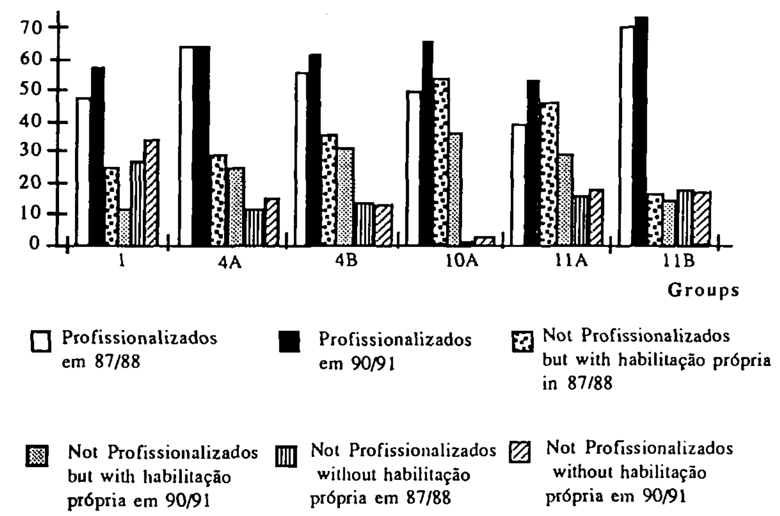


Table 5: Distribution of teachers by teaching group of the second and third cycles, and the secondary level, according to professional qualification.

Teachers of the Second Cycle According to their Professional Qualifications



Science Teachers of the Third Cycle and Secondary According to their Professional Qualifications



7. Equality of opportunity?

7.1 Different status of the schools

The law regulating the Portuguese educational system upholds explicitly the creation, on behalf of the public services, of conditions of equal opportunity regarding both the access to education and educational success. This demand is substantiated in various guidelines and measures that range from classical schemes of enlargement of the school network, allowing access for all, and measures of a social, pedagogical and institutional nature against school failure.

The growth of the private school network, which up to 1974 was composed mainly of Catholic schools with an elitist tradition, came from various initiatives (mainly of a non-denominational and cooperative nature) with the help of the central government, seeking to supplement the basic public network. Subsequent measures have been taken in order to support students and schools of this sub-system, within the framework and spirit of the Law of Freedom of Teaching, which allows parents to freely choose the school (and its educational project) they feel more appropriate for their children's education, while simultaneously guaranteeing equality of attendance in public schools. Despite all these measures, education in private schools has remained more expensive than in public ones. Most of the students of private schools belong to families of high social and economic backgrounds.

There are special private schools that accept children from emigrants' households and foreign children living in Portugal and in which the language of the country where they came from is the school's first language (German School, French School, etc.).

7.2 Regional differences

Conditions of equality are very different not only between private and public schools, but also between schools located in different regions. The high quality recognised in most private schools in urban areas is not always shared by private schools located in smaller urban areas or rural areas. Many of these schools have problems in recruiting qualified staff.

Curricular demands and legal norms are the same throughout the entire education system. Private schools differ from public ones with regard to recruitment methods, career and status of teaching and the internal organisation of the school education process.

7.3 Immigration and migrant populations

There are cooperative agreements that enable the children of Portuguese emigrants to attend special schools integrated into the public school system of their country of residence. According to this programme, children have an opportunity to attend classes in Portuguese language, literature and history.

The protocols observed differ from country to country and from one emigration area to another. However, the general consensus is that adequate conditions are not met in most cases. This fact partially explains why so many Portuguese emigrants prefer to enter their children in the public school systems of their resident country (which ensures easier social integration at the risk of a loss of their cultural identity as Portuguese citizens), or send them to private schools in Portugal that have special rehabilitation programmes.

7.4 Special education for handicapped children?

For children with severe handicaps, special education is generally administered in private schools with the support of both the Ministries of Education and Health. Those with less severe handicaps are integrated into the normal public school system, where they get special back-up. The purpose is to not segregate them from other students. In order to achieve this integration, schools should have technical pedagogical support, as is demanded by the law.

It has been observed, however, that the effort made in this area of special teaching from the sixties up to the eighties has decreased enormously, due to financial difficulties and the concomitant decrease in political investment.

Some work has been done in adapting curricula for special students, such as the development of curriculum materials focused on laboratory work for second grade blind students. A recent research study proposes a specific curriculum for students with poor mathematical abilities. These experiments have had little publicity and are still in a research stage.

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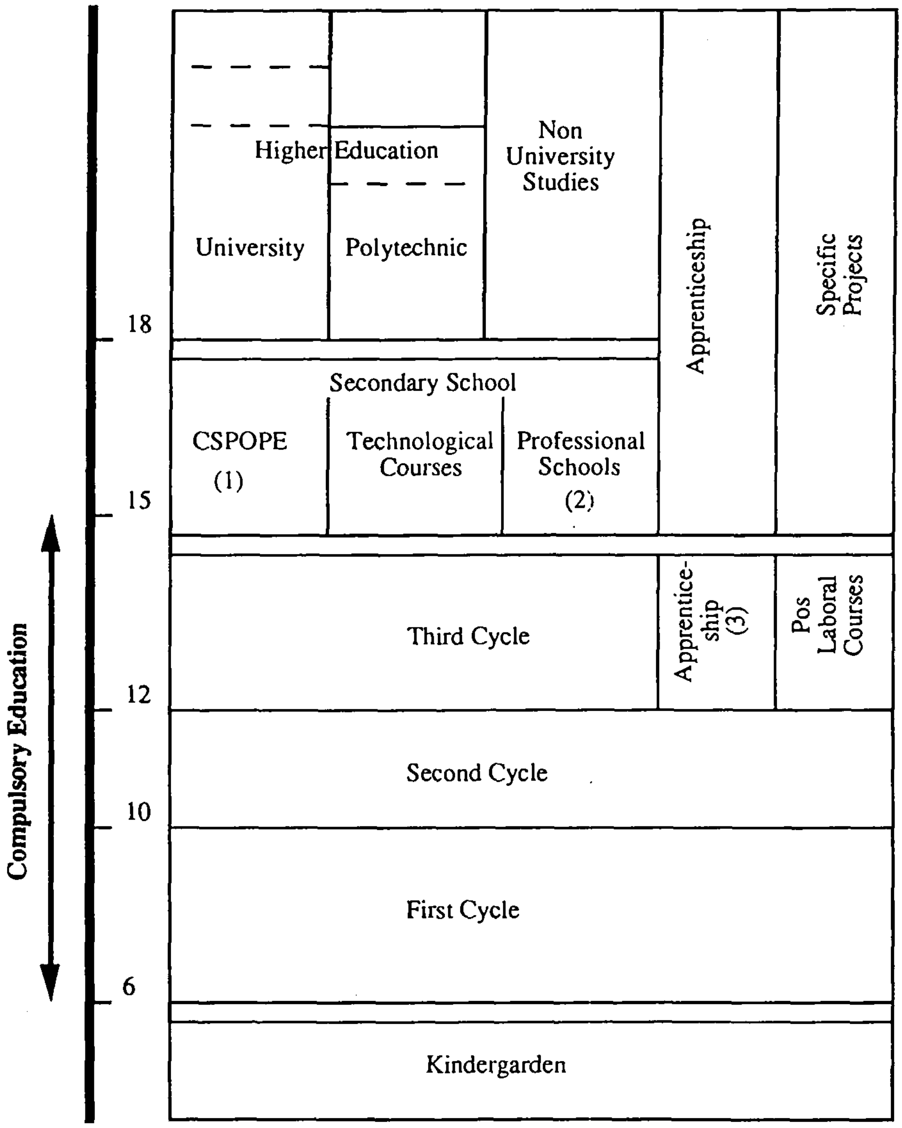
Appendix 1

The Portuguese educational system



Appendix 2

Summary of the Communication Presented by the Portuguese Team

This technical report is the first step of a wider process leading to the understanding of how science education is conducted in Portugal and how it contributes to the scientific literacy of Portuguese citizens.

The report highlighted, among many other aspects, a set of obstacles to the establishment of both science education and scientific literacy as well as a set of dynamics of change demonstrated not only by curriculum innovations, as a consequence of the present educational reform, but also by actual teacher practices in some schools.

We consider that the dynamics of change detected enable both the development and the improvement of science education in Portugal because they correspond to innovative practices actually implemented by some teachers in some schools and because they are consistent with up-to-date approaches supported by educational research and by modern conceptions concerning the teaching-learning process of science. Therefore, we advocate that present authorities in education should create systematic and continuous conditions needed to overcome the obstacles identified and to promote the dynamics of change detected.

a) Obstacles to Science Education

1) Lack of coherence between the theoretical and philosophical curriculum principles and the orientations in the programmes for each subject area;

2) Lack of both adequate and timely teacher training programmes in order to promote the curriculum principles;

3) Lack of resources in general as well as lack of uniformly distributed resources and updated teaching aids;

4) Lack of human resources in order to fulfill the present needs of both formal and informal science education;

5) Lack of collaboration not only between institutions directly related to education (schools, universities, research centres, museums, libraries, etc.) but also involving those institutions which can support the initiatives of teachers and schools (local government departments, private enterprises, etc.);

6) Lack of data from research and evaluation programmes contributing to an overall perspective of what science education is in Portugal.

b) Dynamics of Change towards Science Education and Scientific Literacy

1) Subject integration and interdisciplinary approaches

The curricula for compulsory education show a tendency for the integration of the different subjects. The level of integration is higher in the first cycle and lower in the third cycle in which conventional disciplines are considered. However, interdisciplinary areas such as the school area and the complementary curriculum activities compensate the conventional disciplinary approach throughout the three cycles, enabling students to understand and experience the relationships between the various disciplines.

2) Science-Technology-Society

Technology is approached according to a multiplicity of perspectives that, presently, co-exist in the curricula of several school systems. The relationships between scientific knowledge, technological production and their interactions with society are enhanced by some teachers and supported by educators.

3) The culture of the school

Several elements that seem to be changing in some schools may constitute the seeds for a wider movement of innovation, such as the role of the teacher, the school's education project, the inter-relationships between schools and local authorities, and the development of resource centres.

4) Teaching strategies, space and time allocations

Teaching strategies are shifting to student centred approaches involving project work and cooperative group work. There is also the tendency, shown by some innovative teachers, of connecting classroom activities with students' day-to-day life, applying new technologies, and opening the school's door to the wider world outside.

5) Evaluation/Assessment

Presently, there are discussions about the use of alternative forms of student assessment. This issue, if a serious change occurs, will influence the development of the remaining dynamics of change.

Report from Poland

Wieslaw Stawinski

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

The science content in Polish schools is included in the curriculum both at primary and secondary (I and II) levels (Appendix 2). At the primary level there are 1 to 2 lessons a week for three years. At secondary level I the number of lessons varies with the grade level (grade 4: 5 lessons; grade 5: 5 lessons; grade 6: 7 lessons; grade 8: 8 lessons) (Appendix 2). The lessons are 45 minutes in duration.

1.2 Which sciences are to be taught

The sciences are taught as an integrated subject at the primary level and as separate subjects at secondary levels I and II. The integrated science course is called Social and Natural Environment. The following are taught as separate subjects:

1) Biology with Hygiene and Conservation (Appendix 8);

2) Geography (Appendix 9);

3) Chemistry (Appendix 10, 11);

4) Physics and Technology (Appendix 12).

1.3 Realistic data on the above

During the past four to five years in Poland there has been a trend towards reducing the required number of science and technology lessons at all school levels. This is due to a general desire to reduce the weekly amount of work the students have.

The local school administration as well as the school principals and the teaching staff have the right to change the number of lessons for each subject. They have mainly reduced the number of science lessons and increased the number of lessons in the humanities, for example, Polish and foreign languages.

Another reason for reducing the number of required science lessons is the introduction of various class profiles into the curriculum and the possibility of choosing a higher level of some subjects at higher grades of Polish grammar schools.

The subject Social and Natural Environment is often taught only once a week in primary schools. Science and technology subjects at secondary level I (grades 4 to 8) are sometimes only taught once a week (Appendix 3).

At secondary level II in grammar school and non-science oriented classes, the required science lessons are sometimes only given during the first 2 years (grades 9 and 10). Another situation arises in classes with a biology-chemistry profile where the two subjects are taught in all four grades (9 to 12) with a higher number of weekly lessons. In some schools the students can choose a broader course of various subjects - including science - with a higher number of weekly lessons during the last two years (grades 11 and 12) (Appendix 6). Indeed, in Poland science and technology are taught at all primary and secondary level I schools. This, however, is not true of all vocational (professional) schools.In some grammar schools in grades 11 and 12, optional science courses including the study of the environment and chosen issues from biology, chemistry and geography are also available.

1.4 Recommended learning activities

The Polish school programmes suggest that science and technology teachers use those teaching methods which strengthen students' activity and introduce them to methods of independent and effective learning. Such learning activities include:

1) laboratory work with student observations, experiments and measurements (in biology, chemistry and physics);

2) further field observations and field measurements (in biology, in ecology and environmental protection, in geography);

3) cultivating plants in a school laboratory and garden;

4) caring for animals in a school laboratory;

5) environmental protection at the local level;

6) planning and realising various projects (in biology, chemistry and physics).

The Polish school programmes also recommend the use of those teaching methods which show the student how to look for scientific information and how to use different sources of information. Students are expected to learn how to work with a textbook, with popular science books and (in grammar schools) with scientific journals as well as with worksheets and maps (physical maps).

The number of schools where students learn to work with computers is increasing from year to year, but many schools are still without computers. Limitations to working with computers are due to a lack of computer programs for science teaching and learning.

The secondary level I and II students have to develop, among other things, the following skills:

1) planning and conducting their own observations and experiments;

2) formulating problems and hypotheses;

3) using instruments for measuring;

4) constructing and interpreting drawings (e.g. from microscopic observations) and graphs;

5) comparing objects and processes, analysing and synthesising;

6) formulating conclusions;

7) evaluating phenomena, processes, opinions and judgements;

8) preparing short reports (papers) on their own investigations (observations, experiments, measurements);

9) reading with understanding textbooks, scientific journals and popular science books.

The science teachers sometimes organise botanical, zoological, ecological and geographical field excursions and excursions to institutions (i.e. natural and technical museums, zoological gardens, botanical gardens, planetariums, etc.) and to national parks or nature reserves so their students can make ecological and environmental observations.

However, all of the above-mentioned activities are not organised very often. Everyday teaching is dominated by talk, lecturing, doing exercises on worksheets and reading textbooks; all of which limits student activity. Overloading syllabi and textbooks with teaching content and the steady reduction in the number of lessons a week results in teachers not having enough time to explain the history of scientific issues, to discuss controversies in scientific history, or to develop skills for using science knowledge to solve theoretical and practical issues. Furthermore, their work is very constrained by financial factors.

1.5 Mandatory tests and examinations

The Polish syllabi do not provide for uniform mandatory tests and examinations for all schools and students. As there was a mandatory and uniform programme for each type of school as well as concrete formulated educational goals, it was not necessary to introduce national mandatory tests and examinations. Tests are often introduced by regional (provincial) school authorities as a means of orientation for comparison. These tests are devised by regional in-service teacher training centres.

The steady evaluation of student achievement is the teacher's responsibility. Only at the end of secondary level II (in lyceum and technical schools) are students required to pass written and oral final examinations. The written and oral examinations are devised by the regional school authorities.

1.6 New trends and reforms underway

During the past five years (1989 to 1994) new trends in national education have been observed. In addition to educational innovations there have been some general directions. The Polish Ministry of Education undertook the development of the so-called 'programme minimum' (core minimum) or 'programme foundations'. Using such foundations the teacher can develop his/her own syllabus called 'author's programmes'. Former uniform programmes and textbooks will be replaced by various author's programmes and different textbook versions.

There has also been a trend towards changing the grammar schools or their class orientation and then, accordingly, the number of science lessons (see references).

The state programme foundations recommend (Appendix 5) the optimum number of weekly science lessons for primary and secondary level I and II in comparison with other school subjects. After publication of the first version of the science programme foundation there was lively discussion and strong criticism. The discussion has also been conducted in science teacher meetings and educational journals. In effect, the improved version is better than the first, but the discussion continues.

2. How is science delivered?

2.1 Organisation and authority

Until two years ago, most of the state schools were administered by the Polish Ministry of Education. Only a portion of the vocational and higher schools were subordinated to other ministries. Now (1993/94) some of the public schools have been taken over by the regional or local authorities. The number of private high schools, whose curricula only have to be confirmed by the provincial school authorities and the central government (Polish Ministry of Education), is increasing.

2.2 Resources and funding

The majority of Polish schools receive financial support from the Ministry, through the mediation of the regional educational authorities (of the inspector general's office). Private schools mainly obtain their funds from the school fees paid by student's parents. Some funding (50%) comes from the state. The equipment for science and technology education varies greatly. Some of the secondary schools (grammar and vocational) have a wealth of up-to-date equipment in their laboratories and libraries. In some, the equipment is only satisfactory. In the majority of primary and secondary level I schools (grades 1 to 8) and in many grammar schools the equipment is unsatisfactory for teaching science and technology. Financial resources are very limited and unsatisfactory. Many public primary schools have no laboratory for science and technology. In Poland today there are enough textbooks and worksheets for science and technology education at each level. The problem lies in the high costs the students have to pay.

2.3 Methods of teaching

Because of good development of science teaching methods and the publication of some teaching guides, modern methods of science teaching and learning have been popularised. First, laboratory work is recommended: observation, pupil-led experiments and measurements using group work, fieldwork in biology and geography (see section 1.4). In the daily lessons, however, many science teachers prefer to lecture and work with the textbook. The increasing numbers of students in school classes and limited possibilities for dividing the classes for laboratory work make organising pupil-led observation and experiments difficult. The programmes suggest limiting the homework for primary and secondary level I science. Sometimes the students have to work with the textbook, consolidating information or answering questions posed by the teacher. Sometimes they have to observe natural phenomena, living plants or animals near their homes, or conduct interviews, or visit institutions. In grammar and technical schools students usually have more homework. It usually means working with a textbook or other written material (journals, books, etc.). They sometimes have to do written reports, tests, or chemical or physical tasks, an analysis, an explanation or a mathematical calculation.

2.4 Sources of pedagogic innovation

Most universities and higher schools of education have laboratories or departments of science education. These departments conduct investigations of various educational issues and cooperate with innovative teachers and with teacher training institutes. Pedagogical innovations in Poland include: teaching goals and contents, standards for requirements, teaching methods, new media, science curricula, ecology and environmental education, forms of evaluation, field trips and other issues. Seminars on the issues of teaching innovation have been organised by the departments of biology, chemistry, geography and physics education.

Between 1985 and 1990, there was a national investigation on the modernisation of science teaching and on models for science education (see references).

3. Going beyond school

3.1 Use of out-of school resources

Excursions connected with science teaching are organised at every school level, usually at the beginning or at the end of the school year. Such excursions are to natural and technical museums, zoological and botanical gardens, planetariums, national parks and other reserves, or to locations that are unattractive from a biological and touristic point of view. In preparing for such excursions the science teachers make use of special guides for fieldwork. Schools located far away from such institutions and areas have difficulties organising such activities, mainly owing to financial limitations.

3.2 Consideration of public science-based issues within lessons

Science teachers are encouraged by educationalists to include public science-based issues within their lessons (see references). Such issues include:

- local environmental conservation
- sustainable economic development
- bioethics and ecoethics
- applying scientific discoveries to everyday life
- use of automatic machines and computers.

These issues were discussed occasionally for development of teaching content, but not often enough. The science teachers said they did not have enough time to do so more often. The new curricular programmes (1993) pay more attention to such practical and social issues.

3.3 Science education and vocational training

The vocational schools in Poland are in a state of transition. The system, its curriculum and the structure of its teaching contents have been strongly criticised because of their narrow specialisation. All of these schools teach general science in addition to the professional subjects. Technical schools teach chemistry and physics. In biology-oriented vocational schools (e.g. gardening, forestry and farming schools) students take biology, hygiene, ecology and environmental conservation.

Some years ago the Ministry introduced environmental education as an optional subject into all grammar and vocational schools. But, as a result of decreasing financial resources and fewer weekly lessons, the subject has practically been eliminated from grammar schools and some vocational schools.

3.4 Science clubs and cultural associations

Informal science education in Poland is mainly conducted by radio, television and scientific journals. Educational work is also carried out by various scientific societies (e.g. Polish Copernican Naturalist Society, Polish Chemical Society, Polish Physics Society, Polish Geographical Society, Polish Ecological Society and other societies, the Polish League of Nature Conservation and Polish ecological clubs). In many Polish schools there have been chapters of the Polish

League for Nature Conservation since the 1920s. There are also various special-interest groups such as The Biology Circle, The Chemistry Circle, The Physics Circle, The Geography Circle and The Ecology Club.

For all gifted students with a special interest in science there are regional competitions (at secondary level I) and centrally organised Olympiads (at secondary level II in the grammar schools and technical schools) in biology, chemistry, physics and ecology, geography and marine science.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Data from the IEA/Second International Science Study in 1984 indicated that the achievement levels of Polish students in science compared with other countries are in the middle range and above (see Appendix 7). The best achievements were in geography and biology; physics and chemistry were somewhat lower. The youngest students had problems in the practical application of knowledge and in resolving scientific issues. Differences in students (ages 10 to 14) from cities and villages and their achievement levels have been observed. Students from cities did better than students from villages. This situation is probably related to the quality of the teaching staff and the availability of school equipment.

4.2 Public or political concerns about educational standards

Partial measurements of student achievement in science conducted in Poland between 1985 and 1994 highlight a predictable state of affairs. The best achievement levels were observed in the acquisition of knowledge; achievement was lower in its understanding and in the mastery of practical skills. The above-mentioned data indicate that student achievement in science is not appropriate to contemporary social demands. Thus, in the future, more attention must be paid to a deeper understanding of science content and to the development in students of the problem solving abilities and practical skills necessary to answer human needs in a ever changing world. In this way, sustainable social and economic development can be ensured.

4.3 Suggested reforms

The educational changes in various fields and in many directions are continuing. The reasons are scientific and psychological as well as political. The decentralisation of school administration (authority) and educational decision-making should be continued. Further revision and redefinition of the goals in science and technology education together with improvements in the selection and structure of teaching contents are planned. It must be decided what new subject matter should be included in school programmes and what should be omitted. A didactical transformation of the contents of science and technology education can contribute to a more profound understanding of it by students in primary and secondary schools. Of great importance is the meaningful introduction of environmental contents into all science and technology subjects, by respecting issues of global change, human need and the foundations of sustainable development.

5. Pupil interest and motivations

5.1 Generally by age and gender

Contemporary investigations carried out in some countries indicate that differences in student interest and motivation in science learning are related to age and gender. Younger students (of both genders) demonstrate a higher interest in biology than in other sciences. Among older students, distinct differences in interest are related to age and gender; older boys are mainly interested in technology, whereas older girls are not. Similar trends have been observed in Poland.

5.2 By type of science or topic by age/gender

The investigation of pupil interest in biology conducted in Germany and in Poland indicate the relation between age and gender. At the primary school level, both boys and girls demonstrate a high interest in biology, especially in zoology. Beginning at grade 5 a distinct decline of interest in biology was observed in Germany for both genders. In Poland, as compared with Germany, the decrease is not as fast nor as great.

Other Polish studies on interest in physics reveal a proportionally low level of interest in this science, more so for girls than for boys. But regardless of gender, the interest in physics is insufficient in comparison with contemporary economic and social demands. Boys of all ages and at all school levels are interested in mechanisation (motorisation) and technology. From year to year there has been an rise in the interest in environmental issues among all students, beginning at the primary level. To further deepen interest in science, competitions and Olympiads are organised.

5.3 Options for choice within science

In Poland all secondary level I students (grades 4 to 8) have the same obligatory subjects without differentiation. They can, however, choose between various special interest groups for out-of-school activities and youth organisations (i.e. scouting).

At secondary level II (grades 9 to 12), students can choose either humanities, biology, chemistry, mathematics-physics or ecology courses. When this choice can be made only in grades 11-12, then all students in grades 9 and 10 have to take the general science subjects (i.e. biology, chemistry, physics and geography).

At universities with science faculties, only some of the students prepare to teach science subjects. These are students who take optional courses in the social and educational sciences, science education and do teaching practice.

5.4 Pupils' perspectives on the value of science

A significant number of students recognise and understand the importance of science in solving contemporary environmental and economic issues. Many grammar school students express an interest in studying medicine and biology.

6. Training, status and morale of scientific teachers

6.1 Initial training

Science teachers in Poland are educated in two levels and systems. The first one is the college level, the second the university level. Graduates of grammar schools who choose to study at the college level do so for three years. At the end of these three years they take final examinations qualifying them to teach at primary level and secondary level I (grades 1 to 8). College students are in the main educated in one or two science subjects (biology, chemistry, physics or geography) or technology. College graduates can study for an additional two years at a university or a higher school of education and receive their master's degree.

Future science teacher students can choose another way of study. After graduation they can directly enter the first year of study at a higher school with a science or technology faculty. Once they have completed five years of study and passed their master's exams they receive a degree which entitles them to teach a selected science subject at both secondary level I and II.

6.2 Decision-making authority for the above

The choice lies in the hands of the grammar school or technical school graduate. The school commission organises the final exams and determines whether they have passed or failed. In higher schools the commission for entrance examinations decides whether the candidate may or may not study.

The Polish Ministry of Education determines the principles of science teacher education. It defines the character of the social and educational science courses and sets the minimum requirements (300 hours altogether, and 10 weeks for teaching practice). After meeting these requirements, students earn the right to teach.

6.3 Continuing training

For the professionally active teachers there are in-service (extra mural) studies available in colleges and universities. Participants have to pay a school fee for each semester, but the Polish Ministry of Education grants many of these teachers financial assistance by refunding study costs. Science teachers with a master's degree can participate in various post-graduate study programmes lasting 2 to 3 semesters to improve their own scientific and didactical preparation, revise their knowledge of science and education, develop new programmes and prepare educational innovation. Science teachers with longer educational practice who have participated in extramural studies and distinguished themselves in innovative school work can apply for professional specialisation (first, second and third degree of vocational specialisation).

These teachers must present lessons or out-of-lesson activities before a special commission. They have to prepare and present a report on a chosen field of school work and on a personal further education programme to enhance knowledge both in a branch of science (biology, chemistry, physics or geography) and in the didactics of that science, as well as in educational psychology. The commission for teacher vocational qualifications also inquires about other issues concerning teaching practice and/or their studies.

Acquisition of successive degrees of vocational specialisation stabilise the teachers' position and influence their salary. It should be underlined that most science teachers participate in various postgraduate studies and courses or in conferences to continue their training.

6.4 Number, teacher/pupil ratio, gender, age profile

The number of students per class varies greatly, with an average of 25 to 35 students in various schools. The classes with the greatest number of students are sometimes divided into two groups for laboratory work (in physics, chemistry, biology and technology). This happens more often in grammar and technical schools than in public secondary level I (grades 4 to 8) schools.

The overwhelming majority of science teachers in Poland at every school level are female teachers. There are, however, slightly more male teachers in grammar and technical schools than in the lower levels.

The age profile for teachers ranges between ± 24 and 55 (60) years of age. In the last four to five years the number of middle aged teachers has increased.

6.5 Drop-out rates, late entries, maternal leave

The number of drop-outs has been very low in recent years owing to high unemployment in Poland. Therefore, especially in larger towns, there are not many vacancies for beginning science teachers. Some of the female teachers only take maternity leave, which lasts six weeks, and others opt for the longer educational leave which is for two to three years. Male teachers can also take educational leave. The overwhelming majority return to teaching at the end of their leave time.

6.6 Status and salary

The social status of teachers is not high. The reason is the lower than average salary. Government and parliament have discussed how to increase salaries. A widely published project was to increase the number of lessons per week and at the same time increase salaries.

7. Equality of opportunity?

7.1 Different status of the schools

All private and parochial primary and secondary level I schools accredited by the Polish Ministry of Education have the same rights and powers as the public schools. State funds cover up to 50% of the school expenses.

7.2 Regional differences

The regional differences between schools are not great. The main reasons for differences are more financial than regional. Children from richer families attend private schools with higher school fees. For other children the entrance to such schools is very limited.

7.3 Immigration and migrant populations

Poland currently has virtually no serious problems with teaching a migrant population. The only problems are with Roma children because they do not attend regularly.

7.4 Special education for handicapped children?

Special schools and classes for handicapped children in Poland have the appropriate textbooks and curricula. In schools for the deaf and the blind as well as in hospitals, the science teaching is usually based on the same curricula as in the non-special schools. Blind students have Braille versions of textbooks and there are other, simplified books for the mentally handicapped. When teaching deaf students, more use of the visual media (slides, films, videos) is made. They also use special methodological guides, e.g. an interesting guide on biology field activities for blind students. Children with severe mental retardation attend so-called 'schools of life' without separate school subjects.

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Appendices for Country Report Poland

1) The Polish School System

2) The Sciences Taught in Polish Schools (Programmes 1985, 1986, 1990)

3) The Sciences Taught in Polish Schools (1994)

4) The Sciences and Technology Taught in Poland (Situation With Reduced Number of Science Lessons - 1994)

5) The Sciences in Future Programmes in Polish Schools (draft 1993)

6) Weekly Number of Lessons (periods) at a Grammar School in Cracow

7) The Polish Results in IEA Second International Science Study Measures (1984, Published in Polish - 1990) in Relationship to the Other 35 Countries

8) Polish Biology Curriculum (Main Teaching Contents)

9) Philosophical Foundations and Topics in Real and Future. National Curriculum of Geography

10)National Standards for Teaching Chemistry in Poland

11)Annual Report on Chemical Education in Poland From the Polish Chemical Society (1993)

Appendix 1

The Polish School System

Kind of school-school level	Students age level	Grade of class (years of study)	Name of school
Higher school level	24 23 22 21 20	5 4 3 2 1	University; Technical university; College; Educational University a. oth.
Secondary school level II	19 18 17 16 15	 12 11 10 9	Grammar school (lyceum); Technical school; Basic vocational school
Secondary school level I	14 13 12 11 10	8 7 6 5 4	Elementary (basic) public school
Primary school level	9 8 7	3 2 1	
Preschool level	5-6 3-4	3-4 1-2	Kindergarten

Appendix 2

The Sciences Taught in Polish Schools (Programmes From the Year 1985, 1986 and 1990)

Type of School	Grades	Subject				
		Biology	**Geography**	**Physics**	**Chemistr**	**Technolog**
		Recommended number of lessons				
Lyceum (Grammar School)	12	2(4)*	-(1)	-(2)	- -	-
	11	2(3)*	2(2)	2	2 -	-
	10	2(3)*	2(1)	2	2(1)	(2)
	9	2(3)*	2(1)	2	2(2)	2
Public elementary school	8	2	1/2	3/2	2	2
	7	2	2/1	2/3	2	2
	6	2	2	2	-	2
	5	2	2	-	-	2
	4	2	2	-	-	-
	Natural and social environment					
	3	2				
	2	2(1)				
	1	2(1)				

* In biology/chemistry integrated classes

Appendix 3

The Sciences Taught in Polish Schools (1994)

Type of School	**Grades**	**Subject**				
		Biology	**Geography**	**Physics**	**Chemistry**	**Technology**
		Weekly number of lessons				
	12	2(3)*	1(0)*	2(0)*	-	-
Lyceum	11	2(3)*	2	2(1)*	0(2)*	-
(Grammar	10	2(2)*	1	2	1(2)*	2(0)*
School)	9	2(2)*	1	2	2	2(1)*
	8	1	1(2)	3(2)	2	1(2)
Public	7	2(1)	2(1)	2(3)	1(2)	1(2)
elementary	6	2	2	2	-	1(2)
school	5	2	2	-	-	1(2)
	4	2(1)	2	-	-	1(2)
	Natural and social environment					
	3	2				
	2	2(1)				
	1	2(1)				

* In biology/chemistry integrated classes

Appendix 4

The Sciences and Technology Taught in Poland (Situation With Reduced Number of Science Lessons - 1994)

<table>
<tr><th rowspan="3">Type of School</th><th rowspan="3">Grades</th><th colspan="5">Subject</th></tr>
<tr><th>Biology</th><th>Geography</th><th>Physics</th><th>Chemistry</th><th>Technology</th></tr>
<tr><th colspan="5">Weekly number of lessons</th></tr>
<tr><td rowspan="4">Lyceum (Grammar School)</td><td>4</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>1(2)</td><td>-</td><td>-</td></tr>
<tr><td>2</td><td>2</td><td>1(2)</td><td>1</td><td>1</td><td>0(2)</td></tr>
<tr><td>1</td><td>2</td><td>1</td><td>1</td><td>2</td><td>1(2)</td></tr>
<tr><td rowspan="5">Public elementary school</td><td>8</td><td>1</td><td>1</td><td>1(2)</td><td>1(2)</td><td></td></tr>
<tr><td>7</td><td>1(2)</td><td>1(2)</td><td>1</td><td>1</td><td></td></tr>
<tr><td>6</td><td>2</td><td>1</td><td>1(2)</td><td></td><td></td></tr>
<tr><td>5</td><td>2</td><td>1(2)</td><td>-</td><td></td><td></td></tr>
<tr><td>4</td><td>1</td><td>1</td><td>-</td><td></td><td></td></tr>
<tr><td rowspan="4">Primary school level</td><td colspan="6">Natural and social environment</td></tr>
<tr><td>3</td><td colspan="5">2</td></tr>
<tr><td>2</td><td colspan="5">1</td></tr>
<tr><td>1</td><td colspan="5">1</td></tr>
</table>

Appendix 5

The Sciences in Future Programmes in Polish Schools (draft 1993)

Type of School	Grades	Subject				
		Biology	Geography	Physics	Chemistry	Technology
		Recommended number of lessons				
	12	5*	5*	5*	5*	5*
Lyceum	11	3*	3*	3*	3*	3*
(Grammar	10	2	2	2	2	3*
School)	9	2	2	2	2	3*
	8	2	2	2	2	1*
Public	7	2	2	2	2	1*
elementary	6	2	2	2		1*
school	5	2	2			1*
	4	2	2			1*
Primary	3	Natural and social environment 1*				
school	2	Polish with natural and social environment or natural and social environment 1*				
	1	Integrated contents from Polish, Mathematics, Sciences				

* elective

Appendix 6

Weekly Number of Lessons (Periods) at one Grammar School in Cracow

Grades		**9**			**10**			**11**			**12**	
Section*	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Subject												
Biology	2	2	2	2	3	1	2	5	1	-	5	-
Geography	1	1	1	1	1	1	2	2	2	-	-	-
Physics	2	2	2	2	2	2	-	2	1	-	2	-
Mathematics	3	3	3	3	3	4	3	2	6	3	2	6
Technology	2	2	2	-	-	-	-	-	-	-	-	-

* Explanation:

1 - General section

2 - Biology-Chemistry section

3 - Mathematics-Physics section

Appendix 7

The Polish Results in IEA Second International Science Study Measures (1984, Published 1990) in Relationship to the Other 25 Countries

Subject	Grades	Age level	% of positive answers (solution)	Placement
Integraded Science	4	10	49.7 - 52.5	13th (35 countries)
All Sciences together	8	14	59.5 - 60.4	10th (23 countries)
Biology	8	14	61.0	
Chemistry	8	14	56.0	
Physics	8	14	55.0	
Geography	8	14	67.0	
Biology	12	18	59.2 (72.0)*	8th
Chemistry	12	18	49.9 (61.0)*	8th
Physics	12	18	56.4 (71.0)*	8th

* by specialisation in Biology, Chemistry or Physics

Appendix 8

a) Polish Biology Curriculum (Main Teaching Contents)

Grades 4-8

The following four themes are covered in grades 4 to 8:

1) Various levels of living organism structure

2) Functions of living organisms

3) Conservation of nature and environment and natural resources

4) Hygiene and health.

The teaching contents:

Biology as science - methods of investigations.

Methods of biology learning.

Life conditions on land and water.

Characteristic features of living organisms.

Various single-cell organisms (bacteria, algae, rotozoa. fungi - lichens)

Lower plants - mosses, ferns

Flowering plants - gymnosperms, angiosperms

Structure and functions of plants (respiration, nutrition - photosynthesis, reproduction, circulation of water and mineral salt)

Invertebrate animals. Coelenterates. Platyhelminthes. Aschelminthes. Annelids. Arthropods. Molluscs.

Vertebrate animals - fish, amphibians, reptiles, birds, mammals. Structure and functions of animals.

Human body structure and functions (nutrition, digestion, respiration, circulation, coordination of the nervous and hormone system, excretion, reproduction); health and hygiene.

Evolution of plants and animals.

Ecology: population, biocenose, ecosystem.

Environmental conservation. Pollution of water, air and soil.

Conservation of areas, plants and animals.

Main direction in the development of contemporary biology.

Grades 9 to 12 (at grammar school - Polish lyceum)

The biology teaching contents:

The cell - structure, ultrastructure and function. Cell division-mitosis and meiosis.

The foundations of taxonomy. Classification of plants and animals. Procaryotes. Viruses. Bacteria. Blue-green algae. Eucaryotes. Fungi. Lichens. Green, brown and red algae.

Lower plants - mosses, ferns.

Flowering plants - gymnosperms, angiosperms.

Structure and functions of plants (nutrition - autotrophy: photosynthesis, chemosynthesis, heterotrophy, respiration, circulation of water and mineral salts, reproduction, growth).

Evolution of plants.

Conservation of plant species.

Animals. Procaryotes animals - protozoa.

Invertebrate animals - variety of forms and functions (sponges, coelenterates, platyhelminthes, aschelminthes, annelids, arthropods, molluscs, echinoderms).

Fundamental stages in the evolution of chordate.

Structure and functions of chordata (acrania, vertebrate: agnathans, fish, amphibians, reptiles, birds, mammals - monotremes, marsupials, placentals).

Selected issues from plant and animal physiology including human biology (nutrition, digestion, respiration, locomotion, circulation, coordination - nervous and hormone system, excretion, reproduction and development). The family in human life.

Ecology. Population properties and structure.

Biocenosis - composition of species, main trophical levels, homeostasis, succession.

Ecosystem. Structure of ecosystems. Circulation of matter and flow of energy. Biogeochemical cycles. Productivity of ecosystems.

Scientific foundations of nature and environment protection.

Chosen issues of etology and biogeography.

Heredity and variation of organisms.

Basic issues of evolution.

Perspectives of contemporary biology science development.

Appendix 9

Philosophical Foundations and Topics in Real and Future. National Curriculum of Geography

Real geography as a subject in school relies on a rationalistic module.

Consequence of this approach is a scientific reply and dominates analytic structure.

Primary school (students age 7-15)

Grade IV (10 age)	• Local landscape; Selected landscape of Poland (different land forms: mountains, uplands, plains).
Grade V (11 age)	• Finding and using direction Earth's movements and their consequence (rotation, revolution). Selected landscapes of the earth.
Grades VI-VII (12-13 age)	• Selected topic of physical geography. Regional geography of the world: America, Africa, Australia and Oceania, Asia, Europe.
Grade VIII (14 age)	• Geography of Poland: Environment of Poland compared with Europe. Regional environments in Poland. Population, industry and industrializing. Agriculture and Food. Forests. Poland is situated on the Baltic Sea. Network of transport. Polish co-operation with other countries.

Secondary school (Gymnasium, Students age 15-19)

Grades I and II (age 15)	• Physical geography with geology. Maps. The earth as a planet. Atmosphere. Hydrosphere. Lithosphere. Pedology and Biosphere.
Grade III (age 17)	• Geography of Poland: Environment. Poland's position in Europe. Regional environments of Poland. Population and colonisation. Industrialising. Agriculture and food problems. Communication and functions. Foreign trade.
Grade IV (age 18)	• Man and his action in the World. Environment. Population of the world. Industrializing proces. Different kinds of action. The earth as a human planet.

Future geography in school according to the national curriculum in Poland (1992)

Geography as a subject in Polish schools should refer to the pedagogical and psychological personality and understanding natural science.

Subject:

1) The Earth in space. Heliocentric system. The Earth in the Solar System. Earth's movements.

2) The earth as a life environment. The earth as a system. The earth's spheres. The earth's land forms. Report between elements of environment. Solar energy. Natural condition of Ekuman.

3) Reaction earth-mankind: ways of perceiving the environment. Natural landscape transformed by humans - study examples. Natural resources and their use. Population. Geographical aspects of cultural development. Influences of usage locally, regionally and globally. Past, present and future environment.

4) Economic and political changes in the world: regional, international and global influences. Local area. Poland. Natural and economic potential of Poland compared with Europe and neighboring countries; direction change; open to international integration and national identification. Europe. National and economic potential. New map of Europe: changes, conflicts. Disproportion of development in modern world. Modern global problems and possibilities.

The national geography curriculum in primary schools (grades 4-8) includes all subjects but in secondary school, subjects III-IV are treated in depth.

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Appendix 10

National Standards for Teaching Chemistry in Poland

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Chemistry is a subject taught both in primary and secondary schools in Poland. In primary schools teaching chemistry starts in the seventh grade (2 hours a week) and is continued in the eighth grade (2 hours a week) as well. In secondary schools chemistry is taught in grades I, II, III 2 hours a week as a basic teaching load and in the biological - chemical profile classes the students get an additional 2 hours a week in the last grade (IV).

Changes in the educational system have recently taken place in Poland. At the same time, some work for which the objective is preparation of well planned, complex changes of the present system has been done. The main aim of these changes is to offer the students sufficient knowledge to allow them to use the achievements of modern civilisation. In the opinion of the people responsible for these reforms, this aim will be achieved if teachers and students are given greater freedom to decide about the contents of school education.

Accordingly, teachers will have a choice among a few curricula and textbooks. All of them will have to contain core contents validated by the Minister of National Education. The author of the curriculum will be able to arrange and complete it using his own ideas. A set of curricula available for teachers will always be open which will increase their number. It is assumed that among the curricula, ones combining the contents of related subjects (e.g. physics, chemistry, biology) will also be found. Due to this, teachers instructing such a group of subjects in an integrated way will be able to choose a suitable curriculum. At the same time, national standard requirements in individual subjects must be worked out.

The work on core content preparation for individual subjects started at the beginning of 1992. The Office for School Reforms co-ordinating such work was established within the Ministry of National Education. Its task was, among others, to create the teams working on core content . The team preparing core contents to teach chemistry in primary and secondary schools was made up of two university professors, two school teachers and three persons dealing with chemical education and training future chemistry teachers. The project they prepared was subjected to consultation and discussion by those it concerned. Then it was analysed, revised and completed based on the remarks and suggestions.

In the final stage, the core content was corrected, taking into account its relation to other subjects. For this purpose, a meeting lasting a few days was set where the representatives of the teams working on the core content took part. There the plenary discussions on the final curriculum as well as the work in the topical teams were held. The chemistry core content was discussed in the group dealing with mathematics and natural science subjects.

As a result, it was agreed that chemistry would be still taught two hours a week in the seventh and eighth grades of primary schools. In secondary schools, chemistry will be a compulsory subject for all students at the first and second levels, also taught two hours a week. However, in the last two grades it will be a facultative subject taught three hours a week in the third grade and four hours a week in the fourth grade at maximum.

The agreed core content in chemistry for the primary school is as follows:

a) Substances and chemical changes in the surroundings of man

1) Metals and non-metals - their properties and application (sodium, calcium, magnesium, aluminium, iron, copper, mercury, carbon, sulfur, chlorine, hydrogen).

2) Air as a mixture of gases. Physical and chemical properties of oxygen and nitrogen. Oxides.

3) Element and chemical compound. Symbols of elements.

b) Atomic theory

1) Discontinuity of matter structure.

2) Atom and molecule

3) Chemical reaction

4) Valency of elements

5) Formulae of chemical compounds

6) Chemical equations

c) Water and aqueous solutions

1) Physical and chemical properties of water

2) Advantages and disadvantages resulting from water properties for civilisation

3) Weight percentage concentration of solutions

d) Acids and bases

1) Hydrochloric, sulfuric and nitric acids - properties and application

2) Sodium and calcium bases - essential properties and application.

3) Dissociation

4) Salts as the products of reaction of acids and bases.

5) Essential properties and application of sodium and calcium salts - chlorides, sulfates, nitrates and carbonates

6) Sparsely and readily soluble salts

e) Carbon and its compounds

1) Carbon as an element (diamond and graphite)

2) Methane, ethane, ethene, ethine as the representatives of saturated and unsaturated hydrocarbons. Properties and application.

3) Polyethylene - synthetic materials.

4) Sources of energy containing carbon compounds: coal, petroleum, natural gas.

f) Simple derivatives of hydrocarbons

1) Methyl and ethyl alcohols, glycerol - structure, properties and application

2) Carboxylic acids: formic, acetic, stearic - structure, properties and application

3) Soaps and esters - properties and application.

g) Organic compounds of biological importance

1) Fats

2) Glucose, fructose and saccharine

3) Starch, cellulose and proteins as the examples of macromolecules.

The core content in chemistry for the secondary school refers only to the grades where it is compulsory and is as follows:

a) The structure of atom

1) A simplified model of atom structure

2) Electron configuration in the atoms of elements of atomic numbers from 1 to 20.

b) The contemporary periodic table

1) A periodical change of properties of elements - a periodicity law.

2) Structure of the periodic table

3) Atom structure and properties of elements and their position in the periodic table

4) Electronegativity and its changes based on the periodic table

c) Chemical bonds

1) Atomic and ionic bonds

2) Dependence of chemical compound properties on the type of bonds

d) Chemical reactions - their description and notation

1) Types of chemical reactions (synthesis, analysis, exchange)

2) Mole. Quantitative interpretation of chemical exchange.

3) The course of chemical exchange in time

4) Endo and exothermic reactions

5) Oxidation degree, the simplest reactions of oxidation and reduction

e) Solutions

1) Solution, solvent, solute

2) Saturated and unsaturated solutions - solubility

3) Calculations related to solubility. Molecular concentration

f) Systematic of inorganic compounds

1) Variation of chemical character of oxides of period III elements

2) Bases, acids, salts - nomenclature, preparation, properties

3) Dissociation. Dissociation degree

4) Acid- base indicators; pH scale

5) Reactions in aqueous solutions - neutralisation and precipitation reactions; pH of salt solutions

g) Properties of some metals and non - metals (sodium, calcium, sulphur, chlorine, helium) and their most important chemical compounds

1) Occurrence and abundance in nature

2) Properties of elements and their position in the periodic table

h) Hydrocarbons

1) Variety of organic compounds

2) Saturated and unsaturated hydrocarbons - nomenclature, properties, characteristic reactions, application

3) Benzene as a representative of aromatic hydrocarbons

4) Isomerism

i) Monofunctional derivatives of hydrocarbons - nomenclature, preparation, properties, application

1) Mono and multihydroxide alcohols

2) Aldehydes as products of oxidation of some alcohols

3) Carboxylic acids and their derivatives

j) Difunctional derivatives of hydrocarbons

1) Glycin and alamine as the representatives of aminoacids

2) Peptides and proteins

3) Glucose as an example of simple sugars

4) Maltose and starch as examples of complex sugars

The effects of changes due to competitive curricula and textbooks can already be seen in the case of primary schools. In the school year 1994/1995, teachers and students will be able to choose among five different chemistry textbooks for the seventh grade, all of which have been validated by the Ministry of National Education. Some of them are quite different as far as range and arrangement of the contents and above all methodological conception are concerned. Teachers are facing the hard task of selecting the right textbook depending on various conditions affecting the chemistry-teaching process (interest of students, school equipment, qualifications of teachers).

The results of these changes will be obvious in a few years time. At present it can be said that competition among editors had a positive effect on the level of chemistry textbooks. At the same time, the necessity of selecting the right textbook makes teachers more responsible for the results of their work.

Appendix 11

Polish Chemical Society: Annual Report on Chemical Education in Poland (1993)

Further changes in chemical education have a place in Poland. Some of them are of temporary character which is caused by economic difficulties. In many primary and secondary schools, the number of chemistry lessons has diminished compared with the previous years. This was caused by the decrease in the total number of lessons at school. The decision of which subjects should be taught in a reduced number of lessons was taken by individual headteachers.The Polish Chemical Society called the relevant authorities' attention to disadvantageous consequences of such actions several times.

Simultaneously, with the possibility of working out alternative curricula, an increasing amount of competition in the field of textbooks is observed. For example there are already four textbooks for teaching chemistry in the seventh form of primary school. It gives a possibility of choosing by the teacher a textbook adjusted to teaching conditions. In order to influence the level of the chemistry textbooks, the Publishing Committee was established within the Polish Chemical Society whose positive opinion is to ensure high level (quality) of educational publications in chemistry including university handbooks.

Suitable qualifications of chemistry teachers are a permanent problem. This is particularly evident in the case of primary schools in which a number of chemistry lessons is relatively small and it is rarely enough for full time employment. This requires educating teachers for teaching a few subjects and such is a trend of educational authorities' activity. Moreover, more and more universities organise postgraduate studies giving rights for teaching chemistry, e.g. biology graduates. To determine the actual qualifications of chemistry teachers in primary schools, all-Polish investigations are being carried out together with the Education Division of the Polish Chemical Society this year.

The Education Division of the Polish Chemical Society has over 300 members at present. It organised VII Chemistry Education School devoted to the problems of teaching environmental issues during chemistry lessons as well as using computer and television programmes for it. Over 100 teachers and scientists from all over Poland took part. The next School is scheduled for December this year. The Education Division also participates in the Annual Congress of the Polish Chemical Society in an active way organising sessions on teaching chemistry.

Another activity of the Polish Chemical Society connected with teaching chemistry is establishment of the Jan Harabaszewski Medal. Harabaszewski was a chemistry teacher actively engaged in the Polish Chemical Society activities who contributed significantly to the development of chemistry education in Poland in the inter-war period. This medal is awarded for distinguished chemistry teachers and educators every year as suggested by the Education Division.

Within the Polish Chemical Society, there are studies connected with the 40th anniversary of the Chemical Olympiad in Poland. Their aim is to get to know the careers of the olympiad prize-winners.

An important problem also dealt with by the Polish Chemical Society is development and popularisation of the results of research on chemical education. For some years a competition for the best master theses in this field has been organised. The bibliographical information covering all important international journals in this field is in operation. In March 1994 a scientific seminar, the aim of which was to present the scientific problems in chemical education, was organised at the Warsaw University. There are also some plans for the Polish Chemical Society to organise ECRICE III in 1995.

Report from Spain

Maria J. Sáez

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

Spain is being decentralised administratively and politically (Appendix 1). In terms of the curriculum, the central government has the power to determine the minimum required for certificates to be accepted and valid across the country (Royal Decree, 1991). The various Administrations of the Autonomous Communities have to ensure that it is open and flexible enough to allow teachers to draw up projects and programmes which can be adapted to the characteristics of the pupils and the educational possibilities of each school. Appendix 2 gives a general scheme of the educational system.

Fifty minute lessons are recommended, but schools can decide on a more suitable time period depending on the subject and the characteristics of the pupils.

a) Primary education

The primary education (6 to 12 year-olds) is divided into three two-year cycles. The scientific disciplines are integrated in a subject called Knowledge of the Environment (natural and social sciences).

The compulsory school timetable (since 1991) in line with the minimum is shown below:

Knowledge of the natural environment, First Cycle	175 hours/year
Knowledge of the natural environment, Second and Third Cycle	170 hours/year

b) Secondary education

The secondary education is divided into two levels: the lower secondary (from ages 12 to 16) which is compulsory, and the upper secondary (from ages 16 to

18) which must be completed by students going on to university as well as those accessing higher grade vocational training.

To access intermediate grade vocational training, students must have passed the lower secondary school (Appendix 2).

The lower secondary level is divided into two cycles; the characteristic traits of this stage differ in the structure of the curriculum for each cycle. During the first cycle the common core is more important and there is little room for options and pupils' different abilities; motivations and interests are dealt with within the scope of the classroom. In the second cycle, the structure and organisation of the curriculum is more complex and the room for options is extended as it progresses.

The curriculum organisation for compulsory secondary education is similar to that of primary, although the areas of knowledge tend to be broken down into disciplines or subjects at this stage and some optional subjects. The curriculum for this level, specified in 1991, establishes the minimum teaching requirement and sets the general objectives and contents of each area, as well as the criteria for assessment to be implemented nation-wide. During the first three years, the physical-natural sciences are covered by an area called Natural Sciences (timetable: first cycle 140 hours a year, second cycle 90 hours a year). During the first cycle natural science is a compulsory part of the common core.

For technology, there are 125 hours a year in the first cycle, and 70 hours a year in the second cycle.

Besides the common core, the curriculum includes electives which gain in importance throughout this stage. The Educational Administrations encourage school self-government with respect to the definition and programming of electives. A margin of school hours is left for the Autonomous Communities and the MEC (in its area of direct management) to make necessary extensions and adaptations, a margin which in no event may exceed 45% in the Autonomous Communities which have a second official language other than Spanish, or 35% in those communities without another second official language.

During the last year of this stage, pupils have to choose two of the following areas: natural sciences; plastic and visual arts; music and technology.

The syllabi published by the ministry are organised according to eleven themes, under which are included all of the contents considered relevant for this level. An asterisk indicates that a topic is recommended as an elective subject for the fourth year. Appendix 3 lists the topics.

At the upper secondary level (called bachilleratos) the general arrangement is broken down into broad academic or vocational fields. The LOGSE (General Arrangement of the Education System Act of 1990) established four fields of specialisation (see Appendix 1):

1) natural sciences and health sciences

2) technology

3) arts

4) social sciences and humanities.

Each of these fields give preference to particular university degrees. Similarly, it will be necessary to have taken a given bachillerato subject in order to take certain vocational modules in specialised higher level vocational training, depending on the admissions requirements specified in each case. The curriculum structure for this stage is made up of core subjects, the chosen specialisation field and electives. Therefore, the block of subjects common to all areas will mainly help in pupils' general education building up to the bachillerato as the final stage. The individual disciplines should prepare students more for academic and vocational fields without forgoing the basic educational function. The electives have to contribute to the enrichment and definition of the chosen field. In this respect, the curriculum may include practical training outside the school. The subject Science, Technology and Society (STS) must be offered under this scheme by each school.

The minimum contents and goals of the core subjects as well as the organisation of particular subjects are compulsory and common throughout the country, although there may be variations in their individual implementation. The electives are not be regulated at state level and may, therefore, be regulated by the Autonomous Communities and the MEC itself in its territory.

When Natural Sciences and Health is chosen, the following courses must be taken: biology (70 hours/year), biology and geology (70 hours/year), environmental and earth sciences (70 hours/year), technical design (70 hours/year), physics (70 hours/year), physics and chemistry (70 hours/year), mathematics I and II (140 hours/year), chemistry (70 hours/year).

When Technology is chosen, the following courses must be taken: technical design (70 hours/year), electro-technology (70 hours/year), physics (70 hours/year), physics and chemistry (70 hours/year), mathematics I and II (140 hours/year), mechanics (70 hours/year), technology (70 hours/year).

1.2 Which sciences are to be taught

At the primary level the scientific disciplines are integrated into only one subject, Knowledge of the Environment. The topics included in the curriculum must be structured around themes which are valuable for human beings to know, to experiment with, to construct and reconstruct, while making them increasingly aware of the most important achievements of science. The levels of development, knowledge, basic aptitudes and practical skills which the pupils gradually acquire make it essential to progressively determine and separate these areas.

In the lower secondary school the scientific disciplines (physics, chemistry, biology and geology) are organised as independent areas because students at this age are able to understand concepts, reasoning and abstract inferences, and they can operate with symbols and formalised representations. Thanks to this approach, students completing this educational level begin to distinguish the disciplines and their differences in terms of the object of study and the procedures of research.

In the first courses the approach may be strongly interdisciplinary and in the last courses more discipline defined. The curriculum framework encompasses three issues: knowing contents, using procedures and developing attitudes - such as curiosity and interest about nature and its preservation, etc. (Ministry of Education and Science 1990). To address the different abilities of students, teachers are developing curriculum adaptations, and a specific programme called Diversification is being implemented in some schools as an experiment to attend to all students' differences.

At the upper secondary level the disciplines are completely separate, building up students' ability to learn by themselves, to work in groups and to use the appropriate investigative methods. Similarly, it underlines the relationship between the theoretical aspects of the subjects and their practical applications in society. The propaedeutical nature of the bachillerato comes from its function as a step toward higher studies, be they technical professional studies at university or elsewhere. However, this preparation should not include subjects which belong to later studies.

1.3 Realistic data on the above

Even though at the lower secondary level only one subject called natural sciences includes the four disciplines, teachers still teach biology and geology on one hand, and physics and chemistry on the other, with no integration between them and with no team work in their approach to science education. In fact, the school can choose how to organise these subjects and quite a few use one teacher to teach four months of the natural sciences and another one for physics and chemistry during the last four months. At this level schools must propose some subjects as optional (the acceptance procedure for the schools is such that a subject must be proposed by the department, approved by the teaching staff, informed positively by the inspector and accepted by the Department of Innovation of the ministry). An example of an unaccepted course was the proposal to have laboratory work as a subject under this scheme. This was not accepted as the administration felt laboratory work should be part of the ordinary subjects. An approved course was work with computers for example.

Technology was very recently introduced in the curriculum as a discipline. Therefore, it is very difficult to know what teachers are doing in the classroom. Depending on the various levels and schools, technology is understood in some instances as making things in wood and metal, and in others as using scientific knowledge for the design and manufacture of artefacts. It is important to note that teachers of technology very often have an engineering background.

1.4 Recommended learning activities

The curriculum rccommendations are framed by three issues: contents, procedures and attitudes, as the minimum for the whole country. Procedures include practical tasks such as laboratory work, fieldwork and data interpretation, etc. In fact, the documents published by the ministry exemplifying the new curriculum are organised according to contents and activities. These include laboratory experiences, fieldwork, different types of activities around a kind of problem where students must work with statistics, or must collect data themselves and interpret it, building up graphs or diagrams, etc.

At the primary level, the ministry documents do not explicitly recommend including historical or industrial aspects of science, but do so with social aspects in terms of the natural and social environment.

In compulsory secondary education, the ministry documents do not include the historical aspect of science, but in the procedures again some subjects recommend using different models to understand a theory, e.g. the atomic theory, proposing then to compare the different theoretical explanations given in the last decades. Even if the emphasis is not too important they propose outlining the changes that science has made through time, i.e. the provisionality of science and with it technological development. In fact, it is in the technological subjects where the relations between science and industry can be made clearer. Teachers use historical stories to introduce the topics and use these as a way of motivating students.

In post-compulsory education, the contents include how the theoretical models have changed through the years and how the scientific contents have also changed. It is an idea that is clearly included in order to understand the role of science in the development of western civilisation. From the procedural point of view, they explicitly recommend comparing different theories, e.g. evolution, in which the not only Darwinism and Neo-Darwinism must be studied. All the science subjects include a unit in the beginning on science, technology and society where the relationship between industry and social influence can be made clear.

1.5 Mandatory tests and examinations

There are neither national exams nor tests at the end of compulsory education or at the end of the upper secondary school. The exam system is the responsibility of the teachers and belongs to the domain of school autonomy.

At the primary level, if the student does not obtain the necessary results at the end of the year, it is possible for the student to stay for another year. This extra year should be considered an exception and the principle applied is that the students can only repeat a year twice throughout compulsory education. The same criteria should encourage the students' progression from primary to secondary education. The decision to stay on an extra year will be taken by a review board (composed of the different teachers, the student and coordinated by the tutor of the group of the students). The decision must be accompanied by individual pedagogical measures: general support, concentration on certain areas and curriculum adaptation.

The movement of pupils from one year to the next should be automatic in the lower secondary school. The teachers agree on the requirements for promotion from the first phase to the second. Only at the end of the first phase, as an exception, is there the possibility of repeating a year. Diversity is assured by means of flexible grouping of students in the same group, the creation and development of curricular projects adjusted to educational needs, the use of didactic resources, activities reinforcing and extending knowledge, support and guidance from educational psychologists; the possibility of free choice for part of the curriculum in the last year of the level contributes to this. The compulsory nature of the lower secondary school means that all students should be able to complete it. Therefore, all students who finish this level obtain the same qualifications which are essential for going on to the bachillerato or vocational training. This qualification is accompanied by a brief credit note showing the subjects taken by the pupils in the different areas as well as guidelines toward future studies. The Ministry of Education and Science has defined what is to be done for those pupils who do not obtain the qualification in order to successfully complete this level, which can be prolonged up to a maximum age of 18, if two years are repeated so that they can obtain it in the same way as adults. Social guarantee programmes will, therefore, be created, the aim of which is to ensure that young people at least manage to get the first level professional qualification.

In the bachilleratos there is only one qualification, although the type of bachillerato studied by the student will be noted. This qualification will be issued at the end of bachillerato when the students have passed all subjects. University entrance will, however, require a further exam. The bachillerato qualification gives access to university degree courses.

1.6 New trends and reforms underway

The current reform had an experimental phase which started in 1985 in a few voluntary primary and secondary schools across the country. The experimental phase lasted five years and afterwards the law with the norms and the minimum for the curriculum was approved by Parliament. Once the law was approved, the reform was implemented sequentially. The calendar for implementation is shown in Appendix 4.

There are several aspects which can characterise the reform:

- The change covers three levels:

1) structural, for example the extension to age 16 for compulsory education;

2) organisational, with special emphasis at school level;

3) curricular, for example new subjects are included and old ones have a different weight in the timetable.

- The important focus of change for teachers and administrators is the learners.

Since 1992, some internal evaluations of the implementation process have taken place in the various levels of the educational system, mainly in primary and secondary school (CIDE 1992, 1993). In 1994, the government created the National Institute of Quality and Evaluation, which is responsible for evaluating the Educational System and the reform. It is planned to start developing an evaluation programme for reformed primary education.

Programmes about special educational needs were evaluated by a team of evaluators headed by the General Director of this programme in 1991 and 1992. Other evaluations are being developed by the CIDE about programmes such as 'Schools and Newspapers' and 'Vocational Modules' as a part of the General Reform of Vocational Studies.

The implementation of the ongoing reform is very controversial, and, depending on the sector in the society, the critiques differ. Trade unions say that the reform needs to be implemented with more money (the aim is to spend 6.0% of GDP - see section 2.2.), something which, in their opinion, has been a problem since the economic crisis became so acute two years ago. According to some families and teachers, the reform is lowering the quality of the educational system because the contents are being reduced, especially in compulsory education which has been extended by two years. Other groups of teachers consider the syllabi still rather large. It seems that more negotiation on the implementation process of the ongoing reform is needed.

In the author's opinion, the reform is very ambitious because the whole system is being changed and a real change is needed in the thinking of the people involved, not only educationalists and teachers, but also families. The autonomy and responsibility given to teachers and schools in terms of curriculum development cannot be considered small, but to use it takes time. Students and teachers implementing the reform programmes complain that the textbooks and curriculum materials at their disposal are insufficient. The inspectors claim the in-service courses for lower secondary school teachers do not focus on the issues that teachers need in order to innovate.

2. How is science delivered?

2.1 Organisation and authority

As Spain is immersed in a decentralisation process, the decisions are currently made by the Central Government, the Local Governments with autonomy and the General Ministry in its territory, and the schools.

The Central Government makes the decisions on the core curriculum, thus establishing the minimum teaching requirements, setting the general objectives and contents of each area as well as criteria for assessment to be implemented nation-wide. The time schedule thus fixed is 65% for regions with Castellano (Spanish) as the official language, or 55% for regions with other additional official languages.

The Autonomous Communities make decisions on the remaining 35% (or 45%), using the time for necessary extensions and adaptations. For the lower secondary level they must leave the decisions on optional courses to the school level.

The schools have to propose some optional subjects (see section 1.3).

2.2 Resources and funding

In 1991 the total expenditure on education was 5.4% of GDP, the total spending on primary and secondary education was 3.8% of GDP (OECD 1993). Though the level of expenditure is below OECD average, the increase during the last years has been considerable.

In absolute figures: The total amount spent on education was 2,382,174 millions pesetas, 78.9% from public sources, 21.1% from private sources (mainly families) - see Appendix 5.

The public funding comes mostly from the Central Educational Administration (Ministry of Education and Science), the Autonomous Communities and Local Authorities. For details see Appendix 6.

Public funds do not go solely to state schools, they also subsidise private schools (see Appendix 7) and students grants and allowances (see Appendix 8).

The schools implementing the reform should have specific laboratories for science and others for technology.

At the primary level, the ministry recommends structuring the curriculum in two areas, knowledge and expertise. It is compulsory for each school that both are integrated and that they have at least one room as a laboratory. In compulsory secondary education, the schools implementing this curriculum must have 3 laboratories, one for biology and geology, one for chemistry and one for physics. The schools must have a technology classroom as well. In post-compulsory education each of the four subjects must have its own laboratory as well.

The equipment is provided by the ministry in its territory according the minimum requirements established by law. Schools receive identical packages of equipment and lab materials. The school budgets are not big enough to buy or to develop their own equipment. In the past, the schools did not have much tradition in lab work, and sometimes the equipment and didactic materials provided by the Educational Administration were left packed. Actually, work with practical activities is increasing but teachers sometimes ask the students to bring instruments or mechanical toys to class to begin talking about science matters. Afterwards they start working with the equipment sent by the ministry, which in the past was more academic.

Each school level has a general library (with no specific rules or norms). The general libraries provided by the ministry are short in books and without librarians. The local authorities have special programmes to buy books for school libraries or classroom libraries in primary schools. All purchases not under a special programme must be bought from the school's general budget. The people in charge of the library are teachers who need the hours to fulfil their contracts. Because of the reform, some schools in compulsory education are creating a type of classroom where students have not only books (monographs) for specific topics but also various curriculum materials (e.g. stones and rock collections, molecular models, biological models of the parts of the human body, etc.) and a video collection. In order to obtain all these materials, the department must prepare a project supported by the school and then go to private or public institutions for financing. The textbooks are usually bought privately, although in some areas there are a great number of grants available (see Appendix 8).

As mentioned above, families and teachers claim the textbooks for implementing the new programmes are not yet ready because publishers are waiting for the new plan to be extended to a larger number of schools. The reform education department of the Central Ministry is publishing books trying to exemplify the new type of plans that teachers should prepare, which can be used by the publisher as models for the new books that they must produce. But this situation means that teachers exchange materials organised or created by themselves and students use photocopies. Schools with a longer tradition of team work are producing their own curriculum materials in the form of work sheets for the students who, in this case, use the textbooks for reference.

2.3 Methods of teaching

In general terms, the ministerial documents recommend a methodology for primary education which is described as comprehensive and interdisciplinary. The act states that the aim of the methodology "is pupils' overall development through integration. Teaching will be individualised and adapted to each child's pace of learning."

For lower secondary education, the ministry recommends that the methodology be adapted to the pupils, building on their ability to learn for themselves and to work in groups, introducing them to knowledge of the real world in line with the basic principles of the scientific method.

For the upper secondary school, the didactic methodology recommended will build up pupils' ability to learn by themselves, to work in groups and to apply the appropriate methods of investigation. Similarly, it underlines the relationship between the theoretical aspects of the subject and their practical applications in society.

In such a situation, it is very difficult to give a general picture about what the most common teaching strategies in the science lessons are and how long they are going to last. But it can be said that in most cases teachers who are introducing innovation include 4 points with different purposes in their strategies: 1) teachers are no longer the only source of information, students themselves look for information on their own depending on the educational level, 2) students are doing different types of activities, some of them practical or at least exercises or problems about applied concepts (which was rather uncommon in biology in the past), 3) teachers propose group work not only for practical work but for writing reports about specific topics (even though there is a long way to go yet in order for this to be productive in terms of organisation), 4) many teachers are introducing examples from daily life.

Teachers still give homework to the students.

From empirical research implemented in the classroom for the OECD project 'Curriculum and innovation in learning SMTE in OECD countries', unpublished results show that the focus of teaching in science is on understanding, emphasising that students should be able to relate factual information and explain how they know it, make connections between ideas, and solve problems based on the understanding they have about concepts.

2.4 Sources of pedagogic innovation

In such a legal frame for curriculum change, the main source of innovation is obviously the further training organised by the Ministry of Education and Regional Educational Administrations through different institutions such as teacher centres and universities. The further training can be categorised into two activities: in-service courses (of two types: (a) scientific and didactic refresher courses and (b) short courses) and permanent seminars.

The first type focuses on teachers who are going to be in charge of the first cycle of compulsory secondary education and on those who are going to be in charge of post-compulsory secondary education. Their aim is to build on training in the discipline and cater for didactic training in the teacher's particular subject, which is almost non-existent in the initial training of secondary education teachers. The training takes 300 hours and teachers are free from teaching duties during the intensive stages.

The short courses aim to cater to the needs mentioned by working teachers themselves, usually involving issues directly related with classrooms. Teachers need not leave their workplace to participate.

The permanent seminars are targeted towards all teachers. They are intended as a point of interchange among teachers from the various schools, where they can communicate their experiences and detect the needs for further training. They also serve as a nucleus for reflecting on their own teaching practice and for group work on preparing materials, analysing routines and usual tasks in the classroom. They aim to do away with the traditional isolation of the teacher in the classroom and to help the participants to work in teams involving discussion and decision-making by consensus. The permanent seminars have between 5 to 20 teachers coordinated by the staff of the teacher centres. Rather than development of abilities or the acquisition of knowledge, they aim at professional development and are proving to be a powerful tool in catering to a large number of teachers.

Whereas in-service training can be considered successful in terms of innovation for the older primary school teachers, it is actually considered unsatisfactory in terms of the teachers in the secondary levels. The main problem seems to be due to courses being advertised as training in methodology or assessment when they only give information about the new norms and about the reform law, which in itself is not very useful for classroom change. Learning from practice is an idea which is in the rhetoric of the reform but not included and developed in the in-service courses.

3. Going beyond school

3.1 Use of out-of school resources

A few science or natural history museums in the country can be used as learning resources. Most of them are not participative and have no experience interacting with students - except the one in Madrid and the other, probably the most popular and better equipped one, in Barcelona. Visiting them is not integrated into the daily life of the classroom; they are extraordinary one-off experiences not understood as a source of learning. Only a few families visit them with their children.

Even though it is possible to observe increasing activity in using museums as a learning experience for children, the most popular museums in Spain are for art.

New technologies were introduced in Spain through specific programmes, Mercurio (1987) for audiovisual equipment and Atenea (1985) for computers. In order to understand the scope of these programmes, it is necessary to have an overview of the experimental stage (1985-1990) aimed mainly at creating material and human infrastructures, producing new materials, reflecting on the changes in primary and secondary curricula, including the needs arising from vocational training, arts and special education as well as analysing their impact on school organisation and management. Three separate lines of evaluation were employed to make an overall assessment of the experimental stage of the Atenea project in 1990 (a university department, an international organisation - the OECD - and the programme itself), the 1990-91 and the 1991-92 academic years were planned for the results of these evaluations.

The projects are no longer experimental, the aims being to fully and permanently integrate the use of computer and audiovisual technologies into various subjects and areas of the curriculum by means of projects adapted to each of them. In this field of new technologies, general teacher training takes place in the teacher centres participating in the two projects mentioned and performed by project teacher monitors. It was based on a training model which considers the teacher as the central figure in any innovative process in the schools, and aims to provide teachers with an outline enabling them to transform educational practices by taking their ways of thinking and acting into account.

The training schedule was divided into two stages: the first provided an introduction with interdisciplinary views of the possibilities of computers and audiovisual materials in the various subjects and the use of individual computer tools applicable to education. The second went into the didactic aspects of the teachers' own subjects, asking them to deal with aspects related to experimentation in the classroom, analysing their own methods and putting forward new lines of work.

Concern for environmental problems is one of the aspects which has become especially important in our society in the last few years. Environmental education has been developed to help the pupils understand the extent of such problems, the relation between the community and its surroundings, shaping attitudes of participation and solidarity. Environmental education is integrated into the educational arrangement as a principle underlying the LOGSE and it implements regulations as a lateral area of the school curriculum at all levels of compulsory education. Alongside the non-formal public and private programmes which have been running for some time, the ministry is introducing others such as 'reclaiming abandoned villages', 'travelling schools', 'nature classroom' and calls for grants for projects on Environmental Education. The Department of Agriculture, Public Works and Transport coordinates this programme.

Environmental teaching, education and research centres (CEIDAS) are an instrument for supporting environmental education within the educational system, equipped with the necessary resources for this purpose. On the one hand, they are intended to be a place where teachers can find suitable materials for preparing experiments, projects and programmes for training and sensitising children to the environmental problems of their own surroundings. On the other, they are expected to organise special programmes for teachers' further education on the subject of the environment, as educational professionals are absolutely indispensable when it comes to putting any action into practice in the field of education.

3.2 Consideration of public science-based issues within lessons

Because of the aims and structure of the primary school curriculum (as explained above), the approach for science focuses on the very basic topics, as the real thing is considered very complex for students of this age, except for issues related to the environment, conservation and nature. At the compulsory secondary level, as the goals and the contents are included in the minimum requirements, the public science-based issue that can be easily included is health education. Industrial aspects, or new developments in physics or even biotechnology advancements are not directly related to the topics that the students must deal with. The ability of the teacher to work with newspapers, etc. is also very important, and therefore, several Autonomous Communities are developing programmes to use newspapers in the classroom. However, science teachers, except for a few cases, are not influenced by this trend, because they think the programmes are too long and feel they do not have time to 'waste' with non-academic approaches. Technology may introduce modifications in schools because these teachers have a more 'working-life' background in industry, etc.

The social impact of science is promoted in an important way in upper secondary schools, much more so than in other levels of education, because of the units on STS (see section 1.1).

3.3 Science education and vocational training

Ministry documents stress the importance of having a link between the educational system and the system of production. This has led to the analysis of vocational education, paving the way for a profound transformation of this branch of education which in the past only attracted pupils who failed in the ordinary system of education. This state of affairs was the result of a clear differentiation between the two branches contributing to the discrediting of vocational training among the population.

In 1988 the vocational training reform was submitted for debate. Provincial vocational training commissions have been set up in the 27 provinces under the direct management of the ministry, the main objective of which has been to diagnose the real problems in vocational training and to adapt the supply to the economic and social conditions. This is done by coupling it to demands for qualifications in the system of production, thus ensuring an effective transition from the education system to working life.

The efforts to back and transform vocational training being made in the educational system should be matched by a similar effort in business circles, which should establish closer links with education and help industry to increasingly consider training as a profitable investment. Once the population has been given a broad basic education, this can be completed and modelled in line with the changing needs of the labour market.

Vocational training reform is based on several principles clearly formulated by the General Arrangement Act (LOGSE), the most significant ones being:

- Compulsory secondary education should provide general and basic vocational training and thus make it possible to incorporate technological culture into the basic education of all young people, bearing in mind that any improvement in job training is based on an advance in both basic general and vocational training. Accordingly, a new compulsory core subject called Technology has been introduced.

- The participation of professional specialists in vocational training.

- Incorporation of a period of work experience into the curriculum for vocational training disciplines to give pupils an opportunity to experience real-life working situations, without losing their student status, in a training process based on cooperation between teaching institutions and industry.

- The reform of vocational training content by preparing and approving a new list of intermediate and higher-grade vocational qualifications. After surveying the production sectors and establishing their characteristics, training needs have been identified and job profiles defined for certification. Progress has been made in establishing a system to guarantee that such certificates are permanently updated.

- The new vocational training system is also open for employees to use as in-service courses (occupational training).

The production of a catalogue of initial vocational training certificates has entailed the completion of sector surveys and the formation of working groups for each occupational branch, with members from the system of production (charged with identifying and defining the various jobs profiles by describing occupational skills) and experts in education (charged with defining the contents of training and the characteristics of the teaching and learning process). The result of this work has been the need to adjust qualifications to the requirements demanded by plants and the productive sector today and in the immediate future. The catalogue of vocational training shows approximately 65% of studies are based on the sciences, in the wider sense of the term.

3.4 Science clubs and cultural associations

At present there are only a few science teacher associations in several communities; a national association with a federal structure is on its way. Because teachers' organisations are a recent introduction, not many teachers belong to them, except perhaps the technology and mathematics associations. Student science clubs are not very frequent, but they focus on marginal problems, e.g. primary health care teams who work with the National Drug Plans. All youth drug abuse prevention programmes are channelled through regional plans and in collaboration with some non-governmental organisations related to health education.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Spain was recently incorporated into the IEA project. The first report was scheduled for publication in 1995.

4.2 Public or political concerns about educational standards

In 1994 the Institute of Quality and Evaluation was created which is responsible for preparing evaluation systems for the various educational levels regulated by the LOGSE and their respective schools, as well as conducting research, carrying out surveys and evaluations of the educational system and generally passing in any initiatives and suggestions which may help teaching quality. Its duty is the creation of the standards of education, building up the idea of results plus achievements of students; the evaluation of reforms, and establishment of the indicators system at a national level to evaluate the educational system.

4.3 Suggested reforms

Publication of the first results from the Institute were expected after 1996.

5. Pupil interest and motivations

5.1 Generally by age and gender

One of the aims of the current reform is to guarantee fundamental equal rights to education and equality for girls and boys. Co-educational programmes are being developed in schools financed by various institutions, e.g. local authorities, the National Women's Institute (part of the Ministry of Social Affairs), teachers' centres and educational authorities which are developing a policy about textbooks, elaborating precise recommendations to avoid all types of discrimination. Several books have been published by the ministry dealing with this topic. Some projects have been developed to investigate the Spanish features of non-egalitarian relationships and to develop patterns for action, such as IDEA.

5.2 By type of science or topic by age/gender

A few data are available about girls' and boys' preferences and prejudices toward various types of sciences at a particular educational level; some researchers interviewed for this purpose suggest less preference of the girls for physics but no conclusive data have been published. Yet it was pointed out that the gender variable cannot be separated from the social class origin. Due to the reforms, the age for students' options will decrease and publications indicate this might prove a risk for girls choosing science; in fact the groups of people developing curricula for co-education think that "because the 'hard' sciences are compulsory in secondary schools girls are in a better position to choose future studies."

5.3 Options for choice within science

Empirical findings (Soneira et al. 1993) show that among the students of bachillerato, science occupies the seventh place (out of ten) in the preference of the students, with no differences between girl and boys; moreover ecology was third place. Those who chose science said their decisions are based on what they plan to study at university and the fact they got good marks in past years (not relevant in the case of girls). They said that their decision is not influenced by teachers or parents and the girls said that they have not considered whether or not the studies chosen are appropriate for girls.

5.4 Pupils' perspectives on the value of science

In Madrid, a project in conjunction with several institutions has been developed over the last five years trying to create another image of science and the scientist among secondary school students. The teachers developing this project, all of them with science studies at the university, say that the image of scientists is a male image for girls and boys, with a certain lonely personality and removed from daily life. It is remarkable that girls say they are confident of being able to work as scientists; but the boys think girls are not. Boys declare they feel aggressive if there are more women than men involved in the labs they visit.

Neither girls nor boys say that scientific research has to be associated with experimental work and they have problems connecting science with daily phenomena and social facts. For example, improving the quality of wine is not a scientific process, and, only a few students can see light as it is studied in physics in daily apparatus. Only ecological issues appear to be related to science.

Research on attitudes towards new technologies show that girls are more careful and reflective than boys; boys tend to start working with apparatus without thinking or reading the instruction book.

6. Training, status and morale of scientific teachers

6.1 Initial training

In 1991, a Royal Decree established basic guidelines for the new primary school teacher degree to be observed by universities nation-wide. However, provided they respect these common rules, universities are free to draw up their own curricula, the most important characteristics of which are as follows:

- the first cycle course lasts three years;
- overall teaching hours vary between 20 to 30 per week including practical periods;
- in no event will theory classes make up more than fifteen teaching hours per week.

The training at the School of Education will be made up of a series of subject-related areas to be taught by teachers and subjects with a psychological and pedagogical content, which cater to the various pupil needs in each of the specialities. A period of work experience in schools is also included in this initial training stage. The subjects which make up the basic core of the curriculum, without affecting university self-government and the peculiarities in each of the university catchment areas, are core subjects and subjects according to specialities. Natural Sciences and Didactics is one of the seven, the eighth is teaching practice. Not included are the optional subjects for each speciality, and those subjects that students may freely choose from all Spanish university offerings (approximately 10% of the total).

For membership in the Secondary Education Teachers' Corps, one must have completed a five-year study programme at university, in engineering or architecture for example. Also required is a vocational certificate of didactic specialisation, which is awarded on completion of a pedagogical training course lasting at least one academic year and including a period of teaching practice. The previous Certificate of Pedagogical Aptitude will be equivalent to the certificate of didactic specialisation. Primary school teachers and those having a master's in pedagogy are excused from this requirement, and previous teaching experience also exempts prospective members in given circumstances laid down by the government.

6.2 Decision-making authority for the above

The authorities competent to determine the curriculum for the degrees which must be obtained to be primary and secondary teachers are the government and the universities as described above.

6.3 Continuing training

Further teacher training programmes aim to bring these closer to the areas of activity of teachers. Furthermore, an attempt is made to meet the requirements arising from the implementation of the LOGSE. The teacher training framework plan, passed in 1989, set out the various proposals put forward by the educational administration and the teachers' unions regarding training and grants for further training.

This plan opts for a procedure of training decentralisation and contextualisation in planning and carrying out life-long training: the Provincial Teacher Training plans, as processes of decentralised planning, have as their main objective the training needs brought up by teachers, while taking into account the demands arising from the reform of the education system in their particular area. All the initiatives and efforts of institutions whose main task is teacher training flow into the preparation of the provincial plan.

This establishes the priority for courses of action, coordinates resources and takes up the plans made at each Teachers' centre, coherently integrating all the proposals for activities to be carried out during the academic year. Teacher training activities are voluntary, but all of the activities are assessed through a credit system. This establishes the relation between a number of credits obtained in a set time and an increase in salary.

Secondment, the procedure for (re)assigning staff, can be done at various times in the Spanish system: first, when the teacher becomes a civil servant and, second, when he or she has a permanent (definitive) school to teach at. The first situation means that in the teaching profession becoming a civil servant does not mean getting a job in a particular school at the same time. For about the first three years teachers must apply to different schools until all the teachers on the list before him/her have found one to choose from. The authorities decide which schools must be covered in function of the demographic stability of the area, etc. The list is built up by taking into account the year the teacher passed the civil service exam and the teacher's rating in the exam, and which administration level covers the territory of one Autonomous Community.

In the second situation, independent of the reasons which cause people to apply for a different school, there is a list according to the merits that each has and in which area, such as: being responsible for administrative tasks in the school, being headmaster, etc., having obtained various degrees, e.g. Ph.D., or other types of studies, seniority. Based on these facts and on the vacancies in schools, the teachers choose their own preference following the list prepared. Should the teachers have to move because a school has been closed, the administration places them in area schools but negotiates with them individually so that their rights as a civil servant are not diminished.

Sabbatical leave, called 'studies leave' in Spain, means that the teacher applying for it must present a project and the acceptance of a university department or wherever the studies are going to be pursued. The assessment of these activities is based on a report by the educational inspectors and the decision made by the educational local authorities. Usually it is given for one academic year, but it can be extended for an additional year.

6.4 Number, teacher/pupil ratio, gender, age profile

The statistics available for use refer to the academic year 1991-1992 and show that 517,987 teachers belong to the core level (non-university) of the education system; since 1989-90 there has been a 7.6% increase, and a 13% increase from 1982-83 to 1989-90. Looking at the breakdown of teachers with regard to the variables of gender and educational level (Appendix 9) it is found that the proportion of women teachers in compulsory education (old system) is 64.9%. The breakdown in the three cycles shows 83.6% in the first, 69.3% in the second and 52.2% in the third. In the secondary school (which was not compulsory in the old system) the percentage of women was 53%. In higher education the percentage of women is reversed - only 29.3%. In vocational training the number of women is 64.5% (Appendix 10).

The distribution of women in the different levels of education in public or private schools is shown in Appendix 11.

The distribution of pupils in the various educational levels is shown in Appendixes 12 and 13.

In primary school the maximum number of students per classroom is 25-28.

In the secondary school the maximum number of students per classroom can be 28-30.

6.5 Drop-out rates, late entries, maternal leave

Teachers are civil servants and the drop-out rate is very low, except for a few cases years ago in some provinces where an important group of well-trained teachers (for national programmes) in new technologies moved to work in recently created enterprises. Being a civil servant in Spain carries a status that a lot of people dream of achieving.

Maternity leave is regulated at national level as a minimum. Men and women have an equal chance under law to obtain leave for child care.

6.6 Status and salary

The only statistics available about these issues, collected for old system primary teachers, i.e. the teachers in charge of students between 12 and 14 years old, are included (published in 1991).

Elements defining social class are salary and status. From an economic point of view, the evaluation differs depending on the source of the opinion. The teachers working at this level consider the salary too low. Only 23% considered it well or fairly paid. This group is made up of young teachers and women.

These economic difficulties are mitigated by other financial sources declared by 25% of the population included in the survey, which clearly increases with age, 50 year-olds representing the largest population. The most important source is agriculture because an important part still maintains connections with it or works in the rural areas. In most cases the data show that the partner also works.

This situation applies to three quarters of the population and seven in ten are a working partner. Two thirds of the married men have a partner who also teaches. Female teachers are considered a good partner and are married to middle class men; these women represent the urban culture; they have higher status than the typical housewife and they have a stable and permanent salary.

The opinion of students' families concerning teachers' salaries is that they are well paid. Nine out of ten of the population included in the survey believe this. This group of teachers is, socially speaking, in a good position, which leads them to express a kind of frustration because their expectations are not met, at least financially. Teachers feel other professions, e.g. doctors, lawyers, politicians or journalists, have more social prestige because of the university background (in years) or because of social or political power, etc. But at the same time, when they compare their profession with similar ones in terms of social stratification, e.g. farmers or small shop owners, they think their status is superior because of the social consideration of their job. Female teachers, especially in rural areas, sometimes feel parents consider them to be nannies.

Most of them (three out of five) feel social prestige has diminished in the last decades, even though families do not share this opinion. The researcher who wrote this report pointed out some elements that heavily influenced the social consideration of the profession. These include an increasing number of women, an inferior number of years in university studies, the fact that too many people choose this profession to the exclusion of others, and that social consideration tends to be based on what teachers represent rather than on what they do.

7. Equality of opportunity?

7.1 Different status of the schools

In Spain there are three types of schools: public (run by the state; teachers are civil servants), subsidised (run by private, not necessarily religious, groups; teachers are not paid under the civil servant scheme and get a subsidy from the state according the number of students) and private ones, including foreign schools (Appendixes 14, 15 and 16).

It is very difficult to argue that students attending private schools have advantages over those in public schools, but in urban areas it is possible to observe a slight trend towards private or subsidised schools.

The birth rate in Spain has been decreasing; something which has been evident in primary school since 1985. Since the academic year 82-83 the number of students has dropped by approximately 1,100,000. In Appendix 17 the distribution of students at various levels of education is shown.

7.2 Regional differences

The decentralisation of the educational administration is an ongoing process. The number of schools is increasing in rural areas and villages around big cities, i.e. buildings are sometimes in better condition than in inner cities and with better sports facilities. Since democracy was established, a big effort to balance the various regions and the rural and urban areas has been made. But in terms of the curriculum a few modifications should already be made to provide equal access to various options for the students in rural areas.

7.3 Immigration and migrant populations

Spain is traditionally a country where people used to emigrate; however, in the 70s this trend started to change and the immigration movements started to be important. In 1988, the legal population registered in the Home Office was about 400,000 people. Where these people settle is related to the their nationalities. People from Europe and the USA are in Madrid, Cataluña, Valencia and Andalucia. Portugal is a special case unrelated to the European trend; Portuguese immigrants settle in Castilla La Vieja and Galicia. Immigrants from Latin

America are mainly on the Canary Islands, in Madrid, Galicia and Cataluña. The African population is in Cataluña and the Asian population in Madrid, Cataluña, on the Baleares Islands and in Andalucia.

The age and occupations of the immigrant population vary according to nationality. The immigrants from the more industrialised countries represent the greatest number of people without an activity, but at the same time the smallest number of people unemployed. The contrary is true for African immigrants, with the greatest number of unemployed people in comparison with the other nationalities. Immigrants from industrialised countries have a level of instruction similar to vocational studies (except the North Americans who have a superior level of training) that allows them to find employment. On the other hand, there are the Africans with the lowest training levels and a high proportion of illiterates, whereas the Portuguese are less qualified in terms of labour. The Latin Americans and Asians have a small proportion of illiterates, probably because of the political connotation of immigration. In comparison with earlier statistics, it is possible to note a decrease in immigrants without an education.

The only statistics available until 1992 are about the schooling of the Portuguese because, through an agreement with the Portuguese ministry of education, the immigrants attend the ordinary public schools in Spain which have some Portuguese teachers and special Spanish teachers. These immigrants can apply for special grants from the local authorities where they live as well as for MEC grants. The Ministry for Social Affairs offers special support and various types of aid to all immigrants seeking political asylum. This is to incorporate them into vocational and occupational studies so they can be integrated into the labour market. Special support programmes have been developed to facilitate integration into the school system.

Empirical research implemented by the CIDE in 1992 (unpublished) shows the distribution of immigrants in the various regions of Spain by gender and age (Appendix 18). Appendix 19 shows the number of immigrants younger than 16 and the country they come from.

The FOESSA report (October 1994), based on research implemented by the CIDE in 1992, shows that in the territory administered by the Ministry of Education, 12,191 foreign students (more than the 50% of them living in Madrid) arc integrated into primary and secondary school and vocational studies distributed as follows: 66.4% in primary school, 12.9% in secondary school and 4.3% in vocational training, with 16.4% in infant school.

The distribution for countries is approximately 35.2% from the European Union, 26.4% from Latin America, 10.8% from the Magreb region and 10.1% from Asia. Special provisions for the language needs of students from Morocco are being developed, and teachers are being trained in Arab languages and culture. An important number of foreign pupils are at private schools, sometimes in schools promoted by themselves. The data suggest that only a small percentage of students, probably the immigrants with lower qualified jobs, attend public schools.

7.4 Special education for handicapped children?

There have been substantial changes in the concept and organisation of special education since 1985, when the Royal Decree of 6 March was passed and the scheme to integrate pupils with special educational needs into schools was started. Within this new conceptual framework, a set of measures has been established aimed at improving the educational provision for such pupils to guarantee, whenever possible, the least restrictive school environment.

The Act established academic normalisation and school integration as the governing principles in catering for pupils with special educational needs. Insofar as all pupils need more or less specific teaching aids to achieve the general aims of education, special education is no longer conceived as educating a different kind of pupil and is understood as the set of materials and human resources put at the disposal of the education system so it can satisfactorily meet any provisional or permanent special needs given pupils may have.

Care for pupils with special educational needs should start as soon as these are detected. The educational services needed to stimulate and encourage such pupils exist. The appropriate educational administration ensures that such pupils go to school, and regulates and encourages the participation of parents or guardians in decisions on their schooling. Pupils are only schooled in special education units or schools when their needs cannot be catered for at a regular school. This is reviewed periodically so these children may be moved into a more integrated system whenever possible.

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Appendices

1) General Principles of the Education System: Legislative Framework". Educational National Report (1992)

2) Structure of the Spanish Education System

3) Content in the National Curriculum for Science in Lower Secondary Schools

4) General Schedule for Implementation of the LOGSE

5) Financing of the Total Expediture on Education at Scources

6) Breakdown of Public Spending on Education by Final Providers of Funds

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9) Number of Teachers According to Educational Administration, Level and School Ownership (1991-92 academic year)

10) Percentage of Teachers Broken Down by Level and School Ownership (1991-92), Women

11) Teaching Staff Broken Down by Level and School Ownership (1991-92), Women.

12) Number of Pupils Broken Down by Age and Educational Level (1991-92), both Sexes

13) Number of Pupils Broken Down by Age and Educational Level (1991-92), Girls

14) Pupils Broken Down by Educational Level and School Ownership (1991-92)

15) Students Broken Down by Educational Administration, Level and School Ownership (1991-92 academic year)

16) Schools by Educational Administration, Level and School Ownership (1991-92)

17) Evolution of the Number of Students Broken Down by Educational Level (1982-83 to 1992-93 academic years)

18) Distribution of Immigrants by Regions, Gender and Age

19) Immigrants up to 16 Years

Abbreviations

Laws

LODE Law on the Right to Education (Act 8/1985)

LOGSE Law on the General Arrangement of the Education System (Act 1/1990)

LRU Law on University Reform (Act 11/1983)

School Types

BUP Secondary School - for 14 to 16 year-olds - (old system)

COU Upper Secondary School - for 17 to 18 year-olds - (old system)

EGB Primary School - for 6 to 14 year-olds - (old system)

ETS Engineering Universities

FP Vocational Studies (old system)

Institutions

BOE Boletin Oficial del Estado

CIDE Centro Investigacion y Documentacion Educativa

MEC Ministry of Education and Science

Appendix 1

Legislative framework of the Education System in Spain

General Principles of the education system: Legislative Framework

Spain is currently in the process of reforming the education system at all the non-university levels, a reform which involves both the structure of the different stages and the curricula, organisation of teachers, schools, etc. As a result of this process, the legal framework related to education has recently been amended: the General Arrangement of the Education System Organic Act was passed in 1990 and repeals the previous 1970 General Education Act. The legal principles governing education were laid down in the 1978 Constitution and in the three organic laws which implement the principles and rights it established: Organic Act 8/1985 on the Right to Education (LODE), Organic Act 1/1990 on the General Arrangement of the Education System (LOGSE) and Organic Act 11/1983 on University Reform (LRU).

However, as a schedule of ten years has been set for the implementation of the new law, the educational levels will continue to be structured according to the system established by the 1970 General Education Act until they are gradually replaced by the new levels regulated by the LOGSE.

Constitutional precepts

The Spanish Constitution contains the basic guidelines governing all legislation in educational matters. Three essential aspects can be singled out: firstly, the recognition of the right to education as one of the basic rights to be guaranteed by the public authorities; secondly, other basic rights related to education; and, finally, the division of educational powers between the Central Administration and the Autonomous Communities.

The right to education is set out under article 27 which also establishes free and compulsory basic education; general educational planning, as well as inspection and homologation of the education system by the public authorities; assistance to schools which meet the requirements established by law; parents' right to have their children given the religious and moral education they wish; recognition of the freedom to set up teaching institutions; the participation of teachers, parents and pupils in the control and running of state-funded schools; and university self-government.

Furthermore, the Constitution covers other rights involved in education, such as teaching freedom, ideological and religious freedom, the right to culture, children's rights as laid down in international agreements, human rights in general and the rights of the physically and mentally handicapped and people with sensory impairments.

Another essential aspect for the arrangement of education covered under the Constitution is the decentralisation of educational administration in line with the regional division of the State into Autonomous Communities.

The right to education under article 27 of the Spanish Constitution is regulated by the LODE (Organic Act 8/1985 of 3 July). It states the main purposes of education, as well as the right of all Spaniards to free basic education enabling them to develop their personality and perform a useful activity in society.

The LODE establishes 'the educational agreements' scheme', as it is known, whereby private schools which meet given conditions may be funded from the public purse. This regulation aims to set up a controlled and coherent mix of schools to cater to society's demand for schooling and provide a free choice of school for all on an equal footing.

Finally, this Act establishes the right of the members of the school community to participate in the control and running of state-funded schools. The main participatory instrument at school level is the School Board, a representative body made up of teachers, parents, pupils (from Higher-Cycle EGB), administrative and ancillary staff, members of the Town Council under whose jurisdiction the school comes (state schools) and the school's owner (agreed private schools).

In addition to participation in the internal running of the school, the LODE provides the participation of interested sectors in the general planning of education through the State Schools Board.

Since October 1990, the structure and organisation of the Spanish education system at non-university levels has been regulated by the General Arrangement of the Education System Organic Act (Act 1/1990).

The general aims of this new Act centre on the effective extension of compulsory education for pupils up to 16 years of age, the improvement of teaching quality and the restructuring of the education system.

In the system designed by the LOGSE, the basic principle of which is life-long training, educational activities will be carried out according to the following principles:

1) personalised instruction, encouraging comprehensive education, encompassing know-ledge, skills and moral values in all walks of private, family, social and working life;

2) participation and collaboration of parents or guardians so as to contribute to better achievement of educational objectives;

3) effective equality of rights between the sexes, rejection of any kind of discrimination and respect for all cultures;

4) development of creative abilities and a critical mind;

5) encouragement of habits of democratic behaviour;

6) school self-government in teaching matters within the limits laid down by law as well as teachers' research activities on the basis of their teaching experience;

7) psychological and pedagogical care and educational and vocational guidance;

8) active methodology ensuring the participation of pupils in teaching and learning processes;

9) evaluation of teaching and learning processes, teaching institutions and the different elements which make up the system;

10)links with the social, economic and cultural environment;

11)education in respecting and protecting the environment.

Appendix 2

Structure of the Spanish Educational System (1990)

	2nd-year Doctorate	Third	Higher Education
	1st-year Doctorate	Cycle	
	5th-year	Second	
	4th-year Licentiateship	Cycle	
	3rd-year	First	
	2nd-year Diplome Course	Cycle	
	1st-year		

(1)	Higher-grade Vocational training

age					
17	2nd-year Baccalaureate		Intermediate-grade Vocational Training		Postcompulsory Secondary Education
16	1st-year Baccalaureate				
15	4th-year ESO	Second	Compulsory Secondary Education (ESO)	C	
14	3rd-year ESO	Cycle		O	
13	2nd-year ESO	First		M	
12	1st-year ESO	Cycle		P	
11	6th-year Primary	Third	Primary Education	U	
10	5th-year Primary	Cycle		L	
9	4th-year Primary	Second		S	
8	3rd-year Primary	Cycle		O	
7	2nd-year Primary	First		R	
6	1st-year Primary	Cycle		Y	
5			Infant Education		
4		Second			
3		Cycle			
2		First			
1		Cycle			
0					

(1) University Entrance Examination

Appendix 3

Content in the National Curriculum for Science in Lower Secondary Schools

Concepts:

1. The Units and Diversity of the Matter Structure

- aggregate statements; homogeneous and heterogeneous systems
- mixture, pure compounds, chemical elements
- discontinuity in the material systems; atomic theory; electric nature of matter
- classification of elements; links between atoms
- the most frequent elements and compounds in living organisms and in inert matter

2. Energy

- nature and properties of energy; how it is involved in every activity, how it can be stored, transported, transformed and degraded
- generating energy without transporting mass; wave movement; light and sound
- statement changes; generating heat and its effect
- energy transfer process between different systems: work and heat (*)
- principles of energy conservation (*)
- the problems of energy in our society

3. Chemical Changes

- introduction to chemical transformation; mass conservation
- changes in the process of chemical reactions
- chemical reactions are important in terms of energy, in biology and making material

4. The earth in the universe

- the solar system in terms of size and distance

- the problem of the earth's position in the universe, some historical explanations (*)
- the earth as a planet, its movement and the moon
- the universe: components, scales and means of observation

5. The Earth

- the atmosphere and its protective role; atmospheric phenomena; air: its properties and relevance for living organisms
- water: its properties and relevance for living organisms; the problem of depleting resources; the hydrosphere
- the most important rocks and minerals found in surface soil in Spain; economic relevance
- soil: destruction and recuperation

6. The Unity and Diversity of Living Organisms

- how animals and plants can be organized; relationship between morphology, function and way of life
- the cell as unit of structure, the function of unicell and multicell organization; bacteria and viruses
- the unity of function in living organisms; living organisms as a system; heterotrophe and autotrophe nutrition; sexual and asexual reproduction; relation and coordination

7. Human Beings and Heath

- health and disease; growth and development; the importance of healthy living; physical exercise, oral hygiene, avoiding accidents and infectuous diseases
- nutrition; eating habits and their relation to health; balanced diet; obesity; conservation, manipulation and the food market; people as consumers
- human reproduction; body changes; male and female reproductive organs; fertilization, pregnancy and birth; human sexuality as emotional communication and personal option; different patterns of sexual behavior; sex as an element of discrimination in society; contraceptive devices and new reproductive techniques; venereal diseases; healthy sexual habits

• human relationships and communication; perceiving and processing information in connection with mental health; tobacco, alcohol and drug problem - social and health impact; living healthy using public health service; use and misuse of medication

8. Interaction Between Biotic and Non-Biotic Components in the Environment

• the eco-system and its dynamic components and interactions; material cycles and energy flow

• terrestrial and aquatic eco-systems; biotic and non-biotic factors; interactions

9. Changes in the Environment. Humans are the Most Important Agents for Change.

• natural changes in the eco-system; population changes; rocks change by external geological processes, by internal geological processes (*)

• changes in the eco-system because of humans; conservation and recuperation actions

• the earth: a planet undergoing constant change: fossils as indicators; some historical explanations (*)

10. Forces and Movement

• movement: qualitative study, quantitative approach to rectilinea and uniform movement; calculating acceleration (*)

• forces: the principles of dynamics (*)

• gravitation; body weight; Newton's synthesis (*)

• relevant forces in everyday situation - reassurance

11. Electricity and Magnetism

• electrical phenomena; electric forces and charges

• electric current; transformation of energy in an electric circuit

• magnets; the effect of electric current on the middle of the magnet; qualitative approach to electromagnetic induction

Evaluation Criteria:

1) Be able to use the theory of kinetic energy to explain some natural phenomena as dilation; study changes, how heat spreads and interpret the concepts of pressure in gases and temperature.

2) Be able to obtain pure substances from mixtures using physical methods (distillation, caution and crystallization) which are based in the nature of pure substances. Be able to describe some chemical methods which allow splitting mixtures into their elements and assess the practical applications of these techniques.

3) Be able to apply knowledge of the universal composition of matter in order to explain facts as the existence of chemical elements in organic and non-organic materials and make a difference between elements and compounds.

4) Be able to implement knowledge of the properties of energy in order to explain some natural and everyday phenomena, apply the principle of energy conservation to analyse some transformations.

5) Be able to implement knowledge of the atomic theory and some atomic models to explain the electric behaviour of matter, the conservation of mass in chemical reactions and in obtaining new substances.

6) Be able to interpret some natural phenomena of the solar system by drawing or building models, basing the explanation on the law of gravity to justify the links between the different elements of the universe, the force of attraction on the objects on the surface of the stars and the variation in body weight.

7) Be able to explain the relevance of air and water for living organisms, their chemical composition and properties as well as the existence of atmospheric phenomena and changes in the earth's surface.

8) Be able to identify minerals and rocks using classification guides, observing and collecting data about their properties, establishing the relationship between them and their applications.

9) Be able to explain the units of structure and the function of living organisms using cell theory and to list everyday situations where viruses and bacteria are to be found.

10) Identify the most relevant animal and plant taxonomic models using classification guides, observing the most important properties, establishing the relationship between some particular morphological structures and their adaptations, assessing the importance of adopting a respectful attitude towards the different types of life.

11) Explain the fundamental process which alters food from ingestion until the cells are reached; how do cells use this material. Explain how to develop healthy and hygienic eating habits, avoiding unsuitable consumer practices.

12) Explain the coordinating and balancing function of the nervous system in connection with various stimuli. Point out social factors which may cause dysfunction, the effects on health and the need to adopt a healthy way of living.

13) Be able to establish differences between human sexuality and reproduction and inculcate understanding about how the reproductive organs work, how to facilitate pregnancy, contraceptive devices and personal hygiene.

14) Design and implement experiments using plants and animals to determine variables involved in photosynthesis and respiration, including data evidencing the importance of both in life.

15) Identify an eco-system, outline its properties, its non-biotic and biotic components and interactions.

16) Identify indicators which show change in living organisms, footprint erosion, sedimentation caused by external geological agents.

17) Identify changes in rocks and other natural phenomena through internal geological agents and explain them using recent theories. It is important to recognise causes and set down rules to avoid, prevent and minimise them.

18) Using indicators and data from literature determine pollution, erosion, increasing hole in the ozone layer, extinction of various species; outlining and justifying different issues which enhance more rational use of nature.

19) Point out data which support the idea that the planet earth has changed considerably: landscape, climate, position of the continents, oceans, living organisms.

20) Collect data for distance-time from marks, multiple exposure pictures, well-known experiences and organise the data in charts and graphs to arrive at quantitative conclusions in order to obtain the uniform movement equation and calculate acceleration in simple examples.

21) Identify the forces that act on static objects or movements in simple situations; apply knowledge of these laws, implement them in simple experiments trying to improve exploitation of natural resources.

22) Design and assemble electrical circuits according to safety regulations where possible note electromagnetic effects; the same for direct circuits where it is possible to measure voltage and the potential difference.

23) Explain ordinary phenomena of light and sound transmission, reproduce some of them,outline the laws involved and the conditions required.

24) Determine the nature of scientific work, analysing scientific or technological phenomena, discussing its influence on the quality of life, its constraints and mistakes

Note: The sentences marked with an asterisk indicate what must be included as optional subjects in the fourth course.

Appendix 4

General Schedule for Implentation of the LOGSE

Academic year	New system	Age	To replace
1991-92	Infant Education	3-5	
1993-93	1st and 2nd-year Primary Education	6-7	1st and 2nd-year General Basic Education (EGB)
1993-94	3rd and 4th-year Primary Education	8 9	3rd and 4th-year EGB
1994-95	5th and 6th year Primary Education	10-11	5th and 6th-year EGB
1995 -96	1st and 2nd-year Secondary Education (ESO)	12-13	7th and 8th-year EGB
1996-97	3rd-year ESO	14	1st-year Baccalaureate (BUP) 1st year Vocational Training (FP I)
1997 98	4th-year ESO	15	2nd-year (BUP) 2nd-year FP I
1998-99	1st-year Baccalaureate Intermediate grade Specialised Vocational Training (FPE)	16	3rd-year BUP 1st year FP II (Specialised Education)
1999-00	2nd-year Bacalaureate	17	Course of University Guidance (COU) 1st year FP II (General Education) 2nd-year FP II (Specialized Education)
		18	2nd-year FP II (General Education) 3rd-year FP II (Specialised Education)

Note: First cycle Infant Education and higher-grade Specialised Vocational Training will be gradually introduced over this period, and thus do not figure in the above table

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 5

Financing of the Total Expenditure on Education at Source

Initial providens of funds	**1989**		**1990 (*)**	
	Millon Ptas.	**%**	**Millon Ptas.**	**%**
Total	2.382,174.6	100,0	2.717,817.0	100,0
Public funding	1.880,617.6	78,9	2.168,883.0	79,8
Central Administration	966,374.4	40,5	1.088,477.2	40,0
• MEC	790,275.1	33,1	889,851.7	32,7
• Other ministries	176,099.3	7,4	198,625.5	7,3
Autonomous Community Administration	802,492.9	33,7	955,308.9	35,2
Autonomous Community with powers	771,363.3	32,4	919,195.2	33,9
Autonomous Community without powers	31,129.6	1,3	36,113.7	1,3
Local Autorities	111,750.2	4,7	125,096.9	4,6
Private funding	501,557.0	21,1	548,934.0	20,2
Families	501,557.0	21,1	548,934.0	20,2

(*) Estimated figures

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 6

Breakdown of Pupils Spending on Education by Final Providers of Funds (1989)

Final providers of funds	**Millon pesetas**
Total	1.918,262.6
Educational Administrations	1.598,277.7
• MEC	698,575.9
•Autonomous Communities	899,761.8
• Andalusia	271,149.0
• Canary Islands	78,128.2
• Catalonia	208,584.9
• Galicia	104,513.1
• Basque Country	105,845.0
• Valencia	131,541.6
Other Public Administrations	319,984.9

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 7

Subsidies to Private Education (million pesetas)

Educational Level	**1989/90 academic year**			**1990/91 academic year**		
	National total	MEC area	Autonomous Communities with Powers	National total	MEC area	Autonomous Communities with Powers
Total	212,802	81,756	131,046	248,411	87,744	160,667
Preschool/ EGB*	164,539	63,910	100,629	191,857	69,015	122,842
BUP/COU	9,251	3,461	5,790	11,519	3,803	7,716
FP	2,946	11,172	18,293	34,522	11,452	23,070
Special education	8,008	3,213	4,795	8,621	3,474	5,147
Other disc.	1,539	-	1,539	1,892	-	1,892

* Includes the total allocated to seminaries

Note: Navarre figures under the MEC area in the 1989/90 academic year and under the Autonomous Communities with powers in the 1990/91 academic year.

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 8

Student Grants and Allowances

	1989/90 academic year		**1990/91 academic year**	
	National total		National total	
	Pupils	Sum Millon Ptas.	Puplis	Sum Millon Ptas.
Total	713,497	60,512	698,842	61,196
General call	665,049	57,318	644,512	548,028
Postcomp. sec. and higher education	665,049	57,318	644,512	58,028
Special calls	48,448	3,194	45,330	3,168
Special Education	18,204	1,390	17,326	1,343
Collab,. grants (univ.)	2,585	895	1,763	788
Otther disc.	79	2	99	2

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 9:

Number of Teachers broken down by Educational Administration, Level and School Ownership (1991/92 Academic Year)

	Preschool/ Infant and EGB		BUP and COU		Vocational Training		Special Education (1)		Higher Education	
	total	% state	total	% state	total	% state	total	% state	total	% state
Total MEC(*)	107275	71,09	40751	71,49	24160	81,34	1969	59,47	27636	89,26
Andalusia	51295	80,58	16094	82,77	12049	82,42	729	49,93	9332	95,52
Canary	12574	83,48	4201	88,26	3622	96,27	216	65,28	2643	98,60
Catalonia	43322	57,30	14794	62,72	11709	66,11	996	41,57	9883	88,75
Valencia	26945	71,17	9015	79,46	6111	83,41	278	55,76	6029	96,47
Galicia	19492	77,21	8000	81,48	4527	83,41	493	68,36	2907	98,62
Navarre	3983	64,57	1265	65,85	1087	77,55	56	46,43	1899	17,38
Basque Country	16880	51,87	5530	62,48	4727	53,46	167	37,72	3336	80,25
Total	**281766**	**70,44**	**99650**	**73,67**	**67992**	**78,02**	**4904**	**54,47**	**63665**	**88,98**

Observations:

1) Preschool/Infant and EGB teaching staff includes Preschool/Infant and EGB teachers and regular school teachers staffing special-purpose Special Education units

2) BUP/COU and Vocational Training teachers also teach Experimental Plan pupils

3) 1990/91 figures for University lecturers

(1) Special-purpose Education schools
(*) Area administered directly by the Ministry of Education and Science

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 10

Percentage of Teachers broken down by Level and School Ownership (1991-92), Women

Educational Level	% State	% Private	Total
Preschool/Infant	94,91	97,24	95,67
EGB	63,15	69,11	64,89
• Lower Cycle	81,41	88,78	83,57
• Intermediate Cycle	68,33	71,87	69,33
• Higher Cycle	49,99	57,52	52,23
BUP and COU	53,64	51,36	53,04
Vocational Training	41,28	45,66	42,24
Special Education (1)	65,74	62,96	64,48
Higher Education	29,41	28,25	29,28
Total	**55,12**	**63,23**	**57,20**

Source: Ministerio de Educacion y Ciencia 1994.

Observations:

- 1990/91 figures for university lectures

(1) Special-purpose Special Education Schools.

Appendix 11

Number of Teaching Staff broken down by Level and School Ownership (1991/92), Women

Educational Level	**State**	**Private**	**Total**
Preschool/Infant	28.020	14.000	42.020
EGB	107.185	47.180	154.365
BUP and COU	39.376	13.476	52.852
Vocational Training	21.895	6.825	28.720
Special Education (1)	1.756	1.406	3.162
Higher Education (2)	16.656	1.979	18.635
Total	**214.888**	**84.866**	**299.754**

Source: Ministerio de Educacion y Ciencia 1994.

Observations:

(1) Special-purpose Special Education Schools.

(2) 1990/91 figures for university lectures.

Appendix 12

Number of Pupils broken down by Age and Educational Level (1991/92), both sexes

Age	Preschool/ Infant	EGB/ Primary	BUP and COU	FP	Experimental Plan: Baccala-ureate	Experimental Plan: Vocational Education	Special Education (I)	Higher Education
under one	1479							
1	7835							
2	29374							
3	153190						223	
4	398780						415	
5	435139						623	
6		463342					1015	
7		483353					1199	
8		501419					1388	
9		527779					1542	
10		558381					1758	
11		589719					1929	
12		611476					2279	
13		639300					2565	
14		209880	303905	87859	35270		2815	
15		64790	334055	154068	39444		3262	
16			318149	148819	26980	327	3405	
17			298671	126891	14651	778	2872	1865
18			119142	108545	5536	1913	1923	116417
19			55768	77639	2222	2007	*3307	152425
20			**75458	**171980	**2126	**6460		156982
21								147242
22								134709
23								101478
24								75118
25								55901
26								42321
27								33395
28								26291
29								20991
30								***143611
No record							2308	
Total	1025797	4649439	1505148	875801	126229	13793	32520	1208746

Observations:
(*) Including pupils aged 19 and over.
(**) Including pupils aged 20 and over.
(***) Including pupils aged 30 and over.
(I) Special Education at special-purpose schools only

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 13

Number of Pupils broken down by Age and Educational Level (1991/92), Girls

Age	Preschool /Infant	EGB/ Primary	BUP and COU	FP	Experimental Plan: Vocational Education	Experimental Plan: Baccala-ureate	Special Education (I)	Higher Education
under one	713							
1	3588							
2	13842							
3	75554						102	
4	194576						156	
5	212673						262	
6		225993					407	
7		235297					483	
8		244427					557	
9		257147					584	
10		272075					657	
11		287124					765	
12		297987					906	
13		311387					995	
14		86694	165001	38861	17112		1101	
15		25565	181427	65965	18260		1265	
16			172259	66283	12751	134	1318	
17			162418	58953	7167	375	1110	965
18			62457	52724	2754	1051	726	66152
19			29020	39953	1167	1047	*1438	84007
20			**37498	**90105	**1174	**3283		85017
21								78281
22								70827
23								50286
24								35309
25								25220
26								19093
27								15066
28								11861
29								9470
30								***65279
No record						1078		
total	500946	2243696	810080	412844	60385	6968	12832	616833

Observations:

(*) Including pupils aged 19 and over.
(**) Including pupils aged 20 and over.
(***) Including pupils aged 30 and over.
(I) Special Education at special-purpose schools only.

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 14

Pupils broken down by Educational Level and School Ownership (1991-92)

Educational Level	State		Private		Total
	No. Pupils	%	No. Pupils	%	No. Puplis
Preschool/Infant Education	635288	61,93	390509	38.07	1025797
Kindergarten (0-3)	80563	41,99	111315	58.01	191878
infant school (4-5)	554725	66,52	279194	33,48	833919
EGB/Primary	3015496	64,86	1633943	35,14	4659439
Lower Cycle	637353	64,19	355512	35.81	992865
Intermediate Cycle	1081053	64,75	588572	35,25	1669625
Higher Cycle	1297090	65,28	689859	34.72	1986949
BUP and COU	1080404	71,78	424744	28,22	1505148
BUP	833173	71,34	334684	28,66	1167857
COU	247231	73,30	90060	26,70	337291
Vocational Education	614055	70,11	261746	29,89	875801
FP 1	1315637	66,57	158519	33,43	474156
FP 2	2298418	74,30	103227	25,70	401645
Experimental Baccalaureate Plan	104264	82,60	21965	17,40	126229
Vocational Training	12516	90,74	127	79,26	13793
Intermediate Grade	4768	91,90	420	8,10	5188
Higher Grade	7748	90,04	857	9,96	8605
Special Education (1)	15311	47,08	17209	52,92	32520
Higher Education	1112307	90,02	9643	97,98	1208746
Faculties + Higher Technical Schools (5 year cycle)	693072	92,62	55195	7,38	748267
ETS (Engineering - 3 year cycle)	78082	94,09	490	55,91	82987
Other Subjects (3 year cycle)	341153	90,37	36339	9,63	377492
Total	5476462	66,56	2751445	33,44	8227789

(1) Special Education at special-purpose schools

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 15:

Pupils/Students broken down by Educational Administration, Level and School Ownership (1991/92 Academic Year)

							Experimental Plan									
	Preschool/ Infant		EGB/Primary		BUP and COU		Bacca-laureate		Vocational Modules		FP		Special Education(1)		Higher Education	
	Total	% State	Total	% State	Total	% State	Total	% State	Total	% State	Total	% State	Total	% State	Total	% State
Total MEC(*)	381459	61,99	1747298	64,06	617165	86,42	47585	95,08	6342	97,76	299616	72,65	12711	51,10	569756	92,38
Andalusia	191912	75,02	968108	74,37	256049	80,23	24358	87,06	2350		163993	74,90	5347	40,66	180746	96,16
Canary	41197	75,34	213272	78,56	63205	87,46	1616	100,00	631	100,00	44681	93,44	1286	55,37	36782	98,93
Catalonia	170878	47,35	657472	54,15	213985	64,02	13062	71,65	1668	83,27	158995	57,55	6597	35,39	163816	93,10
Valencia	106317	63,68	473608	64,73	140340	77,23	6288	100,00	1354	100,00	88269	75,78	3061	66,35	107137	96,19
Galicia	63610	68,50	317188	71,37	115849	80,53	1056	93,75	103	100,00	60107	80,40	2001	57,57	65039	96,03
Navarre	14389	55,58	53356	55,91	18073	59,51	3707	100,00	122	87,70	11521	59,93	377	25,73	17775	35,00
Basque Country	56035	42,18	219137	41,01	80482	59,70	28557	55,51	1223	56,75	48619	37,35	1140	27,63	67695	76,09
Total	**1025797**	**61,93**	**4649439**	**64,86**	**1505148**	**71,78**	**126229**	**82,60**	**13793**	**90,74**	**875801**	**70,11**	**32520**	**47,08**	**1208746**	**92,02**

Source: Ministerio de Educacion y Ciencia 1994.

Observations:(*) Area directly administered by the Ministry of Education and Science

(1) Special Education in special-purpose schools

Appendix 16:

Schools by Educational Administration, Level and School Ownership (1991/92)

	Preschool/EGB		BUP and COU		Vocational Training		Special Education		Higher Education	
	Total	of those: state schools	Total	of those: state schools	Total	of those: state schools	Total	of those: state schools	Total	of those: state schools
Total MEC (*)	8412	6481	1276	645	790	427	188	85	341	280
Andalusia	3148	2390	502	360	387	231	74	31	126	109
Canary	940	800	107	77	91	72	23	18	42	40
Catalonia	2969	1711	544	266	465	193	120	37	100	82
Valencia	1845	1283	261	158	182	114	54	28	57	51
Galicia	2009	1662	233	149	188	107	34	16	59	57
Navarre	279	196	40	17	37	19	9	3	22	9
Basque Country	827	457	183	73	176	65	21	8	46	29
Total	20429	14980	3146	1745	2316	1228	523	236	793	657

Observations:
- 1990/91 figures for higher education institutions
(*) Area directly administered by the Ministry of Education and Science
(1) Special Education in special-purpose schools

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 17

Evolution of the Number of Pupils broken down by Educational Level (1982/83 to 1992/93 Academic Years)

Academic Year	Preschool / Infant	EGB	BUP and	FP	Experimental Plan		Higher Education	Total
					Baccalaureat	Vocational		
1982/83	1187617	5633518	1117600	650770			692152	928165
1983/84	1171062	5633009	1142308	695180			744115	938567
1984/85	1145968	5640938	1182154	726000			785880	948094
1985/86	1127348	5594285	1230029	726249	20936		854189	955303
1986/87	1084752	5575519	1265894	734186	33452		902380	959618
1987/88	1054241	5398095	1355278	759796	43770		969508	958068
1988/89	1010765	5263518	1425777	781748	51872		1027018	956069
1989/90	1000301	5080991	1470816	817099	67537		1093086	952983
1990/91	1005051	4882349	1499511	849850	92189	7396	1140572	947691
1991/92	1025797	4649439	1505148	875801	126229	13793	1208746	940495
1992/93	1029438	4476910	1602941	860015	69585	22714	1286653	934825

Observations:

1) 1992/93 data are provisional.

2) The number of pupils enrolled in Vocational Modules prior to the 1990/91 academic year was insignificant and is therefore not included.

3) The LOGSE began to be introduced as of 1991/92. It affected only Infant Education in the 1991/92 academic year, and first-level Primary Education was introduced in the 1992/93 academic year to replace first-cycle EGB. Some schools introduced Conpulsory Secondary Education and the Baccalaureate ahead of schedule in the 1992/93 academic year.

4) Higher education figures do not include PhD students.

Source: Ministerio de Educacion y Ciencia 1994.

Appendix 18:

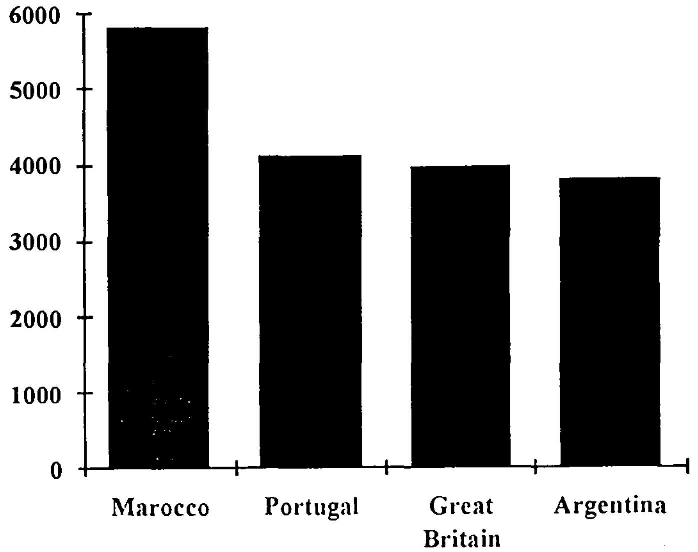
Distribution of Immigrants by Regions, Gender and Age

Region	Total Number	Gender		Age		
		Male	Female	under 16 years	16 to 65 years	over 65 years
Andalucia	70.172	34.864	31.784	3.114	54.597	11.380
Aragon	9.228	5.035	3.740	679	7.094	1.185
Astrurias	9.707	5.090	4.545	1.156	7.309	737
Baleares	35.118	15.169	18.381	1.484	28.573	4580
Canarias	57.179	26.267	28.454	4.119	44.745	7.094
Cantabria	3.061	1.514	1.500	159	2.552	285
Cast-La Mancha	4.191	2.353	1.663	255	3.695	161
Castilla-	12.254	6.568	5.307	843	10.552	563
Cataluna	91.441	52.508	36.414	6.016	77.179	6.422
Ceuta y Melilla	1.630	779	541	113	1.325	161
Euzkadi	15.220	7.904	6.635	1.351	12.204	1.223
Extremadura	4.298	2.614	1.563	235	3.347	638
Galicia	18.777	9.822	8.307	1.231	14.771	2.276
Rioja	1.416	682	590	123	1.182	81
Madrid	132.746	64.788	60.982	8.721	115.593	5893
Murcia	7.998	5.618	2.259	289	7.055	557
Navarra	4.122	2.232	1.681	212	3.661	183
Pais Valenciano	69.756	35.147	32.511	3.623	45.568	15.916
Total	548.314	278.954	246.85	33.723	441.002	59.335

Source: CIDE unpublished results (1993)

Appendix 19

Immigrants up to 16 years (in thousands)



Source: CIDE unpublished results (1993)

Report from Sweden

Björn Andersson

1. Science and technology education in Sweden

1.1 Introduction

Sweden has a nine-year compulsory comprehensive school (7-16 years of age) and a three year voluntary upper secondary school (16-19 years of age) which attracts practically all young people.

Various decisions taken in recent years have resulted in the removal of detailed state regulation of the school system. Responsibility for school activities has been transferred to local authorities, schools, teachers and pupils.

Parliament and government stipulate the goals for education and allocate funds to the municipalities, but how the goals are to be achieved is decided by local authorities and schools.

The activities of comprehensive and upper secondary school are regulated by the *School Act*, which includes timetables, national curricula and syllabi. The School Act is decided by Parliament, curricula and syllabi by government. In the timetables one finds the minimum guaranteed study-time for groups of subjects or separate subjects (comprehensive school) and for courses (upper secondary school). A consequence of the new division of responsibilities between the state and municipalities is that there are no directions and prescriptions concerning teaching methods and organisation of content, e.g. that there shall be group work and subject matter integration. It is up to the teachers to decide which methods to use and how to select and organise content in order to best attain the goals of the curriculum and the syllabi.

1.2 The nine-year compulsory school

a) Syllabi and timetables

The new syllabi for compulsory school were laid down in 1994. The syllabus for a given subject has two types of goals. Firstly, there are *goals to strive for*, which express the general ambition and direction of the teaching when it is a question of developing the pupils' knowledge, insight, understanding, attitudes, skills and so on. These goals are wide and high and concern the subject as a whole. They set no upper limit for the growth of knowledge in the student.

Secondly, there are *goals to attain*, expressing a minimum of knowledge which all pupils are supposed to have acquired at the end of the fifth and ninth grade respectively.

The syllabi further describe the structure and character of each subject by stating its core, central concepts, theories, most essential perspectives, etc. Given the fact that subjects are different in character, they are described differently.

Concerning science and technology, two things are worth mentioning in this general context. One is that technology is compulsory with goals to attain both at the end of grade 5 and 9; the other is that science is treated both as a whole and as individual subjects (biology, chemistry and physics).

The stipulated minimum guaranteed study-time for the compulsory school subjects is 6,665 clock hours. Of these, 790 are for the pupil's own choice, e.g. of a foreign language other than English. In addition to the 6,665 hours, there are 410 for the local school to use, e.g. to create a profile of its own, which can be music, environmental studies, etc.

Of the 6,665 hours, 885 are for the subjects geography, history, religion and civics, and 800 are for biology, chemistry, physics and technology. The distribution of these clock hours among subjects and grades is locally decided in relation to the goals of the syllabi.

b) Content

When it is a question of biology, chemistry and physics, the goals to strive for, which are common to all three subjects, give a good idea of the general directions and aspirations of compulsory school science:

In science education, the school shall strive to let the pupil:

• experience the joy of discovery and experimentation and develop his/her inclination and ability to ask questions about phenomena in nature;

• develop knowledge about scientific concepts and models, and an awareness that these are human constructs;

• gain an understanding of the scientific way of working and develop his/her ability to present own observations, conclusions and knowledge in written form;

• become aware of how knowledge about nature develops and how it is formed by, and forms, man's picture of the world;

• develop care and respect for nature and responsibility for both the local and global environment;

• develop knowledge about the evolution of the cosmos, the earth, life and man;

• gain insight into how matter is studied at various levels of organisation (e.g. atom - molecule - cell - organism - population - community);

• develop knowledge about the flow of energy from the sun through various natural and technical systems on earth and about natural cycles of matter.

As can be seen from these goals, it is not only scientific concepts and models that are important, but also science as a knowledge-generating process, including an historical perspective.

In the general introduction to the syllabi for biology, chemistry and physics it is stressed that environmental problems today demand a public understanding of basic scientific concepts, e.g. in order to be able to discuss and judge environmental factors that are not perceived by the senses but may nevertheless be harmful, such as radiation, electric and magnetic fields and substances.

As an example of subject-specific goals, there follows those in chemistry to be attained by all pupils at the end of grade five.

The pupil shall:

• be able to describe, compare, sort and order substances according to their properties;

• have knowledge of the concepts solid, liquid and gas as well as boiling, evaporation, condensation and solidification;

• know how to handle hazardous and dangerous chemicals in the home and how they are labelled;

• know some factors influencing the decomposition of materials and how decomposition can be prevented.

Now over to technology. The goals here are again to strive for a sound idea of the general directions and aspirations of the subject.

In its technology education, the school shall strive to let the pupil:

• develop insight into the knowledge traditions and development of technical culture and into how technology influences man, society and nature, e.g. when it is a question of environment, welfare, working conditions, employment and other areas of social life;

• develop familiarity with common tools and methods of work at home and at places of work, and knowledge about other technology that surrounds us;

• develop an ability to reflect upon and judge the consequences of different technology choices for man, society and nature;

• develop an ability to transform knowledge of technology, the use of technology and construction into standpoints of his/her own and practical action;

• develop a positive interest in technology and confidence in his/her ability to solve technical problems.

c) Marking

The marking is goal-related. A scale with three steps is used, namely 'passed', 'passed with distinction' and 'excellent'. For each subject, criteria for 'passed' and 'passed with distinction' will be issued by the National Agency for Education. It is up to the teacher to decide about 'excellent'. Marks are given from grade 8 onwards. The marking system is under development and future changes may occur.

1.3 Upper secondary school

a) Sixteen national programmes

In the new upper secondary school, which was introduced in 1993/94, there are 16 national programmes, 14 of which are primarily vocationally oriented and 2 of which are primarily in preparation for higher education. The programmes, which are all of three years' duration, are intended to give a broad basic education within a vocational field, as well as providing the foundation for continued studies on completion of the upper secondary school. The 16 programmes are:

child care and leisure	aesthetic	hotel and restaurant trades	land and animal husbandry
construction	transport technology	industry	natural sciences
electricity	trade and administration	foodstuffs	health care
energy	handicrafts	media	social sciences

Some of the programmes are specialised in the second and third years in the form of national branches, e.g. a science branch and a technology branch within the natural sciences programme. Each programme is described with respect to its purpose and goals.

b) An upper secondary school based on courses

In order to enable the upper secondary school to function flexibly and offer students choices, it is based on different courses that are easy to alter without affecting the organisation as a whole.

A subject syllabus may consist of a number of courses, linked to one another. For example, in the mathematics syllabus one finds the courses A, B, C, D and E. Course A is studied by all students, no matter what programme they are in. Courses B and C are studied both in the natural and social sciences programmes, and D and E only in the natural sciences programme.

Students are given a choice of courses both within the programme selected as well as from other programmes, thereby enabling them to take an individualised course of studies. The same courses are found in the upper secondary school and further education for adults, making it easier to supplement education with courses of one's own choosing.

c) Core subjects and characteristic subjects

Upper secondary education is intended to prepare students both for continued education and working life. For this reason some subjects, called core subjects, are common to all programmes. These are (minimum guaranteed time in clock hours for study of each subject's core part in parenthesis):

Swedish (200)	civics (90)	mathematics (110)	sports and health
English (110)	religious studies (30)	science (30)	aesthetic activities (30)

The total time for the core subjects is 680 clock hours. This is 30% of the minimum guaranteed time for study.

In addition to the core subjects, students take subjects which are characteristic of their programme, i.e. subjects which give a programme its profile. They are called characteristic subjects and take up 50 - 60% of the guaranteed time for study.

Some of the characteristic subjects in the natural sciences programme, their courses and guaranteed time for study, are given in the table below:

course	**science branch**	**technology branch**	**course**	**science branch**	**technology branch**
biology A	50 h	50 h	maths C	50 h	50 h
biology B	60 h	-	maths D	40 h	40 h
physics	220 h	220 h	maths E	60 h	60 h
chemistry A	140 h	140 h	environment	60 h	60 h
chemistry B	40 h	-	technology A	60 h	60 h
maths B	40 h	40 h	technology B	-	120 h
			technology C	-	90 h

Maths E and environmental studies are alternative courses.

d) Science

The subject 'science' (*naturkunskap* in Swedish), as has been mentioned above, is a core subject. The course common to all students is called 'science A'. In addition to that, science is a characteristic subject in the social sciences programme. The course is called 'science B' with a guaranteed time of 70 hours.

In the case of 'science A', the goal of the course is that pupils shall acquire knowledge in order to understand, and take a personal position on, environmental, energy and resource issues.

After finishing the course, the pupil shall:

- have insight into how phenomena in nature can be investigated and analysed by means of experimental methods;
- have scientific knowledge about the conditions and the development of life;
- master concepts necessary for understanding the structure and dynamics of ecosystems and realise the consequences of disruptions of the systems;
- be able to give examples of natural cycles of matter and how human activities may influence them;
- be able to describe and analyse different natural and man-made flows of energy;
- be able to describe and analyse man-environment interactions, particularly with reference to the content of his/her own programme;
- be able to describe local and global environmental problems and discuss actions to solve them;
- be able to interpret and critically analyse arguments concerning environmental and resource issues and realise that different decisions imply different consequences.

e) Marking

The marking is both course and goal related. A scale with four steps is used, namely 'not passed', 'passed', 'passed with distinction' and 'excellent'. For each course, criteria for 'passed' and 'passed with distinction' have been issued by the National Agency for Education. It is up to the teacher to decide if a pupil is qualified enough to get 'excellent'.

2. Teacher education

Teacher education in Sweden has a long history. Prior to 1977, primary school teachers were trained in institutes that did not belong to a university. Secondary school teachers had a university degree, usually in two main subjects, after which they completed an additional year of pedagogical training.

With the 1977 reform, all teacher training became integrated into the higher education system, either as part of a university, a university college, or a separate School of Education.

The essential characteristics of the present teacher education system were laid down in 1988. In 1993, a new education reform was implemented making higher education more decentralised. The government sets the goals, authorises the granting of degrees and provides the basic structure of the degree programmes. The course content is determined by each institution. The new reform also means a greater freedom of choice for the students.

2.1 Compulsory school

Since 1988, all training for compulsory school teachers is included in one general programme, known as the compulsory school teaching programme. It has two sub-programmes which overlap in order to give the teacher the possibility to teach a broader range of grades:

- the 140 point programme for grades 1-7
- the programme of 160-180 points - after 1993 always at least 180 points - for grades 4-9 (one point corresponds to one week of full time study.)

The curriculum for grades 1-7 has two main specialisations. One is in Swedish, general subjects (with particular emphasis on social subjects), and a practical artistic subject. The other is in mathematics, general subjects (emphasising science subjects), and one practical artistic subject. The science subjects' part in the latter specialisation is about 20 points.

Students training for grades 4-9 can choose between the following subject specialities:

- Swedish and other languages
- home language, Swedish as a foreign language and English

- social sciences
- mathematics and science
- science (environmental and ecological profile)
- a practical artistic subject together with Swedish, mathematics and foreign languages.

The students specialising in science begin their subject matter training with a compulsory course in either mathematics (20 points) or environmental science (20 points). After that they choose courses corresponding to 100 points in mathematics and science subjects. They can take 60 points in one major subject and 40 points in another. They can also choose to study all the science subjects, i.e. mathematics, biology, chemistry and physics. In addition to the 100 points, interdisciplinary studies (10 points) are also part of their curriculum. Technology is not a subject in itself, but integrated in the science and interdisciplinary courses. Education courses and teaching practice are sandwiched between the subject courses (40 points). The students also have to study educational research methods, conduct a small investigation of their own, and report it in the form of a paper (10 points).

In order to be admitted to the various science specialisations for grades 1-7 and 4-9, the students must have studied mathematics and science subjects at the science or technology branch of upper secondary school and have at least a mark of 3 (on a 1-5 scale) in those subjects.

2.2 Upper secondary school

Beginning in 1993, students are required to complete a 180 to 220 point programme with 80 points in a first (major) subject and 60 points in a second subject; 80 points is always required in the study of. for example. a language and civics. There are also education courses, usually sandwiched between subject matter courses. The courses comprise, for example, practical work, science education seminars including methods, and pedagogics. Conducting an investigation and reporting it in the form of a paper is also part of the training.

In the area of science, the following combinations of subjects are possible: maths-physics, maths-chemistry, chemistry-biology, chemistry-geography and chemistry-biology-general science.

There is also a 40-point programme with the same content as the education courses just mentioned for those who have completed at least 140 points of university education with at least 80 points in one subject relevant for school teaching. The same programme is available for those who have degrees in engineering, architecture, economics/business administration or a Ph.D.

The entrance requirements for the science specialisations are the same as for the comprehensive school programme.

3. Out-of-school resources

3.1 The science centre movement

There are at present efforts under way to establish new science and technology centres in Sweden as well as to improve and widen the role and significance of the existing centres. The general picture is best described by quoting Israelsson (1995), a Swedish leader in the field:

"The science centre movement in Sweden dates back only about ten years. Before then, the science centre concept was known only to a limited number of museum professionals, scientists and educators. Small projects were carried out and plans had been laid for several years by museum directors, university planners and educational entrepreneurs, but it was not until the second half of the eighties that the first science centre finally was opened to the public.

The start of the science centre movement in Sweden was encouraged by government action and the activities of government agencies. Those actively responsible for creating new science centres are found within the university world, with some of the already existing museums, but also with communities and county administrations. Science centres in Sweden are still not numerous, but those existing show more diversity between them than is usually the case in other parts of the world. Different ways of approaching science and technology and differences in organisation and responsibilities account for differences in size, scope and activities.

Government concern to strengthen the position of science and technology in Swedish society as a whole will also strengthen and change the role of science centres. Developing science and technology centres as tools in the strategic planning of the future has once more, and very strongly, been on the agenda of the Swedish government. During 1993, government action has been taken to improve conditions for science/technology centre activities within education in Sweden, with a special view to their role in teacher training. Grants were given to a number of science/technology centres to strengthen their work especially in teacher in-service training activities, and these activities are now being reviewed and evaluated. A first report will be available during 1995.

3.2 Television

There exists a variety of programmes with a science-technology content in Swedish Television (TV1, TV2). Some are aimed directly at school, others at a general audience. Among the latter, 'The world of science', 'Medix', 'In the middle of nature' and 'One with nature' should be mentioned. On average between 5 and 10% of the population watch these programmes. Women are more interested in medicine, men in technology. Rather few persons in the 3-15 age group watch (2-3%). There are a bit more in the 16-29 age group (about 5%). Very little is known about how these programmes influence the scientific literacy of the population.

4. Science teaching in compulsory school

4.1 Grades 7-9

During the national evaluation of compulsory school in 1992, the science teachers in grade 9 were asked many questions about their working conditions, teaching practice, aspirations and so on (Andersson, Emanuelsson, and Zetterqvist, 1993c). They usually answered by agreeing or disagreeing, on a five point scale, to statements. Based on a national sample, the following can be said:

1) Of the science teachers, 68% are men and 32% women, with a mean age of 46 and 43 years respectively. They have studied on average 4.5 years at university or university college, both science subjects and educational courses. Usually they are trained in two or three subjects. The level of subject matter knowledge is expressed in points. One point corresponds to one week of full time study. Teachers with biology as part of their university training have on average 70 points in that subject. For physics, chemistry and mathematics, the corresponding figure is 40.

2) The teachers were asked questions about the climate of their work and how they feel about it. A general impression from their answers is that the science teacher is a positive person with high self-confidence and a sense for the importance of his/her work in society. He/she feels appreciation from the students, experiences work as stimulating and satisfying and says that colleagues

provide help, support and appreciation. There is one negative aspect to report. The teachers do not agree with the statement 'I think my work offers good opportunities for career development.'

3) Concerning teaching practice, the overall impression is that a relatively traditional pattern is dominant. The teacher conducts demonstrations and the pupils try to follow the course of events. The pupils carry out experiments of their own, quite often following detailed written instructions. The impression of a traditional pattern is reinforced when you take a look at the pupils' judgments. According to them, the most common activity during science lessons is listening to the teacher; the second is copying what the teacher has written on the chalkboard.

4) The teachers want to change their practice towards more student activity and responsibility. They want to stress the understanding and application of science concepts more and increase open-ended experimental problem solving. The students answer in a more conservative way than their teachers when asked about the changes they want in teaching practice. They like to listen to teachers' lessons and work according to detailed lab instructions.

5) The teachers and the students meet on one fundamental point: both parties want to increase student involvement in the planning of work.

6) The teachers have rated, on a five point scale, how important fourteen objectives of science education are in their teaching, e.g. 'understand concepts and theories' and 'develop responsibility for one's own health'. They have rated both how it is in reality and how they want it to be ideally. The objective 'particularly observe and develop the girls' interest in science' gets the lowest rating of all objectives, both in reality and ideally.

4.2 Grades 1-6

There are no systematic data on a national level about science teaching in grades 1-6. However, there is a certain consensus among observers that very little if any teaching of content from physics and chemistry goes on. Biology and some physical geography are the only science subjects dealt with.

The average number of students in a class was, for the whole of Sweden in 1993, 20 in grades 1-3, 22 in grades 4-6, and 25 in grades 7-9. These numbers tend to increase due to reductions in municipal expenditure.

5. Dynamics of change

5.1 Five factors stimulating change

There are at least five factors which will both stimulate and force the Swedish science education system to change:

1) The whole school sector, including teacher education, is in a phase of deregulation, decentralisation and re-allocation of responsibilities between national and local authorities. The state is to guarantee the equivalence of schooling throughout the country. The main principle is for the state to define goals and guidelines and for the municipalities to be responsible for the achievement of the goals.

2) By the year 2000, a considerable shortage of civil engineers and scientists is predicted. In order to compensate for this, Sweden needs to increase the number of students going through the natural science programme of upper secondary school by about 6,000 per year. If upper secondary school goes on as usual it will turn out 14,000 students from the science programme at the end of the century. Thus, we are talking about the need for a 40% increase. At present, the distribution by gender is 70% boys and 30% girls.

3) Comprehensive school students' performance in science, measured on a national level, leaves a great deal to be desired (Andersson, Emanuelsson, and Zetterqvist, 1993a, b). Grade 9 students often have considerable difficulties in solving problems which demand an ability to apply scientific concepts. Either they do not have them or they are not able to activate them. There is very little increase in conceptual understanding as a result of science teaching in the social sciences programme of upper secondary school (Jansson, 1994, Jansson and Andersson, 1994).

4) There is widespread concern in Swedish society for environmental problems and a growing awareness that scientific knowledge is necessary (but not sufficient) to understand them. Environmental issues were on the agenda during the recently finished work on a new curriculum and new syllabi for comprehensive school. In her guidelines for the work, the Minister of Education stressed that the pupil should get a comprehensive view of environmental issues. This may clash with the rather strong academic subject matter tradition which is prevalent at the upper part of compulsory school.

5) There is a growing awareness of the constructivist view of knowing and learning. The first wave of interest was related to Piaget's stage theory of cognitive development. Two types of investigations were carried out in Sweden

as in several other countries. Firstly, textbooks were analysed. It was found that these to a great extent demanded formal operations in order to be fully understood. Secondly, the pupils using the textbooks were tested with Piagetian tasks. It was found that the majority belonged to the stage of concrete operations. These results pointed to a considerable gap between pupils' level of cognitive development and the conceptual demands of science courses, which was considered an explanation of the often poor results of teaching efforts. The importance of seeing science teaching from the pupil's perspective was also emphasised. Discussions were held about how to better adapt course requirements to the initial cognitive state of the pupil.

Gradually the stage concept became the subject of increasing criticism. When researchers tried to operationalise it by test problems, it became very fuzzy. However, the Piagetian period opened up, once and for all, the pupil's perspective, and science educators in Sweden, as in many other parts of the world, began to ask new questions, e.g. "What are the students' conceptions of light, heat, electricity, motion, transformations of matter, life and evolution?" Those and other questions have by now resulted in thousands of empirical studies. A main result is that students, before teaching, have everyday conceptions of natural phenomena which can often be described in a clear way and which differ markedly from the conceptions of science. Another major finding is that the science concepts tend to be forgotten, whereas the everyday ones remain some time after teaching.

This new line of inquiry takes a main interest in the content rather than the forms of thinking, which were in focus during the Piagetian period. Nevertheless, again we can see the gap between the pupil's thinking and the conceptual demands of science courses, described in a much more detailed way, area by area, than during the Piagetian period. Also, general descriptions of everyday thinking are offered which remind us of Piaget's general descriptions of preoperational and concrete operational thought. Thus, everyday reasoning is pictured as unreflective and context bound. The demands for consistency and logic are small, and knowledge is formed in an unconscious way in various situations.

These results are well known in teacher training circles, and also disseminated to practising teachers, particularly at comprehensive school. At first the results were denied by the teachers: "Our students do not think like that!" But when the teachers informally replicated the investigations reported, there was a change in attitude. "Our eyes have been opened to something very important that we didn't know before." Those who become experienced with this line of research think that the constructivist view of knowing and learning in combination with the many detailed results of investigations and related insights generates many new ideas on teaching science content which are worth exploring.

5.2 From a compulsory school in two separate parts to a grade 1-9 perspective

There is already some evidence that the decentralisation of responsibilities is bringing about cooperation between primary level teachers and subject matter specialists at grades 7-9. The reader recalls that the students are guaranteed 800 clock hours of teaching in science subjects and technology during their comprehensive school years, that there are goals to strive for from grade 1 to 9. and goals to attain at the end of grades 5 and 9. This means that the teaching of science and technology must be planned in a 1-9 perspective. Formerly grade 1-6 and 7-9 were two quite separate systems with little communication between them about science education.

Whether or not this incipient communication will help teachers in grade 1-5 overcome their reluctance to teach science and technology remains to be seen. It is a well known fact that those teachers generally are lacking scientific knowledge and understanding. Therefore, the step to an inquiry-oriented classroom in science is a quite big one. If you hardly know yourself how to make a bulb light up by connecting it in the right way to a battery, you can hardly be expected to engage in discussions about electric circuits with curious and inquisitive pupils!

Thus it is the teachers that set the limit on what it is possible to achieve in primary grades. They are good in the humanities and the social sciences. They understand artistic thinking better than scientific thinking. What then can be done? It is important not to give up in-service training. It is important to let the teachers, most of whom are women, experience:

- that their pupils generally are very interested and active if they are given opportunities to experiment themselves and to discuss their experiences and ideas;

- that pupils generally like to put forward and discuss their own explanations of science phenomena, provided that they are treated with respect and interest;

- that scientific knowledge quite considerably increases understanding of environmental problems;

- that scientific knowledge can be of benefit for people, e.g. in health care;

- that scientific knowledge can provide improved understanding of phenomena in everyday life;

- that scientists are people like you and me.

In other words, it is a question of bringing out the human and social aspects of science and emphasising its rich pedagogical possibilities.

A long-term strategy adopted in Sweden in order to promote the development of science in primary grades is to stimulate teachers to specialise in science early during their pre-service training. (See section 2.1 about the programme for grade 1-7.)

5.3 From remembering terminology and facts to understanding and insight

Quite naturally, the predicted shortage of civil engineers and scientists, and students' weak performance in science, are of concern to the National Agencies of Education and Higher Education respectively. Among the activities going on to improve the situation, the Science and Technology project (*NOT-projektet* in Swedish) should be mentioned. It is a five-year joint venture between the two agencies. One of its aims is to put the problems of science education on the agenda of educational discussion. The project tries to stimulate local development by arranging regional and national conferences and acts as a catalyst for various initiatives.

a) Science in grade 7, 8 and 9

Among the problems discussed, that of developing science teaching in grades 1-6 has already been mentioned. Another one is the large amount of science content in grades 7, 8 and 9. The explanation for this is probably that the founding fathers of compulsory school wanted Swedish pupils to have a broad orientation in science that was of similar scope as that of grammar school (*realskolan*). There was also a practical problem - to get textbooks quickly. Grammar school textbooks in biology, chemistry and physics became the model. The market is still dominated by separate subject matter books with much content, although a more coordinated approach has been ventured by one publishing house, giving them about 10% of the market. Of course, an abundance of content is an obstacle to penetrating discussions and opportunities to apply concepts in new situations. This might be a major explanation of the rather poor results in the national evaluation mentioned above.

b) The subject 'science' at upper secondary school

A similar problem exists in the social sciences programme of upper secondary school. The joy of understanding may be drowned in a flood of terminology and facts, as one teacher put it. Textbook writers are eager to inform students about that vast area of knowledge called science, and they assume students have already mastered several basic concepts at comprehensive school, which is not always the case. The effect of this can be the same as for grades 7, 8 and 9 - an abundance of sometimes difficult content forces students to memorise with little understanding.

c) Physics at upper secondary school

Upper secondary physics is demanding. It is a question of mastering maths as well as physics. Teachers and interested parents report that the approach of many pupils is to try to find a formula in which to plug in numbers. More experienced problem-solvers proceed differently. They first try to come to grips with the problem in qualitative terms. Then they go on to a mathematical treatment.

Learning formulae is one way of coping with physics and obtaining a mark that is not too bad. Understanding physics in a more profound way is much more difficult, but in the long run more rewarding. Therefore it is perhaps a good idea to stress qualitative thinking more in upper secondary physics.

Changes aimed at overcoming the problems described in this section are believed to attract more students to science, boys as well as girls. It is also emphasised in the discussion that bringing out the human and social aspects of science is important when it is a question of motivating girls to study science.

There is a growing awareness of the problems discussed in sections 4.2 and 4.3. This is likely to lead to some experimentation and, finally, some significant changes.

5.4 Strengthening the research base for science education

Another initiative by the National Agencies for Education and Higher Education respectively is to stimulate research and development in science education at universities and university colleges. One example is a rather large national seminar for science educators that meets regularly. The overall aim is to develop the innovative capabilities of the participants. Distinguished European scholars in science education are invited to present and discuss their specialities.

The National Agency for Education has arranged a conference with most of the Swedish researchers dealing with science education, and other meetings will follow. One aim is to find out how to coordinate efforts in order to improve science education at various levels of the school system. Until now, efforts have been rather scattered, depending greatly on devoted pioneers.

Science education research is a rather young discipline in Sweden. The first Ph.D. thesis was examined in 1976 (Andersson, 1976). It dealt with the development of spatial concepts in primary grade children as a result of science teaching. Titles of some other theses are 'Archimedes in the class-room' (Lybeck, 1981), 'Development of knowledge through experiment-centred dialogues about D.C. circuits' (Kärrqvist, 1985), 'Conceptions of matter - a phenomenographic approach' (Renström, 1988), 'Students' understanding of scientific explanations in relation to biological contexts' (Pedersen, 1992), 'Compulsory school pupils' understanding of ecological processes' (Helldén, 1992), and 'Different worlds, different values. How girls and boys meet physics, chemistry and technology at the upper level of compulsory school' (Staberg, 1992).

Interestingly, the specialist at the National Agency for Education, who has been analysing the consequences of students' weak performance in science (see section 1.4), is expressing himself in terms of theories of knowing and learning rather than organisation (Strömdal, 1994). Thus he claims that a science education reform must begin by clarifying and developing basic concepts. Broadly speaking, he recommends that research and developmental efforts should be based on a social constructivist view of knowing and learning.

5.5 From the academic subject matter tradition of school towards the individual's need to understand the world

In all Swedish comprehensive school curricula (the first one is from 1962) it is noted that traditional subject matter teaching (biology, chemistry and physics taught separately) is not enough to understand the world. For example, environmental issues cut across many subject matter boundaries. Therefore, ideas and proposals about the coordination and integration of subject matter content are continually being put forward, notably from the National Agency of Education.

However, in practice the traditional mode of teaching separate subjects has been very dominant.

There is now a discussion going on about the need to change this pattern. If we disregard the natural sciences programme of upper secondary school, it is noted that the main purpose of science education is to prepare the student for life and living and for an active citizenship. Therefore, a discussion of what content to select must begin in the world around us rather than in the academic subjects.

If, then, we turn to the world, we note a number of processes that may be called 'explosions' because they take place at a rate that is without precedence in human history.

a) The population explosion

The number of people on Earth is expanding rapidly. The growth rate at present is 90 million per year. We are now 5.5 billion. Half of us are below 18 years of age. Within the next 50 years the population is expected to double.

b) The transformation of matter and energy explosion

Particularly in industrialised countries, matter and energy are transformed at an increasing rate - in mines, refineries, engines, furnaces, process industries, etc.

c) The acting on the environment explosion

The population growth and the transformation of matter and energy explosion mean that our actions on the environment take place at an increasing rate.

d) The north-south gap explosion

The conditions of living vary considerably among countries. The differences between industrialised and developing countries, between 'north' and 'south', tend to increase rapidly. Therefore we may talk about a gap explosion.

e) The information and communication explosion

The amount of information and possibilities for communication are growing exponentially. Rates of doubling are typically less than ten years.

f) The mastering explosion

The above-mentioned five explosions lead to more and more problems to cope with and to master. Current efforts to improve learning at school is part of the mastering explosion.

The effects of all these explosions are rapidly changing our world and are reported everyday in the media. It is difficult for anyone to create any kind of structure out of the flood of information. Many questions are asked with concern and worry, e.g.: Can the planet feed a growing population? How badly polluted is the environment? Is there energy enough to ensure a good life for everybody? What can be done to solve the problems?

It is reasonable that questions like these be dealt with at school in such a manner as to help students create structures that enable them to grasp the myriad items of information and observation at hand, and in a way that prepares them to take action now and in the future. Achieving this is no easy matter. The knowledge base of school consists of the traditional subjects and their academic counterparts; but these subjects were once developed for answering other questions than those just mentioned above. In order to answer these new questions, one must link together knowledge from many areas, and from diverse subjects. If you think for example of what can be done to reduce acidification, you must select a very large system for your thinking, namely one that consists of the subsystems *nature, technology and man/society* (system NTS). It is a question of describing and analysing the effects of acidification in nature, which requires scientific knowledge. You must also know which natural and technological systems are causing acidification, and what the technology in question means to man and society. Then you have a knowledge base for discussions and action.

The problems of today and tomorrow put demands on school that traditional subject matter teaching alone cannot meet. Therefore, we must invent suitable complements. The thinking outlined above has already led to some reorientation in practice. A new series of textbooks in science and technology for grades 7-9, taking a coordinated approach and stressing an understanding of environmental problems, is about to be published. This is likely to lead to some decline in the use of single subject textbooks in science. Pioneering work in opening up the perspective summarised above has been done by Bodil Jönsson and her collaborators (Jönsson and Wickenberg, 1992).

A good example of Sweden's interest in environmental education is its very active participation in the Baltic Sea project. One of its objectives is to increase student awareness of the environmental problems in the Baltic Sea area and give them an understanding of the scientific, social and cultural aspects of the interdependence between man and nature. All the countries around the Baltic participate. The general coordination of the project is for the time being managed from Stockholm. The working language is English. Information about publications is given in the appendix.

5.6 From a transfer towards a constructivist view of knowing and learning and then...

Constructivism has been at the centre of research efforts in science education for a rather long time. A sketch of some developments within this tradition was made in section 5.1. It was reported that research results had opened the eyes of the researchers and teachers to the pupil's perspective. The many detailed descriptions of students' thinking together with explanations of the constructivist conception of the knower-known relation has helped teachers move from a partly unconscious transfer view of learning towards a constructivist one. The pupil is looked upon as an active constructor, rather than a passive recipient, of knowledge.

The question is whether constructivism, including detailed empirical results and related insights, will continue to be a productive tool for improving science teaching. I am inclined to answer yes, provided that the following three points are taken into consideration.

The first is to realise that constructivism is not a theory of teaching, but a way of looking upon knowing and learning. It provides a certain direction to one's thinking, but no particular teaching method follows from it. Constructivism does not forbid lectures, nor does it prescribe inducing cognitive conflicts. I once described to a friend what I believed was my personal struggle to change from a transfer to a constructivist view, and got the question: In what way has constructivism changed the relations with your children? I couldn't answer at first, but then I said: I believe I am more relaxed. I am not so focused on teaching them. I see more possibilities than that to help them construct. The teacher-pupil relation is paradoxical. Sometimes it is best not to teach in order for the pupil to learn.

The second thing to consider is the complexity of the human mind and the fact that the mind lives in a society. A thinking act does not only involve everyday conceptions of the phenomena studied, e.g. DC circuits, but many other aspects as well, such as conceptions of space, time, causality, school, learning, science, not to mention motivation and interest. It is tempting to explain the rather poor results of the national evaluation by saying that the teaching has not taken into consideration the initial conceptions of the pupil and adapted conceptual demands accordingly. There is no doubt some truth in this, but it is important not to stop there. When we think about how to improve the conditions of learning we must look at the whole system (conditions at school, how other subjects are taught, national curriculum, the social environment from the family to the larger society, and so on).

The third point is about which attitude to take towards everyday conceptions and thinking. There are various types of thinking and knowing, e.g. everyday, scientific, artistic and vocational ones. For the science teacher, scientific thinking is central, simply because one of the goals of school is to stimulate the pupils to develop some lasting insight into the concepts and models of science. With this goal in focus, a natural first impulse is to look upon everyday thinking as a cognitive enemy, which must be fought down. There are some good reasons for this point of view. You cannot understand either chemistry or environmental problems if you think that matter disappears upon burning, which is a rather common everyday conception. Furthermore, the general features of everyday thinking are contrary to scientific habits of mind such as a striving for generality, consistency and the reproducibility of observations and experiments.

But the relationship between everyday and scientific thinking and knowing is more complicated than that. Without a considerable amount of everyday knowledge it is not possible to develop scientific thinking. That was one of Piaget's major points. He explained the emergence of scientific thinking by describing the evolution of thought from everyday life (the preoperational and concrete operational stage) to science (the stage of formal operations).

Another perspective on the relationship between everyday and scientific thinking emerges if we think of science as a human activity in a social context. Then questions about responsibility for man, society and nature come up. These cannot be dealt with by means of scientific knowledge alone. They are primarily answered with reference to one's total life experience, i.e. everyday knowledge.

In other words, school science must for various reasons make use of everyday thinking and knowing. Therefore, it is reasonable not to look upon it as something hostile and bad. Instead it is suggested that we consider everyday, scientific, artistic and vocational thinking as complementary forms of knowing and understanding. It is a challenging task for school to develop all these types of knowledge, not least by stimulating interaction between them.

Take as an example everyday and scientific thinking. Several observers claim that a given area of science develops as a separate cognitive system in the mind, apart from the corresponding everyday conceptions. The pupils know for example the chemical formula for photosynthesis, but facing a real tree they claim that it has absorbed all its matter from the ground. They can apply Ohm's law in calculations, but in a real situation they treat a round battery and a bulb as unipolar when trying to make the bulb light up. And so on. The advantages of interaction between everyday and scientific conceptions are in these cases obvious. On the one hand, the scientific conceptions may be stabilised and generalised by being applied to objects and phenomena normally assimilated into everyday thinking. On the other hand, everyday thinking may be stimulated by being confronted with scientific conceptions.

Teaching must of necessity take the pupil's understanding of the world as its point of departure; thereby a productive tension between everyday and scientific conceptions may be created. And scientific conceptions are certainly not limited to textbooks and lessons but include new ways of looking upon the world. It is important that pupils realise this. They should not only be able to draw and explain the textbook picture of the phases of the moon, but also observe the real moon and predict the direction of the sun. They should not only know the formula for photosynthesis but also be able to link the sawmill or the pulp industry in their community with photosynthesis in needles. And so on.

Scientific thinking as such is not easy. It implies a considerable mental reorientation for any person for whom everyday thinking is the dominant mode of operation. It will probably take from five to ten years to develop, provided the individual genuinely tries to practise it. Problem solving, discussions with arguments and counter arguments, time to reflect, and a teaching situation in which there is something to understand - these are a few stimulating factors. For the science teacher, it appears to be important that as many school subjects as possible contribute to the process. It is also urgent to see the problem in a grade 1-12 perspective.

How we must proceed in concrete terms in order to develop scientific thinking, knowledge and understanding among a significantly larger part of the student population than at present remains an open question. Perhaps this is as good a reason as any for European collaboration.

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Appendix:

Sources of information about the Swedish school system

VERKET FÖR HÖGSKOLESERVICE (VHS)
(National Agency for Higher Education)
Box 7851
S-10399 STOCKHOLM
Phone: +46-8-4535000 Fax: +46-8-4535140

For example, the following seven page long paper about Swedish teacher education is available: A. Besmanoff, C. Stenborg-Blom, Teacher education in Sweden. NARIC-report 1994:1, 1994.

SKOLVERKET
(National Agency for Education)
S-10620 STOCKHOLM
Phone: +46-8-7233200 Fax: +46-8-244420

The National Agency of Education does not distribute any written information in English but answers questions about the Swedish school system.

MINISTRY OF EDUCATION AND SCIENCE
S-10333 STOCKHOLM
Phone:+46-8-7631822 Fax:+46-8-7231192

For example, the following publications in English might be of interest:

- A new curriculum for the upper secondary school.
- 1994 curriculum for compulsory schools (Lpo 94)
- 1994 curriculum for non-compulsory schools (Lpf 94)

The Ministry of Education has also published (in 1993) a book in English: 'The Swedish way towards a learning society' (170 pages). It can be ordered through:

ALLMÄNNA FÖRLAGET AB
S-10647 STOCKHOLM
Phone: +46-8-7399630 Fax: +46-8-7399558

The Baltic Sea Project

Information about the project, e.g. a newsletter, can be obtained from:

MS SIV SELLIN
BSP General Co-ordinator
National Agency for Education
10620 STOCKHOLM
Phone: +46-8-7233274 Fax: +46-8-244420

Learners' guide No 1, called 'Working for a better water quality in the Baltic Sea' (200 pages). The book can be ordered through:

LIBER DISTRIBUTION
Publikationstjänst
S-16289 STOCKHOLM
Phone: +46-8-6909576 Fax: +46-8-6909550

Report from United Kingdom

Joan Solomon and Sue Hall

Introduction

Science education is compulsory in the United Kingdom between the ages of 5 and 16 years. However, the structure, type and assessment of the science curriculum in each of the four countries of the UK differ widely.

a) England and Wales

The majority of pupils attend state-maintained schools which are obliged to follow the National Curriculum, most of these are co-educational comprehensives (see Appendix 1, Table 1). The National Curriculum, the first in the history of education in Britain, was introduced as a result of the 1988 Education Reform Act. Implementation of the science curriculum began in 1989: it has sustained two major revisions and the third version is due to be introduced in 1995.

The design of the science curriculum followed on a period in which the following problems had been discussed vigorously by the science education community:

1) how to accommodate three science subjects (physics, chemistry and biology) into the available curriculum time;

2) the well-documented evidence of pupils' gender-related preferences for particular sciences;

3) the conviction that all pupils should study a balanced curriculum of all the sciences up to age 16.

All three issues were addressed by the final product, a balanced curriculum taken from all three science subjects, occupying curriculum time for two subjects, and compulsory in state-maintained schools for all pupils up to age 16 (see appendix 2 for Science in the National Curriculum).

Science education after age 16 is not compulsory; students opt for either academic or vocational courses, usually of two-year duration, in schools or colleges of further education.

b) Scotland

Almost all Scottish schools, primary and secondary, are co-educational comprehensive.

The National Curriculum equivalent in Scotland is the 5-14 Development Programme, a curriculum guidance which, unlike the English and Welsh National Curriculum, is not statutory, but is widely followed. The first stage of the curriculum (Pl to P7 - see Appendix 1, Table 2) runs from years 5 to 12 and the first two secondary years (S1 and S2). Here science is part of the core subject Environmental Studies, which includes social subjects, technology, health education and information technology.

Students post-14 study for the Standard Grade (S3 and S4 - to 16 years), for which science is one of eight modes in the curriculum. Students post-16 years (beyond S4) can choose to study one year for Highers in separate sciences (biology, chemistry, physics and human biology), or vocational courses (Scottish Vocational Qualifications). (For details of the structure of the Scottish curriculum see Appendix 2).

c) Northern Ireland

Most schools are grant-aided and statutory controlled. At 11 years there is selective entry to grammar and secondary schools (approximately one-third/two-thirds entry). Co-education is less common here than in England or Scotland.

The introduction of a common curriculum paralleled the introduction of the English and Welsh National Curriculum. Science is taught as part of science and technology in primary school (P1-P7) and as science in secondary school (F1-F5).The science curriculum is currently undergoing review.

1. Science in the National Curriculum

1.1 Recommended number and duration of lessons

a) England and Wales

The National Curriculum structure is divided into four phases of learning.

1) Key Stage 1 - pupils aged 5 to 7 (Year 1 - Year 3)

2) Key Stage 2 - pupils aged 7 to 11 (Year 4 - Year 6)

3) Key Stage 3 - pupils aged 11 to 14 (Year 7 - Year 9)

4) Key Stage 4 - pupils aged 14 to 16 (Year 10 - Year 11)

Science is a compulsory subject for all pupils in all stages up to age 16.

However from age 14 (Key Stage 4), pupils may choose to study Single Award science to gain one qualification in the nation-wide examination - General Certificate of Secondary Education (GCSE). The majority sit for Double Award science to obtain two GCSEs. Others take three separate sciences (physics, chemistry and biology) to obtain one GCSE per subject taken.

It has been recommended that between 10% and 20% of curriculum time in school should be spent on science in all Key Stages.

A review of the National Curriculum for science was completed at the beginning of 1994. The recommendations for science, which include substantial changes, can be found in Appendix 3.

Before the 1988 Education Act, technology was in a state of change. Earlier it had been taught as a part of Craft, Design and Technology (CDT) and included woodwork and metalwork. During the 1980s the craft aspect diminished and several schools experimented with having a combined science and technology faculty. This facilitated, for example, the teaching of electronics. However, in the National Curriculum, technology became a separate core subject and is now distinct from science in the school organisation. A new Design and Technology curriculum is currently being developed.

b) Scotland

It is recommended that 25% of curriculum time in primary school be devoted to the environmental studies area. In secondary stage, 10% of curriculum time should be occupied by science.

Post-14 science education is governed by the Standard Grade examinations taken at 16 years, which is approximately parallel to GCSE. Science is one of eight modes in the curriculum and is offered as integrated science at Foundation, General and Credit levels, and as separate sciences at Credit and General level.

Post-16 education in science is either for the Higher examinations taken at 17 years in five subjects which may include physics, chemistry, biology and/or human biology. In S6 students can choose to study these same subjects for the Certificate of Sixth Year Studies (CSYS), a course which is broadly equivalent to A-level and which can be used for entry to both English and Scottish universities. Some schools also offer the English A-level in two or three sciences at age 18 years to enable students to enter English university courses. There are also new vocational qualifications (GSVQs) currently being piloted in science (see section 3.3).

c) Northern Ireland

Students in primary schools study science within the science and technology curriculum area. It is recommended that science should occupy 10% of curriculum time, but a recent consultation indicated that schools required at least 30% more time to fulfil the curriculum at Key Stages 1 and 2 (NICC, 1993). As a result of this, a review is under way to reappraise the content of the curriculum at these stages.

1.2 Which sciences are to be taught

a) England and Wales

Since the introduction of the National Curriculum the choice available to pupils is between Single or Double Award science, or three separate sciences, at Key Stage 4. Double Award courses may be either modular, coordinated or integrated science, all of which incorporate physics, chemistry, biology, some earth science and astronomy into the time normally allocated for two subjects. This is the commonest option.

The science content is reduced in the Single Award course to the time normally allocated for one subject. This option is, according to the government, intended for students gifted in languages or the arts. The content has been chosen, it is said, to provide a suitable basis for the public understanding of science, although it is curious to find in the latest amended version that ecology has been omitted while electromagnetic induction is retained. However, where it is used in schools, it is for the generally less able students.

Separate subjects - biology, physics and chemistry - are also available as options which treat the Key Stage 4 curriculum at greater depth and breadth than does Double Award science. Double Award science is by far the most popular, with over 80% of pupils studying this option in 1993 to 1994 (see Appendix 1, Table 3).

The Programmes of Study in the National Curriculum include brief references to teaching the History of Science and the Nature of Science. (See final section.)

b) Scotland

From ages 5 to 12, most schools teach science as part of environmental studies. Integrated science is taught from ages 12 to 14, after which separate sciences are available to students studying the Standard Grade at credit and general levels. Students can, however, opt for a more general course which includes elements of biology, chemistry and physics.

c) Northern Ireland

All schools must offer the Single and Double award science courses for Key Stage 4 (up to 16 years). Many schools, particularly grammar schools, offer the three separate sciences, physics, chemistry and biology as an alternative.

1.3 Realistic data on the above

England and Wales

It has been reported (see Appendix 1, Table 4) that during the academic year 1991-1992, pupils in years 7 to 9 spent, on average, only 11% of curriculum time on science, compared to the 12.5% required, and at Key Stage 4 (year 10 and 11) pupils spent 13% on Double Award and 8% on Single Award science. By contrast, a report by government inspectors a year later, looking at a sample of over 300 schools in the fourth year of the National Curriculum, suggested that in general schools were indeed spending the required 20% of curriculum time on Double Award science, and 10% on Single Award science.

The number of pupils taking separate subject sciences at GCSE has plummeted by 67% over the four-year period from 1989 to 1992 as a result of the implementation of the National Curriculum. The number of pupils taking Double Award science to GCSE more than doubled between 1990 and 1992 (see

Appendix 1, Table 5), whereas the number taking the Single Award dropped by 17% (accompanied by a 4% cohort reduction in GCSE entries).

1.4 Recommended learning activities

a) England and Wales

Despite a rhetoric which denies giving instructions on how subjects are to be taught, indications are set out in the official documents. The Science National Curriculum includes within its structure an Attainment Target (AT1 - see Appendix 2) which is exclusively practical and investigative work. At Key Stage 1 and 2 (ages 5 to 11), it is recommended that half the curriculum time for science be devoted to practical work. This reduces to 25% at Key Stages 3 and 4.

Britain has a long tradition of pupil practical work but there is doubt as to how far AT1 (Sc1) on scientific investigations has increased this. The requirement to assess the pupils' investigations in considerable detail set out in statements of attainment which are not clear in their progression from one level to the next has made this task difficult. However AT1 has certainly changed the nature of the practical work carried out in schools from the 'recipe verification' of known principles, to investigations which tax the pupils' own skills and knowledge.

Programmes of Study currently within the National Curriculum orders are statutory and specify a variety of activities which pupils must experience. These include demonstrations and practical work. It is also recommended that students at all Key Stages should have experience of field work, particularly for Attainment Target 2 - Life and Living Processes. (See Appendix 4 for a summary of Programmes of Study.) These are likely to change in the pending review of the National Curriculum.

b) Scotland

The guidelines for 5-14 Environmental Studies include Programmes of Study which suggest more detailed strategies for delivering the recommended integrated science course than the English version. These include planning, approaches to learning, cross-curricular links and classroom management. (See Appendix 4.)

c) Northern Ireland

The science Area of Study in the curriculum includes a number of criteria which students up to Key Stage 4 are expected to cover. These include how scientific and technological ideas have developed over time, and an understanding of the role of information technology. (See Appendix 4.)

1.5 Mandatory tests and examinations

a) England and Wales

National Assessment Tasks (NATs), formerly known as Standard Assessment Tasks (SATs) are compulsory at the end of Key Stages 2 and 3 (ages 11 and 14) in the core subjects, which include science. The format of these tests has been altered substantially since their inception in 1991, and they may change again as a result of the latest curriculum review (Dearing, 1993 - see Appendix 3). Teachers' trade union action has prevented the administration of these tests for the past two years (see final section).

The General Certificate of Secondary Education (GCSE) is taken by 90% of students at 16 years. This is administered by a series of independent examination boards from whom the schools are allowed a free choice. Examination papers are differentiated as basic (or foundation - levels 3-6), central (or intermediate - levels 5-7) and further (or higher - levels 7-10) reflecting ranges of attainment within the National Curriculum levels. These are likely to change as a result of the pending review of the National Curriculum. Assessment of Attainment Target 1 (AT1) practical work is carried out by teachers and externally moderated by examination boards.

The assessment of Key Stage 4 is accredited through the GCSE which has a seven grade pass structure from A to G, plus the starred A grade (A*) for excellence. Students hoping to go on to further education in science - either Advanced level or vocational courses - are usually expected to achieve GCSE Double Award science at grade C or above, plus at least three GCSEs in other subjects, two of which have to be English and mathematics. The GCSE science Single Award is not considered to be sufficient for A-level entry due to its limited science content.

All school leavers (at 16 years) are issued with a National Record of Achievement document which includes all achievements in and out of school, some of which may not be tested by examination.

The General Certificate of Education (GCE), Advanced Supplementary (AS) and Advanced (A) level examinations follow two-year post-16 courses (years 12 and

13), and are usually taken in just three subjects, e.g. physics, chemistry and biology.

Over half the entrants to first degree courses at higher education institutes hold three A-levels, with 15% holding two A-levels (the remainder of higher education entrants hold professional or vocational qualifications - see Appendix 1, Table 6).

Conditional offers for higher education places are usually made to A-level candidates prior to the examinations. The grades required depend largely upon the course pursued; popular and/or academically demanding courses such as medicine and veterinary science often require high grades (such as three A grades, or two A and one B grades). Less popular courses, often in the pure sciences, require three grade C passes, and sometimes lower. Low take-up numbers for pure science courses often allows A-level candidates with lower grades access through the 'clearing house scheme' after results are published. The clearing house scheme provides details of courses at institutions throughout the country which still have places available after allocation of places to those students who achieved the required grades.

The science General National Vocational Qualification (GNVQ) is currently in its pilot year, and offers an alternative to the GCE A-level courses. It is broadly equivalent to two A-levels, and covers all three science subjects (physics, chemistry and biology, with generally more chemistry and biology content than physics) in less depth than A-level with emphasis on vocational rather than theoretical content. The role of GNVQs as a route to higher education is currently the subject of debate.

b) Scotland

There is a single examination board in Scotland (SEB) which administers the Scottish Certificate of Education (SCE) Standard and Higher grade examinations. Standard Grade examination papers are set at three levels; foundation, general and credit. Science is offered in single subjects - physics, chemistry and biology - at the credit and general levels only and in integrated science at all three levels.

Assessment of the SCE Standard grade has two components, a written examination taken at 16 years (end of S4) and internal assessment of practical work by teachers.

SCE Highers are taken post-16 in biology, chemistry, physics and human biology. Students may thereafter study the Certificate of Sixth Year Studies (CSYS) in biology, chemistry and physics. Highers allow access to higher education, with the majority of students holding three or more Highers.

The General Scottish Vocational Qualification (GSVQ) in science is being piloted this year, and will offer an alternative post-16 course. The GSVQ as a route to higher education is still under discussion.

c) Northern Ireland

Statutory assessment at the end of each of the Key Stages (ages 7, 11 and 14) is currently being introduced. These assessments are based on both teacher assessment and Common Assessment Instruments (CAI) tests.

Students at age 11 were selected for grammar school by performance on verbal reasoning tests. These have been being replaced by the Key Stage 2 assessments.

The GCSE and vocational courses in Northern Ireland are very similar to those in England and Wales.

1.6 New trends and reforms underway

a) England and Wales

The National Curriculum has undergone one major change since its inception and has recently been reviewed yet again. The latest modifications are stated in full in Appendix 3. Briefly, these include a reduction in science content, an associated reduction in recommended curriculum time, and changes in the ten-level accreditation structure. The latest review also recommends that no further changes should occur for at least five years following the current amendments, due to be in place by 1995.

b) Scotland

The guidelines for the non-statutory environmental studies area of the curriculum were issued in final form in April 1993. Schools are in the process of adopting these guidelines.

A revision of the upper secondary curriculum (post-16) is currently taking place. This reform, the Higher Still Development Programme, will be introduced from the 1997-98 session.

c) Northern Ireland

A review of the science curriculum is currently being undertaken, looking particularly at the Programmes of Study for Key Stages 1 and 2 (7 and 11 years). The main problem being addressed is the breadth and depth of content of the curriculum, with a view to substantial reduction. The recommendations are due to be published later this year.

1.7 Decision-making authority for above

a) England and Wales

Monitoring and review of the National Curriculum is implemented centrally by the School Curriculum and Assessment Authority. It comes under the government's Department for Education.

Monitoring and review of vocational qualifications is implemented by the Department for Education together with the Department of Employment through the National Council for Vocational Qualifications.

b) Scotland

Monitoring and review of the curriculum is implemented centrally by the Scottish Regional and Island education authorities through the Scottish Office Education Department.

Vocational education is monitored by the Scottish Vocational Education Council (SCOTVEC).

c) Northern Ireland

The Northern Ireland Council for Curriculum and Examinations and Assessment (NICCEA) is being introduced this year, replacing the Northern Ireland Curriculum Council (NICC). This central body will be responsible for both implementation and assessment of the common curriculum.

2. How is science delivered?

2.1 Organisation and authority

a) England and Wales

The central government department responsible for education in general in England and Wales is the Department for Education (DFE) (formerly known as the Department of Education and Science). It is headed by the Secretary of State for Education, a cabinet minister. The DFE is staffed by over 2000 people who may remain in post when the Secretary of State, or the government, is changed, but may move to another department when civil service administration demands this.

Many new initiatives during the last decade have arisen from the government's Employment Department, including the Training and Vocational Education Initiative (TVEI) which provides grants for programmes of technical and vocational education for 14 to 18 year-olds in schools and colleges. The recent introduction of General National Vocational Qualifications (GNVQs) is also being closely monitored by the Employment Department.

Quality assessment of schools is carried out for the government by teams of inspectors employed by the Office for Standards in Education. Inspecting teams may also include briefly trained non-specialists who bring in other skills.

The Welsh Office Education Department is responsible for schools and further and higher education. All other areas of educational management, including teachers' pay and employment, remain the responsibility of the DFE.

England is divided into 109 Local Education Authorities (LEAs) and Wales has eight. These have responsibilities for the schools in their area, but remain under the control of the DFE. The LEAs are subsidiaries of local councils, and function through a committee of elected councillors (representing political parties). Although the committee members hold ultimate authority, Chief Education Officers and their Science Advisors (or Inspectors), who are employed by the LEA and remain in post when the committees change, are influential.

The Education Reform Act of 1988 dramatically diminished the responsibilities and funding powers of the LEAs in two ways. The first required them to delegate certain responsibilities to the governing bodies of schools and colleges. Governing bodies are made up from elected members, such as parents, teachers, and other individuals, and now have delegated responsibilities including management of the budget, the setting of spending priorities, and the appointment of staff. This scheme, which allows governors to manage schools, is known as the Local Management of Schools (LMS).

Secondly, a scheme was introduced by the Act which allows schools to 'opt-out' of local control and receive their own funding directly from the DFE through the newly formed Funding Agency for Schools, effectively bypassing local (LEA) control. These schools acquire Grant Maintained status (GMS) and are said to be self-governing. Only 4% of English schools are currently self-governing.

Independent schools are usually funded directly by fee paying students. City Technology Colleges have been recently established and are charitable companies limited by guarantee and are funded by government together with local industry.

b) Scotland

The central government department responsible for education in Scotland is the Scottish Office Education Department.

At local level, Scotland has nine regional and three islands area education authorities (EAs). There have been no changes in their responsibilities similar to those in England and Wales.

c) Northern Ireland

The central government department responsible for education in Northern Ireland is the Department of Education Northern Ireland (DENI).

At local level, there are five Education and Library Boards which are appointed centrally by the DENI and which administer schools and further education.

All schools are managed by boards of governors, but funding of these schools depends upon their status as either controlled (funded by Education and Library Boards), voluntary maintained (funded partly by DENI and partly by Education and Library Boards) or voluntary non-maintained (partly DENI funded and partly by fees).

2.2 Resources and funding

a) Funding

Government spending on education in general is about 5% of the gross domestic product (around £33 billion in 1993). Nearly two-thirds of the education expenditure in the UK is allocated to local authorities in England, 8% to Scotland and 4% to Wales.

Around 70% of the expenditure within local authorities is for teaching staff. Other staff, which include administrative and non-teaching support staff, take up around 6% in schools and 15% in colleges. Of the remaining expenditure, some 4% is allocated to books and resources, and 15% to buildings and premises.

b) Resources for science in school

1. Accommodation

Primary schools have recently been required to improve their provision for the teaching of science as science became a compulsory subject for all pupils. These requirements included sufficient worktop space, storage areas, running water and electrical points. In a recent report by the Office for Standards in Education four years into the National Curriculum, only two-thirds of primary schools were found to have suitable accommodation for teaching science (OFSTED, 1993). Additionally, few schools were able to provide the equipment required for pupils to reach the higher levels of Key Stage 2 in the National Curriculum (see Appendix 2).

In secondary schools, it is expected that laboratories should be provided for all pupils to provide access to the Double Award science courses. These should be suitably furnished with sufficient bench space, running water, gas and electrical supplies, fume cupboards and storage provision. Generally two or three laboratories are served by one Preparation Room, with added storage and work space for laboratory technicians. (These are generally poorly qualified and on low pay. They are often married women with children of school age, who may gain knowledge and qualifications on the job).

Inspectors found that just over three-quarters of schools had sufficient laboratories for the majority of science lessons, although some science lessons were still taught in classrooms. A small percentage of schools were prevented from allowing some pupils to take the Double Award science course because of a shortage of laboratories.

2. Equipment

Most primary schools were seriously under-resourced in terms of science equipment at the introduction of the National Curriculum. Four years on, government inspectors report that only one-fifth of primary schools have a good supply of equipment and resources, with a further 55% having resources just sufficient for a few children in each class to work with at any moment in time (OFSTED, 1993).

Secondary schools are expected to provide sufficient equipment for all students to have access to all levels of the National Curriculum. This includes major items such as oscilloscopes and good quality microscopes. The inspectors found that over 80% of schools had satisfactory equipment, although some schools have insufficient funding to allow for maintenance of adequate quantities of equipment. Large equipment, such as balances and microscopes, could often not be bought or replaced because of the limits of funding allocations.

3. Information Technology

Information Technology is a cross-curricular subject in the National Curriculum to which science is expected to contribute significantly. Schools are expected to allow science students access to IT equipment within the laboratory. However, inspectors found that only half of schools have sufficient computer equipment for IT, and that in schools with IT equipment it is rarely used effectively.

4. Text-books and worksheets

Schools are allowed to decide which text-books they buy from a considerable range of material commercially available. The recent rapid and substantial changes in the National Curriculum requirements for science has prevented many schools investing in sets of text-books until there is some stability in the curriculum content.

Inspectors reported that there were generally sufficient text-books for use in class, but only one-fifth of schools allowed pupils personal copies for use at home. This was either due to lack of funding or uncertainty about the future of the curriculum. Many schools have developed their own worksheets and booklets, and issue these for use in class and at home in the place of text-books.

These schools re-allocate funds for books to reprographics for production of these resources.

2.3 Methods of teaching

a) Primary Schools

Science in primary school was until quite recently often taught through multidisciplinary projects, or through cross-curricular topics and themes. The majority of teaching for all subjects in primary school is in small groups (DES, 1992), with less whole-class teaching. A recent report by a leading HMI suggests, however, that whereas small group investigative work is a key element in science learning when well supported by the teacher, groups of pupils working on different tasks in the same classroom are often denied sufficient teacher attention for effective learning (Gould, 1994). This reflects a continuing debate on whether teaching at primary level should have a whole-class, or child-centred, focus.

The Department for Education recommends that science teaching should incorporate a balance of activities including reading, writing, talk, collaborative activity and practical work. There is also pressure to move from topic work carried out by groups taking on different aspects, to specialised subject teaching to the whole class. This is particularly relevant to science in which few primary teachers are well qualified.

b) Secondary Schools

Science teaching in secondary school also features small group work, but with whole class teaching much more prevalent.

OFSTED suggests that the best science teaching in secondary schools combines teacher exposition, pupil-based activity and teacher questioning. When explaining scientific concepts as a whole class activity, teachers often make use of audiovisual aids, prepared overhead projection slides, and practical demonstrations, as well as the traditional jotting of key words and phrases on the chalk board. Such exposition often introduces investigative work and teachers are encouraged to ensure the purpose of the practical work is clear, and that the key scientific concepts are in place. This latter requirement is of particular importance for the assessment of the science Attainment Target 1 (see Appendix 2 and section 1.4). The effective use of questions by teachers has been well researched. OFSTED suggests that teacher questioning has three positive outcomes; to encourage a relationship with the work, to stimulate thinking and to monitor understanding (Gould, 1994). The Department for Education also recommends that all students at all Key Stages should have experience of field work (see section 1.4).

The lecture mode of teaching is rare in lower secondary school, but tends to be a significant part of teaching at A-level, together with some practical work (more in chemistry and physics than biology). Post-16 pupils are also often encouraged to work alone on project work or from text-books, which many find challenging due to the dramatic change from the teaching style of the lower secondary school.

A-level biology pupils often participate in field courses which usually take place over several days at a recognised field or environmental centre. However, the study of ecology at A-level does not necessarily have to take place in the field.

2.4 Sources of pedagogic innovation

Teachers are expected to decide for themselves on the way in which science is delivered in their own classrooms (see section 1.4). The majority of staff in teacher training institutes, including university departments of education, have taught in schools, so that innovations which originate there are likewise informed by classroom practice.

The Association of Science Education is an organisation run by science teachers which publishes several key journals (e.g. School Science Review, Primary Science Review, Education in Science) which are designed to introduce teachers to new and different ways of teaching science. Over 20,000 science teachers are members of this association (around two-thirds of currently practising science teachers). The secondary science journal is currently sent to 16,500 members, some of which are institutions, while around 6,000 members receive the primary science journal.

Journals of research into science teaching are also published by the education sections of the Institutes of Physics and Biology and the Royal Society of Chemistry. These also contain tips on teaching, using new equipment and reviews of new text-books. Some secondary science teachers subscribe to these, but they are more commonly to be found and used in university departments of education.

3. Going beyond school

3.1 Use of out-of school resources

Schools in the UK make good use of several major venues for enhancing the teaching of science in school. These include the Science Museum (which includes the Launch Pad and Flight Lab hands-on science sections), the Natural History Museum (both in London), the Exploratory (in Bristol) and the Planetarium (London). Last year, over 200,000 British school children visited the Science Museum (there were also 38,000 visits by school children from overseas) and around 50,000 school children went through the Exploratory.

Each Local Education Authority (LEA) holds a list of recognised venues for school visits including field and environmental centres, hands-on science centres, museums and industries.

Primary schools generally make more use of out-of-school visits than secondary schools. Fifty-five percent of visits to the Science Museum last year were made by children of year 7 (11 years) and below. More visits were made by pupils aged 8 to 11 (40%) than any other age group (see Table 7 in Appendix 1 for details of visits by age group and Key Stage). However, longer stay trips, such as at LEA-held field centres, which tend to be well away from the majority of schools (for example, in established national parks such as the Lake District and Snowdonia) are made more by secondary schools. LEA-held field centres are usually well used, often to such an extent that schools have to book for weekend and week-long visits some months in advance.

3.2 Consideration of public science-based issues within lessons

a) Science, Technology and Society (STS) (see also final section)

Within the current National Curriculum orders, the Programmes of Study indicate that pupils should be aware of issues such as genetic engineering (AT2), society's use of energy resources (AT4), and manufacturing processes (AT3) (see Appendix 2 for full details of the Programmes of Study). These, however, are to be found only in the higher levels of the National Curriculum (8 and above) and may not be taught to the majority of average ability pupils.

There are GCSE and AS level examination options in STS available for pupils. The uptake of these courses is relatively small comprising less than 4% of the GCSE science entries and around 15% of AS science entries.

The Association for Science Education (ASE) produce a series of teaching packs for pupils (SATIS) at all Key Stages, and at A-level, which teachers are able to use to supplement their teaching. These are related to Statements of Attainment in the National Curriculum.

b) Health and sex education

The Education Act 1988 required that all pupils should receive health education in school. More recently, the 1993 Education Act required that from September 1994 all pupils in maintained secondary schools, and some pupils in primary schools, should also receive sex education, including information on HIV and AIDS. This is not necessarily the responsibility of science teachers; it is often taught within Personal and Social Education (PSE).

The Health Education Authority, with support from the Department for Education, is currently coordinating the UK involvement in the European Network of Health Promoting Schools project, which is an initiative of the World Health Organisation, the Council of Europe and the European Community intended to make health education a whole school approach.

3.3 Science education and vocational training

Three pathways for science education have been identified in a recent review of the National Curriculum; academic, vocational and occupational. Academic education is offered in schools through the GCSE and GCE A- and AS-levels. Vocational education is now being introduced in science through the new science General National Vocational Qualification (GNVQ). This is currently being piloted in Further Education colleges and schools.

The GNVQ Foundation and Intermediate courses are all recent and are currently under review. The GNVQ (Advanced) course is for post-16 pupils, offered as an alternative to A-level, and equivalent to two A-level qualifications.

All three courses are designed to provide a broad science base in all three subjects (chemistry, biology and physics) - although critics have suggested that the course is currently lacking in physics content - but at a less theoretical level than A-level, and with far more emphasis on vocational science, such as in medicine, manufacturing and industry. These courses also covers core skills such as Mathematics (The Application of Number), English (Communication Skills) and Information Technology. This is an innovation in post-16 science courses which may possibly influence the future development of A-level programmes. (Full details of the structure of the GNVQ courses are in Appendix 4.)

Scotland is also developing vocational courses in parallel with those being developed in England and Wales. These are known as the General Scottish Vocational Qualifications (GSVQ) and are also in their early stages.

Work placements

Many students have the opportunity for a work experience in school time in year 11 and post-16 years. This is arranged and supervised by schools. Students may go for a two or three week period in local industry or commerce and receive credit for their work in their Record of Achievement.

In 1992, 92% of secondary schools and 56% of primary schools had links with local businesses (DFE, 1993). Over 90% of secondary school final year students (year 11) were involved in work experience placements, and 51% of the schools reported that this had contributed to assessed GCSE course work.

Rural schools often have difficulty finding a sufficient number of suitable work placements for their students. It is this difficulty which has prevented the National Council for Vocational Qualifications (NCVQ) from making work experience a mandatory aspect of GNVQ science courses.

3.4 Science clubs and cultural associations

In-school science clubs, organised and run by teachers outside school hours (after school and at lunchtime), have been a successful method of enhancing science education and offering enthusiastic students access to aspects of science not often available in the classroom. However, the pressures of implementing a changing curriculum, with its associated assessment requirements, have forced many teachers to drop such out-of-school commitments, and such clubs are now less common in maintained schools.

There are external incentive awards available for science students who work with their teachers on science projects out of school time. These include the CREST (Creativity in Science and Technology) Awards, which offer bronze, silver and gold awards to individuals and groups of students who produce work on an approved science or technology project. The British Association for Young Scientists (BAYS) also encourages secondary school students to take part in science fairs and events designed to promote interest in science. The Times Educational Supplement (TES) newspaper sponsors awards in environmental science education within the same framework as CREST. Industry often sponsors science competitions; last year Nuclear Electric sponsored the Science Challenge for students from 9 to 13 years. Other organisations such as the Chemistry Club, the Institute of Biology, the Institute of Physics and the Royal Society of Chemistry also sponsor events designed to entice secondary school students into science-based careers.

4. Students' achievement vs. society demands

4.1 Results in IEA and national critiques

Measurements of achievement in schools

One of the stated objectives of the 1988 Education Act was to provide more choice for parents. Previously, choice among maintained schools was limited not only by the location of the parental home, but also by LEA policy. This was designed to prevent one state school from becoming more elitist or more disruptive than its neighbours. Intake was therefore 'managed' to ensure that schools had a rough parity of pupil ability. LEAs are no longer allowed to do this as schools arrange their own intake of pupils.

Of course the 'choice' of paying fees for your child's education still remains and it is a measure, perhaps, of the public concern about standards in education that the proportion of pupils attending these schools has been rising.

Maintained schools have been required to publish their examination results for public scrutiny for over ten years. However, a recent education bill has placed more emphasis on comparison of results between schools by means of result 'league tables'. Parents are encouraged to make use of these comparisons when selecting secondary schools.

The government states that such performance tables "increase public awareness of the quality of the education provided by the schools concerned and the educational standards achieved in those schools". Hence, by introducing an element of competitiveness between schools, the government hopes to raise standards.

This has led to concern that a table of raw results does not take into account differences in intake, and is misleading (National Commission on Education, 1992). The term 'value added' has been used to determine how well schools are able to improve upon the qualities students bring to secondary school from their primary years. In order to determine the added value achieved by schools, it is necessary to take into account the intake factors which are not reflected by examination results alone. These include gender, ability at 12 years, family background and the family background of the other school students (reflecting the general social status of the catchment area). It is generally accepted than only when schools are able to report their 'value added' factor, rather than how many students achieved GCSE and A-level passes, will fair comparisons be made.

4.2 Public or political concerns about educational standards

A recent government White Paper (HMSO, 1994), dedicated to ensuring that Britain remains competitive in the world market place, includes a section on education and training. Within this, the government has identified several reforms intended to improve education and training through school and beyond. These reforms are listed in full in Appendix 5, but include more opportunities for vocational education for pre-16 year-olds (through GNVQs) and the provision of work experience placements for all 14 and 15 year olds.

The National Advisory Council for Education and Training Targets (NACETT) is devoted to setting and monitoring education targets for schools. Foundation Target 1 has been set for 1997 for all schools and states that "80% of young people should obtain five A to C passes at GCSE, an intermediate GNVQ or an NVQ (National Vocational Qualification) at level 2". NACETT reduced this target slightly at a meeting earlier this year to four GCSE passes, and reported that last year 61% of young people, up to and including age 19, had met the original target. This reflected a 4.3% increase on the 1992 results.

The Department for Education encouraged schools to take part in the Third International Mathematics and Science Survey (TIMSS) which is intended to identify variations between countries in both curricula and student attainments in mathematics and science.

4.3 Suggested reforms

The National Curriculum has recently been the subject of a major review. This was prompted by complaints from teachers about the time taken to cover the National Curriculum. Teachers were invited to write to Sir Ron Dearing who headed up the review committee and these do seem to form the basis of the proposed changes (see final section). These reforms are listed in Appendix 4.

5. Pupil interest and motivations

5.1 Generally by age and gender

It is generally recognised that primary school children, boys and girls, enjoy science and are enthusiastic in their learning. There appears to be a natural propensity for discovery and exploration of the world in this age range, and the use by primary school teachers of project work and experiment probably encourages this. However, this enthusiasm appears to diminish rapidly during secondary school, and data suggests that the majority of students entering Key Stage 4 find science 'boring' and 'difficult'.

This decrease in motivation appears to correlate with age and the time spent in science lessons. Opinions as to the reasons for this change in motivation differ, but it needs to be observed that a similar effect is to be found in most school subjects, although possibly less pronounced than in science. While practical work may retain its appeal for boys, it is less effective with older girls. The increase in the mathematical component of the work may contribute to the decrease in student motivation.

5.2 By type of science or topic by age/gender

Gender studies indicate that generally secondary school age boys find physics more interesting than girls do, and that they may be more able to grasp physics concepts. However, the introduction of compulsory science of all complexions has shown that girls may even out-perform boys in science at Key Stage 4 when the option to choose is removed (see next section). Recent figures still show that girls tend to prefer biological sciences and have a greater interest in environmental issues.

5.3 Options for choice within science

Since the 1988 Education Act made science compulsory for all up to 16 years, there has been little opportunity for students to make science choices. One of the main reasons for introducing science in the National Curriculum as a compulsory subject was to counteract the problem of girls opting out of science - particularly physics - courses at age 14 (see section 1.1). As a result, girls are generally achieving higher grades and a greater number of passes in science GCSE (Double award, Single Award and separate subjects) than boys, although more boys are opting for A-level courses in physics and chemistry and are more likely to pursue an undergraduate course in science.

GCSE entries in the separate sciences have indicated in previous years that over twice as many boys enter for physics than girls, 30% more boys take chemistry than girls, and 20% more girls enter for biology (see Table 5.3, Appendix 1). Of those girls entering for physics GCSE, however, 74% achieve grade A to C, compared with 69% of boys, with over twice the number of boys scoring grades D to G than girls. This supports the general view that only the more able girls are prepared to face the bias against females taking physics. The National Curriculum requirements should result in a more equal representation of males and females entering the separate sciences.

5.4 Pupils' perspectives on the value of science

Children tend to hold an image of scientists as male, bespectacled, bald and absent-minded. This cartoon imagery is often accompanied by very vague, and often inaccurate, impressions about science, the role of scientists, and the contribution science makes to the world (Solomon et al, 1993).

Data indicates that male school leavers are far more likely to pursue a career in science through a first degree course. Females generally take science A-level courses as a route to careers such as nursing and child care. Males are far more likely to opt for two or more science A-level courses - taking two sciences plus mathematics, or three sciences - than females, who tend to take biology plus one other course in either science or the arts.

6. Training, status and morale of scientific teachers

6.1 Initial training

a) England and Wales

Since 1984, all secondary science teachers entering the profession must have a first degree in a science-related subject, or equivalent professional qualification, plus one year postgraduate training (PGCE). This provides Qualified Teacher Status. An exception to this was always available for graduates in shortage subjects such as physics, who might forgo the PGCE. An alternative route is provided by the Bachelor of Education (B.Ed.) degree, a four-year course which provides both further education (for secondary science teaching this might be in one or more sciences) and professional training in education and teaching.

In 1988, schools were allowed to employ teachers without teacher training on the licensed teacher scheme in order to counteract teacher shortages in science. The scheme allowed people with qualifications and experience outside education to train in schools for two years to achieve Qualified Teacher Status. This scheme also allows teachers trained overseas to qualify to teach in this country.

Until recently, postgraduate teacher training has been provided exclusively by higher education institutions in association with schools. In 1992, funding for university departments of education was drastically reduced. A year later the Department for Education issued a directive to allow schools to design and deliver their own postgraduate teacher training schemes (see final section).

Science in primary schools is taught mostly by non-specialist teachers with a general B.Ed. degree at primary level (two years further general education which only recently has needed to include science, plus two years professional education in teaching). Many schools employ Science Coordinators, some of whom may have a first degree in science; those who do not undergo a 20-day in-service training course in science.

b) Scotland

Students in Scotland undertake courses which lead to the award of a Teaching Qualification (Primary Education) or a Teaching Qualification (Secondary Education). Graduate students in both courses undertake one year full-time training. A non-graduate may undertake a four year vocational degree course leading to a B.Ed. and Primary Education qualification. All science secondary teachers are required to have a first degree, or equivalent qualification, before undertaking the further one year course. The percentage of secondary science teachers holding a four-year honours degree is high; 70% for chemists, 60% for biologists and 58% for physicists.

c) Northern Ireland

Teacher training in Northern Ireland is broadly comparable to that in England and Wales.

6.2 Decision-making authority for the above

Initial teacher training is the responsibility of four home government Departments. These are:

1) England - The Department for Education, London (known as the Department of Education and Science prior to 6 July 1992);

2) Wales - Welsh Office, Education Department;

3) Scotland - The Scottish Office Education Department, Edinburgh;

4) Northern Ireland - Department of Education, Northern Ireland, Belfast.

The English Department for Education has established a new statutory body this year - the Teacher Training Agency, which will be responsible for administering all central funds for initial teacher training in England (see final section).

The government also plans to extend the powers of the Higher Education Funding Council for Wales to enable it to fund teacher training in Welsh schools.

6.3 Continuing training

Teachers are entitled to at least four days in-service training (INSET) each year; these are generally days on which the school is closed, and the nature of this training is determined by the school's senior management. This time is not necessarily used for curriculum (science) training.

Secondment and sabbatical leave for further training is rarely available for teachers. INSET offered by the Local Education Authority can be available to selected teachers, usually on a one-day course basis. These courses are supported by the Grants for Educational Support and Training (GEST). Teachers often attend courses during weekends and holidays, for which no extra pay is currently awarded (the School Teachers' Review Body is attempting to challenge this).

Primary school science coordinators who take part in a 20-day GEST - funded course may be charged with disseminating what they have learnt to other teachers. Her Majesty's Inspectors (HMI) have noted that this dissemination of science knowledge rarely takes place. This may be due to lack of time and opportunity for in-school meetings devoted to this (OFSTED, 1993).

In 1992, 58% of teachers undertook some training when students were in school, with 85% attending INSET on days when the school was closed. 43% of teachers attended INSET after school hours and 20% attended weekend courses. In total over 90% of teachers attended some sort of training during the year.

Regular Science Department meetings in secondary schools have traditionally been used to introduce and discuss innovation but the pressure of new assessment methods has changed the topics discussed.

6.4 Number, teacher/pupil ratio, gender, age profile

In secondary schools in England and Wales, across all subjects and including science, one-third of practising teachers, usually the older ones, still do not hold a degree. There are currently over 33,000 full-time science teachers who have graduated in science. Of these around 33% of hold a first degree in biology, just over 20% in chemistry and 19% in physics. The remainder hold other science degrees such as geology, biomedical science, etc. (see Appendix 1, Table 8).

The relative shortage of physics and chemistry graduates in teaching has led to these subjects being taught by non-specialists. Although DFE incentives (such as cash bursaries for science trainee teachers) have encouraged more physics and chemistry graduate entrants to teacher training, about 7% of physics and chemistry teaching is still carried out by teachers with no qualifications in these subjects past A-level. Integrated and, to a lesser extent, modular science courses lead to a far higher proportion of non-specialist science teaching to GCSE (age 16 years). This hides the real level of non-specialist science teaching.

The majority of science teachers (about 40%) are now in the 40 to 49 year age range, with 10% under 30 years (see Table 9).

The pupil/teacher ratio for all schools (nursery, primary and secondary) for the year 1992-93 was 17.7/1. Within primary education, the average ratio is around 22/1; in secondary education the average ratio is 16/1.

The number of students in science classes can vary between 20 to 35 in years 1 to 9, and 15 to 25 in years 10 and 11. The numbers depend upon whether the classes are divided according to ability. (Average class size for primary education is 26.6 and for secondary education 20.9 based on all schools. These figures include small rural primary schools and secondary schools with small sixth form classes).

Twenty-two percent of primary classes have over 30 students as do 4.7% of secondary classes.

6.5 Drop-out rates, late entries, maternal leave

Nearly one-quarter of newly qualified teachers leave teaching within their first year. Within teaching as a whole, in 1993, four percent of teachers left primary education for a variety of reasons (including new career, age retirement and maternity leave) and the same percentage left secondary education. There are less teachers leaving the profession now than at any time in the last five years, probably due to the high rate of unemployment. There are also fewer teachers moving schools for experience or promotion, possibly due to the difficulties in selling and buying houses in the present economic conditions.

The majority of newly qualified teachers entering science teaching are between the ages of 20 to 30 years. Of these, over 60% have entered by taking a first degree immediately followed by a PGCE. Others have gained experience in industry or abroad before entering the PGCE course. About 20% of newly qualified science teachers are mature entrants (over the age of 30 years). This is a relatively new trend.

Women teachers are entitled to maternity leave under the government's guidelines for public sector workers. To qualify for maternity leave, which allows women to take up to 29 weeks from the birth of the child, teachers must have worked for more than 16 hours a week for two years prior to the seventh month of pregnancy. Whilst on leave, teachers are entitled to 90% of their average salary for six weeks, followed by 12 weeks of maternity pay, which is currently only £48 per week.

6.6 Status and salary

Improvements in teachers' salaries have brought them into line with the salaries achieved by similarly qualified individuals in other professions. The Teachers' Pay Review Body reported this year that the average earnings of male teachers are in line with those of all non-manual male workers. Female teachers, whose average salary is somewhat less than male teachers due to the fact that more male teachers hold positions of responsibility which command greater remuneration, have salaries well above average female non-manual workers.

Newly qualified teachers enter the profession on a 17-point pay scale, which currently ranges from £11,571 to £31,323 (known as the standard national scale, SNS). The starting point for a new teacher depends upon age, qualifications and previous experience, and is decided by the school governors, who are responsible for the appointing of teachers. A newly qualified teacher with a first degree and PGCE at the age of 22 years would enter at point 2 (£12,633 per annum). In comparison, data from the Association of Graduate Recruiters indicates that, in general, a 21 year-old second class honours graduate receives an average salary of £13,000. A mature entrant (over 30 years), with experience in industry or elsewhere and with similar qualifications could enter up to point 6 (£16,410).

Teachers on the SNS scale rise by one incremental point each year, which gives an increase in salary of around six per cent. This is in addition to the government's pay awards, which are generally in line with inflation.

Teachers who undertake additional responsibility are often awarded extra points on the scale, for example, taking on responsibility for health and safety in school could be rewarded with two pay points. Heads of science in secondary schools and primary school science co-ordinators are usually awarded extra allowances for responsibility, which can enhance the standard scale by 10% or more. (Table 10 shows the SNS salary scale for teachers, together with salary scales for careers requiring comparable qualifications.)

Teachers' salaries are not a discouragement to recruitment in science. Indeed they compare favourably with those of qualified laboratory scientists. Far more disincentive is provided by reports of violence in the classroom. Teachers' unions have reported on this factor and its sensational nature has been magnified, perhaps, by press coverage. Nevertheless school students are undoubtedly less controllable than in time past, schools suffer arson attacks more frequently, and teachers are more often injured by student attack. Science and science teachers might be thought to suffer from this kind of violence more often than other disciplines, but there is little evidence to support this conclusion. Student theft of science equipment is also at a high level.

The general status and morale of teachers is not high in Britain and the most probable reasons for this are government polemic (see final section) and student misbehaviour in class. The status of science teachers is no less or more than that of other teachers.

Nevertheless, at the present time, there is competition for most teaching jobs in the UK because of their almost unique stability of tenure. Apart from gross neglect of duty or sexual impropriety, it is still very difficult to dismiss teachers from their jobs, although this may change.

7. Equality of opportunity?

7.1 Different status of the schools

Within the numbers of primary and secondary schools, there are some religious schools which receive funding from both the Department for Education and their own religious organisations. Independent fee-paying schools with a religious denomination (especially Muslim) also exist.

Other independent schools can be divided into two categories; the very selective, high-status public schools, such as Eton, and those with a special philosophy for helping, for instance, slow learners, such as the Rudolf Steiner schools. In general, independent schools are regarded as providing 'the best opportunities' for education, as reflected by staff to pupil ratios (around 11/1 compared to 16/1 in state-maintained secondary schools), examination results and numbers of students who go on to higher education. These are followed by City Technical Colleges and religious schools. Reports suggest that it is the state-maintained inner city schools which are currently failing to provide education in general - and science education in particular - of a high enough standard (see section 7.2).

7.2 Regional differences

It has been recognised that in certain inner city schools, students may fail to receive adequate opportunities for science education. In a recent report by the Office for Standards in Education (OFSTED, 1993), inspectors noted that inner city area schools were generally displaying low standards in science, and students in these schools were taught the Single Award science course, rather than the recommended Double Award. This effectively precludes these students from following post-16 science courses and scientific careers.

OFSTED further reported that schools with a predominantly disadvantaged intake (the majority of which are inner city schools) generally lacked staff with a balance of science specialisms. The standard of physics teaching in these schools is particularly low, with reports of errors in printed materials and inaccurate teaching.

The nature of the low standards of science education in inner city schools arises from the failure to recruit and retain well-qualified staff, together with the levels of social deprivation and associated discipline problems. Students from inner city areas generally have little parental support for study, no books in the home, and few opportunities to develop skills outside school. Sporadic government attempts to inject cash into these areas has failed to solve these problems.

7.3 Immigration and migrant populations

It is not unusual to find high percentages of immigrant students in inner city schools. This makes severe language demands on teachers and, as a result, the science education of such students is often of a lower standard than in other schools. This problem is increased by the communication difficulties that many immigrant students may have.

However, there have been significant moves to ensure that all ethnic minority students have equal opportunities to learn and understand science. Two of the documents issued alongside the Science National Curriculum (Science for ages 5-16; Guidance to the Science National Curriculum), recommend the teaching of science with a multicultural perspective. The Association for Science Education have also issued a discussion paper on Science and Multicultural Education (ASE, 1989). The intention is to provide a curriculum in science that is both antiracist and multicultural, and that allows ethnic minority students to access and understand scientific concepts. Specialised support teaching and bilingual teaching materials are recommended for those with language difficulties, but are in short supply.

7.4 Special education for handicapped children?

In 1978, a Department for Education and science committee reported on the problems for educating students with special educational needs (SEN). These problems include physical disabilities, learning and communication difficulties, and social problems, and may affect up to one-fifth of all students.

The committee recommended that the majority of SEN students should be integrated into mainstream schools. Currently about 1% of the school population are in schools described as 'special', dedicated to SEN students (such as schools for the hearing or visually impaired). However, this percentage is falling as more SEN students are accepted - or are being forced - into mainstream schools.

The Science National Curriculum has been structured in a way that allows differentiation; content and activities which can be structured to the needs of individual students. Teachers of mixed ability classes, which include SEN students are expected to match learning materials and concepts to the ability of the student. Science is seen to be one of the few subjects that SEN students can succeed at - it is practical and can be related to everyday experience. Students who are unable to follow written or verbal instructions appear to gain from visual stimuli, such as practical scientific demonstrations. In practice, however, HMI have reported that often teachers fail to achieve differentiation in science teaching. Schemes of work which should show planned differences in work provision for able and less able groups were rarely found during inspections, and the needs of lower ability students were often neglected. The demands of integrating SEN students into science classrooms often presents more of a challenge than most teachers can easily meet without more specialist classroom help. Since the funding of LEA's has been so sharply reduced in favour of school funding (see section 2.1) provision for SEN pupils, classroom assistants and special resources, has declined.

8. Opinions about the conflict of influences on science education

The following two sections represent two different reflections on the present state of science education. Although these are unattributable, they represent the views of knowledgeable and influential sources.

8.1 Continuing conflict

At the top of the academic scientific tree in Great Britain stands the Royal Society. In 1983 it produced a report on Science Education in Schools, and in 1985 on the Public Understanding of Science. In the latter it stated that a good science education lies at the heart of a proper public understanding of science. It produces a response to all government papers on education.

The 1988 Education Act was conceived in the aftermath of a period of industrial action by teachers. When this strike was broken, the consultative body on pay awards (the Burnham Committee) was disbanded and the then Secretary of State for Education opened a bottle of champagne in Parliament to celebrate 'victory'! This signalled the beginning of a struggle between the government and the teachers.

The first draft of science in the National Curriculum was worked out by a Science Working Group headed by a professor of Science Education and comprising teachers and science educators. The curriculum was wide ranging, covering 22 different Attainment Targets including the Nature of Science and Science, Technology and Society. The latter was removed almost instantly by, it is rumoured, the Prime Minister's office. The Nature of Science, which included accounts and controversies from the history of science, only lasted until late 1993. (The latest review of the National Curriculum has seen the revival of the Nature of Science at Key Stages 3 and 4, but with a much reduced content compared to the original version.)

By this time the battle-lines had been drawn up somewhat differently. The government no longer looked to educationalists (from university departments of education) for advice and leadership; instead they relied upon a combination of parent power and industrial influence to help them defeat the power of Local Educational Authorities. Their public polemic proclaimed that power was being devolved to the schools and the parents; in practice central control by government was being very much strengthened. By 1993 the new Education Act gave the Secretary of State unprecedented power over the curriculum and the funding of schools.

The government attitude towards teachers has been equivocal. The whole system of testing pupils and publishing the results in 'league tables' accessible to parents, was supposed to bring 'market forces' to bear on the teachers through the parents' choice of schools. Secondary school teachers, however, have largely nullified the government's intentions by refusing to operate the tests to be taken at age 14.

The government approach to teachers has become more apparently conciliatory after this effective show of power. Initial teacher training, once the province of the universities, has been offered to the schools. The funding of university departments of education depends to large extent on teacher training so this move has dealt them a damaging blow. It is not clear to what extent hard-pressed school teachers are pleased by the offer to provide professional education, especially when a new governmental, not professional, body - the Teacher Training Agency - has been set up to oversee the work.

The third attempt to write a National Curriculum was put into the hands of a former senior civil servant who had also worked in private industry. His first step was to invite teachers to write in with their complaints and suggested remedies. Not surprisingly the result of this was a much slimmed down curriculum. The removal of technology from the compulsory core for age 14-16, and its change from a cultural/innovative subject to a craft work setting, in addition to the removal of the Nature of Science from the Attainment Targets (although still in the recommended Programmes of Study, suggests a 'back to basics' approach to science, as to much else in British education.

One point which indicates rather clearly the uncertain attitude of government towards teachers is the struggling General Teaching Council. This has been in embryonic existence for some four years, but with no government backing. It was to have been the professional body for school teachers, who are not civil servants in Britain as they are in other EC countries. It might also have taken over from the old Schools Council, disbanded in 1985, which was an influential and innovative body in terms of curriculum development.

Science has not been the major academic discipline in the personal education of any recent Education Ministers. This may make science education more or less vulnerable to ill-considered change. The retention of AT1 (Scientific Investigations) in the latest order was said to be against the wishes of the Education Minister for schools, but backed by at least one influential scientist. On the other hand professional historians have not always proved to be friends of school history, or ministers with literary leanings of English literature. A new generation of government ministers, brought up with compulsory science education in the National Curriculum, may change the locus of power for good or for ill.

8.2 A rushed innovation in need of overhaul

Basically we have just one version of the National Curriculum, which has only been tinkered with on two occasions but not basically changed. It was originally produced ahead of all the subject curricula in a period of just nine months, which was not enough to make a coherent document. It lacked then, and still lacks now, any proper rationale.

'Back to basics' may correctly describe the latest amendments to the Mathematics and English orders in the National Curriculum. In science the situation is slightly different. The emphasis is now on 'facts' rather than 'opinions'. This movement has been led by civil servants in the Department for

Education and has resulted in the removal of green issues from the science curriculum.

The other influence for change which is felt in the DFE, is the continued resistance of secondary teachers to student testing. In order, perhaps, to placate them, the syllabus has been slimmed down and made more manageable. So far no change in teacher attitude has been produced. The simplified Attainment Targets are fewer in number, but since each is longer and often composite, there is said to be little reduction in the time required for assessment in practice.

We need to start a full-scale debate on the aims of science, the key concepts, and how we can teach the different age-groups of students effectively. Only then will we be in a position to devise a coherently restructured National Curriculum.

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Appendix 1

Table 1: Number of students attending schools in England by type, 1992

School type	**Number of students (thousands)**
State-maintained primary	4089.5
State-maintained middle	185.9
State-maintained secondary comprehensive	2394.4
State-maintained secondary modern	104.6
State-maintained secondary grammar	110.4
State-maintained sixth form colleges	87.2
State-maintained technical	26.1
Self-governing secondary	105.8
State-maintained special schools	92.1
Non-maintained independent	566.7
Non-maintained special schools	5.8
Total	**7768.5**

Source: Adapted from Government Statistical Service Statistical Bulletin 18/93, Statistics of Schools in England, January 1992.

Table 2: Year group structure and nomenclature for schools in England, Wales, Scotland and Northern Ireland

Primary						**Age/years**			
Country	**4/5**	**5/6**	**6/7**	**7/8**	**8/9**	**9/10**	**10/1**	**11/12**	
England R	Y1	Y2	Y3	Y4	Y5	Y6	Y7		
Wales	R	Y1	Y2	Y3	Y4	Y5	Y6	Y7	
Scotland		P1	P2	P3		P4	P5	P6	P7
Northern Ireland	SY1	SY2	SY3	SY4	SY5	SY6	SY7	F1	
Secondary						**Age/years**			
Country	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**	**17/18**			
England	Y8	Y9	Y10	Y11	Y12	Y13			
Wales	Y8	Y9	Y10	Y11	Y12	Y13			
Scotland	S1	S2	S3	S4	S5	S6			
Northern Ireland	F2	F3	F4	F5	SY13	SY14			

Source: Adapted from Open University ES821 Study Guide, Science Education in the UK, Germany, Japan and the US (1993).

Key:

R : reception

Y : year

SY : school year (SY1-SY7 are also known as P1-P7

F : form (F1-F5=SY8-SY12)

Table 3: Percentage of maintained secondary schools offering named science subjects by year group, 1991/92

Percentage of schools					
	Year Group				
Subject	**7**	**8**	**9**	**10**	**11**
Combined science	98	97	91	---	---
Single award	---	---	---	51	55
Double award	---	---	---	87	83
Biology	2	3	10	13	17
Chemistry	2	3	11	14	16
Physics	2	3	11	13	16

Source: Government Statistical Service 1994, Statistical Bulletin 5/94, Curriculum Provision in Maintained Secondary Schools in England.

Table 4: Average percentage of curriculum time devoted to all science subjects by year group, 1991/92

Percentage of curriculum time					
	Year				
Subject	**7**	**8**	**9**	**10**	**11**
Combined science	11.1	11.4	11.2	----	----
Single award	----	----	----	8.6	8.0
Double award	----	----	----	13.	12.7
Biology	5.0	6.7	6.3	6.2	5.9
Chemistry	5.0	6.7	6.3	6.4	6.9
Physics	5.0	6.7	6.3	6.9	7.5

Source: Adapted from Government Statistical Service 1994, Statistical Bulletin 5/94, Curriculum Provision in Maintained Secondary Schools in England.

Table 5: GCSE entries for all science subjects for England and Wales from 1989 to 1992

Subject	1989	1990	1991	1992	Percentage change
Biology	225052	185155	126809	72960	- 67.6
Chemistry	197220	161321	117175	66797	- 66.2
Physics	224164	183829	125655	72155	- 67.8
Single award	----	114079	105194	94837	- 16.8
Double award	----	150161	321655	479633	+ 219.4
All subjects	4678701	4578336	4468046	4488337	- 4.1

(There are no results available for Double and Single award science for 1989)

Source: Government Statistical Service 1993, Statistics of Education Public Examinations GCSE and GCE 1992, Department for Education.

Table 6: Qualification on entry of first year students to first degree courses in England, Wales, Scotland and Northern Ireland

Numbers of students with qualifications (thousands)								
Type of institution	**3**	**A-Levels 2**	**1**	**Vocational ONC/HNC /HND**	**Prof qual**	**SCE highers**	**O/S**	**No**
England								
Universities	57.	3.8	1.	2.1	6.9	0.1	3.0	0
Polytechnics	25.	14.7	2.	13.5	8.0	0.2	3.2	3.4
Other institutions	7.4	7.1	1.	2.7	2.9	0.1	0.5	1.0
Wales								
Universities	5.1	0.7	0.	0.3	0.6	0		0.3
Polytechnics	0.5	0.3	0	0.3	0.1	0	0	0
Other institutions	0.5	0.8	0.	0.4	0.1	0	0	0
Scotland								
Universities	3.4	0.2	0.	0.7	1.2	0.5	0.7	0
Central	0.7	0.1	0	0	0	1.4	0	0
Colleges of education	0	0	0	0	0	1.4	0	0
Other institutions	0	0	0	0	0	0	0.2	0
Northern								
Universities	2.9	0.4	0.	0.1	1.0	0	0.4	0
Teacher training	0.2	0.1	0	0	0	0	0	0

Key: ONC : Ordinary National Certificate
HNC : Higher National Certificate
HND : Higher National Diploma
SCE : Scottish Certificate of Education
O/S : Overseas qualifications
No : No qualifications
Prof Qual : Professional qualifications usually awarded by professional bodies

Source: Government Statistical Service, Higher Education Statistics for the United Kingdom 1993, HMSO: London.

Table 7: Details of educational group visits to The Science Museum, London, during April 1994

Age/Key Stage	No. of groups	No. of visitors	% of total
0-4 years	3	67	0.27
5-7 years (KS1)	37	2233	8.86
8-11 years (KS2)	139	6633	26.33
12-14 years	131	6869	27.27
15-16 years	145	6541	25.97
17+ years	112	2848	11.31
Total	**567**	**25191**	**100.00**

Source: The Science Museum, Educational Group Visits - Stats Summary April 1994.

Table 8: Details of science teacher qualifications in primary and secondary schools in England, 1992

Type of qualification	Number of teachers with qualification		
	Men	Women	Total
First degree in biology	5215	4815	10030
First degree in chemistry	5474	2051	7525
First degree in physics	5104	1317	6421
First degree in other	7349	2374	9723
Certificate of education (no first degree in science)	3559	4145	7704
No degree or teaching qualification	1172	1135	2307

Source: Government Statistical Service Statistical Bulletin no. 24/93, Teachers' qualifications and deployment in maintained secondary schools in England 1992.

Table 9: Details of age distribution of full-time science teachers in English secondary schools, 1992

Subject	Age of teacher				Total (thousands
	Under 30	30-39	40-49	50+	
	(percentages)				
Biology	12	33	41	14	15.0
Chemistry	9	27	48	17	15.0
Physics	8	26	46	19	15.9
General	18	33	34	15	16.5
Other science	11	31	41	17	13.7

Source: Government Statistical Service, Statistical Bulletin 24/93, Teachers' qualifications and deployment in maintained secondary schools in England, 1992.

Table 10: Standard National Salary Scale for teachers, as from 1 April 1994, compared with other professions

Qualified teachers		Laboratory Scientists
Spine point	Salary (£)	Salary (£)
0	11,571	10,980
1	12,264	11,774
2	12,999	12,455
3	13,779	13,260
4	14,607	13,958
5	15,480	14,870
6	16,410	15,665
7	17,394	16,505
8	18,438	17,362
9	19,614	18,200
10	20,832	19,057
11	22,068	20,267
12	23,832	21,395
13	25,419	22,696
14	27,450	23,973
15	28,683	-----
16	29,976	-----
17	31,323	-----

Appendix 2

The Science National Curriculum for England and Wales

The curriculum is divided into four Attainment Targets (ATs):

1) Attainment Target 1: Scientific investigation

2) Attainment Target 2: Life and living processes

3) Attainment Target 3: Materials and their properties

4) Attainment Target 4: Physical processes

Within each AT there is a ten-level structure; each level is defined by a Statement of Attainment, which indicates the science content students should know or understand. Each Key Stage incorporates a number of levels:

- Key Stage 1: levels 1 - 3
- Key Stage 2: levels 2 - 5
- Key Stage 3: levels 3 - 7
- Key Stage 4: levels 4 - 10

Within each level, there may be 2, 3 or 4 strands which make up each Statement of Attainment. For example, level 3 of AT 2 (Life and living processes) states:

1) Pupils should know the basic life processes common to humans and other animals.

2) Pupils should know that human activity may produce changes in the environment that can affect plants and animals.

3) Pupils should know that green plants need light to stay alive and healthy.

When students have reached the level stated, they are accredited the level and the strand, e.g. AT 2 level 3(a).

Each Attainment Target is supported by a Programme of Study which provides teachers with statutory guidelines for the subject content and related activities. These are listed below. Teachers are expected to use the Programmes of Study as a basis for work schemes and lesson planning.

The Programmes of Study are sub-divided into sections, known as strands, and numbered (i) to (v). Within the Programmes of Study, these strands are identified separately. The strands are:

Attainment Target 1: Scientific Investigation

Pupils should develop the intellectual and practical skills which will allow them to explore and investigate the world of science and develop a fuller understanding of scientific phenomena, the nature of the theories explaining these, and the procedures of scientific investigation. This should take place through activities which require a progressively more systematic and quantified approach which develops and draws upon an increasing knowledge and understanding of science. The activities should encourage the ability to plan and carry out investigations in which pupils:

1) ask questions, predict and hypothesise;

2) observe, measure and manipulate variables;

3) interpret their results and evaluate scientific evidence.

Attainment Target 2: Life and living processes

Pupils should develop knowledge and understanding of:

1) life processes and the organisation of living things;

2) variation and the mechanisms of inheritance and evolution;

3) populations and human influences within ecosystems;

4) energy flows and cycles of matter within ecosystems.

Attainment Target 3: Materials and their properties

Pupils should develop knowledge and understanding of:

1) the properties, classification and structure of materials;

2) explanations of the properties of materials;

3) chemical changes;

4) the Earth and its atmosphere.

Attainment Target 4: Physical processes

Pupils should develop knowledge and understanding of:

1) electricity and magnetism;

2) energy resources and energy transfer;

3) forces and their effects;

4) light and sound;

5) the Earth's place in the Universe.

The National Curriculum has recently undergone a radical review, and as a result the content has been changed. Appendix 3 lists in full the details of these changes. Areas of the Programmes of Study which are affected by these changes are underlined. Italicised areas of the Programmes are non-statutory examples supporting the Statements of Attainment.

Programmes of Study

Attainment Target 1: Scientific investigation

Key Stage 1

Pupils should be encouraged to develop investigative skills and understanding of science in the context of explorations and investigations largely of the 'Do....', 'Describe which....' and 'Find a way to.....' type, involving problems with obvious key variables which are within their everyday experience.

These activities should:

- encourage pupils to use and develop their scientific knowledge and understanding;
- involve pupils and their teachers in promoting ideas and seeking solutions;
- promote at first hand the exploration of materials (living and non-living) and events;
- encourage an appreciation of the need for safe and careful actions;
- encourage the sorting, grouping and describing of materials and events in their immediate environment, using their senses and noting similarities and differences;

- encourage the use of non-standard measures, for example, hand-spans, and the use of standard measures;
- introduce the idea of a 'fair-test';
- develop an understanding of the purposes of recording results and so encourage systematic recording, using appropriate methods, including block graphs and frequency charts;
- encourage the interpretation of results;
- encourage pupils to question what they have done and suggest improvements.

Key Stage 2

Pupils should be encouraged to develop investigative skills and understanding of science through activities which:

- help them to use and develop scientific knowledge and understanding;
- encourage the raising and answering of questions;
- foster understanding and practice of safety and care;
- are within their everyday experience and provide opportunities to explore, with increasing precision;
- build on existing practical skills;
- require an increasingly systematic approach involving the identification and manipulation of key variables;
- involve the use of secondary sources as well as first-hand observations;
- include the use of computers and simple electronic devices, such as digital watches, in their experimental work.

These activities should:

- involve variables to be controlled in the development of 'fair tests';
- involve problems which can be solved qualitatively, but which increasingly allow for some quantification of the variable;
- encourage the formulation of testable hypotheses, drawing on their developing knowledge and understanding;

- develop skills of using equipment and measurement, encouraging them to make decisions about when, what and how to measure;
- encourage systematic listing and recording of data, for example, in frequency tables and bar charts;
- promote the search for patterns in data;
- foster the interpretation of data, and evaluation against the demands of the problem;
- involve the capture, transmission, storage and retrieval of information using computers and sensors;
- encourage pupils to appraise their investigations and suggest improvements to their methods.

Key Stage 3

Pupils should be encouraged to develop investigative skills and understanding of science through activities which:

- are set within their everyday experience and in wider contexts, and which require the deployment of their investigative skills and the use and development of scientific knowledge;
- use an increasingly systematic and safe approach;
- require them to plan and carry through investigations in which they may have to identify, describe and vary more than one key variable;
- require increasingly precise quantitative approaches to the measurement of key variables;
- require them to make strategic decisions about the number, range and accuracy of measurements;
- require them to select and use increasingly complex apparatus and instruments to enhance observations and measurements;
- encourage systematic recording using methods appropriate to the data and purpose of the activity;
- involve the use of secondary sources as well as first-hand observations;

- encourage the interpretation and evaluation of collected data, using progressively more specific statements related to the demands of the problem, using mathematical relationships where appropriate;
- encourage the search for patterns in data and the ability to make simple predictions based on findings;
- allow the appropriate use of circuits containing sensors activated by a variety of environmental factors such as temperature, light, moisture, tilt, pressure and magnetic field;
- offer opportunities to develop computer skills to store process and retrieve information and to control and collect data during experiments;
- offer opportunities to understand the limitations of scientific evidence and the provisional nature of proof;
- encourage them to appraise critically their investigation and suggest improvements to the methods.

Key Stage 4

Pupils should be encouraged to develop investigative skills and understanding of science through activities which:

- relate to their everyday experience and to new contexts, involving increasingly abstract concepts and the application and extension of scientific knowledge, understanding and skills, where pupils need to make decisions about the degree of precision and safe working required;
- promote invention and creativity;
- encourage detailed planning and evaluation in the light of findings;
- encourage the use of secondary sources;
- are increasingly complex because they involve derived and/or interacting variables;
- require key variables to be controlled or taken into account, and pupils to recognise that need;
- require them to generate theoretical models and to test them;
- may take place over a period of time and require sampling techniques;

- require accurate measurement, with identification and quantification of, and accounting for, experimental error and anomalous results;
- encourage the systematic recording and presentation of data using, as appropriate, a full range of forms, including graphs and mathematical relationships;
- encourage pattern searching in complex data and predictions requiring abstract reasoning;
- involve the critical evaluation of data;
- give opportunities to use information technology to gather and display data from experiments, to access and organise data relevant to their study of science, and to use programmable systems to control external electronic, electrical or mechanical devices;
- explore the nature of scientific evidence and proof but in addition they should also:

1) distinguish between claims and arguments based on scientific considerations and those which are not;

2) distinguish between generalisations and predictive theories;

3) study examples of scientific controversies and the ways in which scientific ideas change.

- encourage them to appraise critically their investigations including consideration of errors and suggest related improvements to their methods.

Attainment Target 2: Life and living processes

Key Stage 1

1) Pupils should find out about themselves and develop their ideas about how they grow, feed, move, use their senses and about the stages of human development. They should be introduced to the main parts of flowering plants and investigate what plants need to grow and reproduce. Pupils should be introduced to ideas about how they keep healthy through exercise, personal hygiene, diet, rest and personal safety; and to the role of drugs as medicines.

2) Pupils should consider similarities and differences between themselves and other pupils and understand that individuals are unique. They should have

opportunities, when possible through first-hand observation, to find out about a variety of animal and plant life and become aware that some life-forms became extinct a long time ago and others more recently. They should sort living things into broad groups according to similarities and differences using observable features. Over a period of time, pupils should take responsibility for the care of living things, maintaining their welfare by knowing about their needs and understanding the care required.

3) Pupils should study plants and animals in a variety of local habitats, for example, playing field, garden and pond. They should discuss how human activity produces local changes in their environment.

4) Drawing upon their study of living things in school and the local environment, they should be introduced to the idea that plants are the ultimate source of all food in the living world. They should investigate how far everyday waste products, for example, garden refuse, paper, plastic materials and cans decay naturally and use this knowledge to improve the appearance of their local environment.

Key Stage 2

1) Pupils should be introduced to the major organs and organ systems of mammals and flowering plants. They should explore some aspects of feeding, support, movement and behaviour in relation to themselves and other animals. They should explore ideas about the processes of breathing, circulation, growth and reproduction. They should investigate the factors that affect plant growth, for example, light intensity, temperature and amount of water. Pupils should study how microbes and lifestyle can affect health, and learn about factors that contribute to good health, including the defence systems of the body, diet, personal hygiene, safe handling of food, dental care and exercise. They should be introduced to the fact that while all medicines are drugs, not all drugs are medicines. They should begin to be aware of the harmful effect on health resulting from an abuse of tobacco, alcohol and other drugs.

2) Pupils should investigate and measure the similarities and differences between themselves, animals and plants and fossils. They should be introduced to how plants and animals can be preserved as fossils. They should have the opportunity to develop skills in identifying locally occurring species of animals and plants by observing structural features and making and using simple keys. They should be introduced to the idea that information is passed from one generation to the next.

3) Pupils should explore and investigate at least two different habitats and the animals and plants that live there. They should find out how animals and plants are suited to these habitats and how they are influenced by environmental conditions including seasonal and daily changes and measure these changes using a variety of instruments. They should develop an awareness and understanding of the necessity for sensitive collection and care of living things used as the subject of any study of the environment. They should study aspects of the local environment affected by human activity, for example, farming, industry, mining or quarrying and consider the benefits and detrimental effects of these activities. They should be made aware of the competition between living things and their need for food, shelter and a place to reproduce. They should study the effects of pollution on the survival of living things.

4) They should be introduced to the idea that green plants use energy from the sun to produce food and that food chains are a way of representing feeding relationships. They should investigate the key factors in the process of decay such as temperature, moisture, air and the role of microbes. They should build on their investigations of decay and consider the significant features of waste disposal procedures, for example, in sewage disposal and composting and the usefulness of any products.

Key Stage 3

1) Pupils should explore and investigate how flowering plants and mammals are normally organised at cellular and macroscopic levels. They should study life processes, feeding (including digestion and assimilation), respiration, removal of waste, movement, behaviour, growth, reproduction and sensitivity, particularly as they relate to human beings. They should investigate the requirements for photosynthesis in green plants, the resulting products (sugars, starch and oxygen) and the minerals required for healthy growth. They should study respiration, growth and sexual reproduction in plants. They should have opportunities to explore and investigate the uses of enzymes and microbes, for example, in the baking, brewing and dairy industries. Pupils should extend their study of the ways in which the healthy functioning of the human body may be affected by diet, lifestyle, bacteria and viruses (including Human Immunodeficiency Virus (HIV)), the abuse of solvents, tobacco, alcohol and other drugs, and how the body's natural defences may be enhanced by immunisation and medicines. They should study the human life cycle, including the physical and emotional changes that take place during adolescence, the physical and emotional factors necessary

for the well-being of human beings in the early stages of their development, and understand the need to have a responsible attitude to sexual behaviour.

2) Pupils should broaden their study of locally occurring plants and animals to other organisms and be introduced to the major taxonomic groups. They should have opportunities to group organisms on the basis of similarities and differences and to use keys to name organisms.They should measure and investigate variation between individuals in a range of living things, giving attention to their welfare. They should translate data into trends and norms and consider genetic and environmental causes of variation and extinction. They should study how information in the form of genes is passed on from one generation to the next. They should be introduced to the idea of selective breeding.

3) Pupils should study a variety of habitats at first hand and make use of secondary sources to investigate the range of seasonal and daily variation in physical factors, and the features of organisms which enable them to survive these changes. They should be introduced to the factors affecting the size of populations of organisms, including competition for resources and predation. They should study the effects of human activity, including food production and the exploitation of raw materials, on the purity of air and water and on the Earth's surface. They should come to appreciate that beneficial products and services need to be balanced against any harmful effects on the environment.

4) Pupils should be introduced to pyramids of numbers and biomass as ways of quantifying relationships within food chains. They should study the cycling of materials in biological communities and be introduced to the classification of waste products of human activities as biodegradable or non-biodegradable, and investigate ways of improving the local environment.

Key Stage 4

1) Pupils should extend their study of the major organs and organ systems and life processes. They should explore and investigate sensitivity, coordination and response, and should relate behaviour to survival and reproduction in plants and animals. They should investigate limiting factors in photosynthesis, and the use of photosynthetic products in plants. They should explore how the internal environments of plants and animals are maintained, including water relations, temperature control, defence mechanisms, solute balance, for example, sugars, carbon dioxide, urea, and the human embryonic environment. In the context of their study of the major human organs they should consider the factors associated

with a healthy lifestyle and examples of technologies used to promote, improve and sustain the quality of life. They should consider how hormones can be used to control and promote fertility, growth and development in plants and animals, and be aware of the implications of their use. Pupils should have opportunities to consider the effects of solvents, alcohol, tobacco and other drugs on the way the human body functions.

2) Pupils should use keys to assign organisms to their major groups and have opportunities to measure the differences between individuals. They should consider the interaction of genetic and environmental factors (including radiation) in variation. They should be introduced to the gene as a section of a DNA molecule and study how DNA is able to replicate itself and control protein synthesis by means of a base code. Using the concept of the gene, they should explore the basic principles of inheritance in plants and animals and their application in the understanding of how sex is determined in human beings and how some disease can be inherited. Using sources which give a range of perspectives, they should have the opportunity to consider the basic principle of genetic engineering, for example, in relation to drug and hormone production, as well as being aware of any ethical considerations that such production involves. They should consider the evidence for evolution and explore the ideas of variability and selection leading to evolution and selective breeding. They should consider the social, economic and ethical aspects of cloning and selective breeding.

3) Pupils should make a more detailed and quantitative study of a habitat, including the investigation of the abundance and distribution of common species, and ways in which they are adapted to their environment. They should explore factors affecting population size, including human populations. They should have opportunities, through fieldwork and other investigations, to consider current concerns about human activity leading to pollution and effects on the environment, including the use of fertilisers in agriculture, the exploitation of resources, and the disposal of waste products on the Earth, in its oceans and in the atmosphere. They should relate the environmental impact of human activity to the size of population, economic factors and industrial requirements. The work should encourage pupils to use their scientific knowledge, weigh evidence, and form balanced judgements about some of the major environmental issues facing society.

4) Pupils should consider energy transfer through an ecosystem and how photosynthesis initiates this process. They should consider how food production involves the management of ecosystems to improve the efficiency of energy transfer and how such management imposes a duty of care. They should explore cycling of the elements and biological materials in specific ecosystems, for example, seas, farms and market gardens, including the role of microbes and other living organisms in the cycling of carbon and nitrogen. They should relate their scientific knowledge to the impact of human activity on these cycles and ecosystems and to the disposal of waste materials.

Attainment Target 3: Materials and their properties

Key Stage 1

1) Pupils should collect and find similarities and differences between a variety of everyday materials. These should include natural and manufactured materials such as rocks, soil, air, water and other liquids, cooking ingredients and metallic objects. They should explore the properties of these materials referring, for example, to their shape, colour and texture, and consider some of their everyday uses. They should see how some can be changed by simple processes such as dissolving, squashing, pouring, bending and twisting.

2) -

3) Pupils should develop an awareness of which materials they are using are naturally occurring and which are manufactured. They should explore the effects of heating some everyday substances, for example, ice, water, wax and chocolate, in order to understand how heating and cooling bring about melting and solidifying. They should observe materials such as dough, wood and clay which change permanently on heating.

4) Pupils should observe and compare natural materials found in their locality, including rocks and soils. They should observe the effects of weathering in their locality.

Key Stage 2

1) Pupils should investigate a number of different everyday materials, grouping them according to their characteristics. Properties such as strength, hardness, flexibility, compressibility, mass ('weight'), volume and solubility should be investigated and related to everyday uses of the materials. Pupils should be given

opportunities to compare a range of solids, liquids and gases and recognise the properties which enable classification of materials in this way. Pupils should test the acidity and alkalinity of safe everyday solutions such as lemon juice using indicators which may be extracted from plants, such as red cabbage. Pupils should know about the dangers associated with the use of some everyday materials including hot oil, bleach, cleaning agents and other household materials. Experiments on dissolving and evaporation should lead to developing ideas about solutions and solubility. They should explore ways of separating and purifying mixtures such as muddy water, salty water and ink, by using evaporation, filtration and chromatography.

2) -

3) Pupils should explore the origins of a range of materials in order to appreciate that some occur naturally while many are made from raw materials. They should investigate the action of heat on everyday materials resulting in permanent change, these might include cooking activities and firing clay. Pupils should explore chemical changes in a number of everyday materials such as those which occur when mixing Plaster of Paris, mixing baking powder with vinegar and when iron rusts. They should recognise that combustion of fuel releases energy and produces waste products including gases.

4) Pupils should have the opportunity to make regular, quantitative observations and keep records of weather and the seasons of the year. This should lead to a consideration of the water cycle. Pupils should investigate natural materials (rocks, minerals, soils), sort them by simple criteria and relate them to their uses and origins. They should be aware of local distributions of some types of natural materials (sands, soils, rocks). They should observe, through fieldwork, how weather affects their surroundings, how sediment is produced and how soil develops. They should consider the major geological events which change the surface of the Earth and the evidence for these changes.

Key Stage 3

1) Pupils should have the opportunity to compare and study a range of physical properties, including density, thermal and electrical conductivity of metals. The materials could be man-made or naturally occurring, and should be studied in everyday uses. This study should involve working with solids, liquids and gases and include metals, ceramics, glass, plastic and fibres. They should make measurements where appropriate and develop understanding of the main ways to

classify and group the materials. By experiment pupils should see that gases have mass. They should learn how to distinguish between elements, compounds and mixtures. Using indicators, they should classify aqueous solutions as acidic or alkaline on the basis of their pH and investigate the reaction between acids and bases. They should classify metals and non-metals, some by direct observation and others with the help of tables of data, and should recognise similarities and trends within groups in the periodic table. Their study should involve at least one group of metals and one of non-metals. Pupils should make predictions from the reactivity series of metals. Pupils should learn how to separate and purify the components of mixtures.

2) Pupils should investigate changes of state, diffusions, dissolving, and the behaviour of gases under different conditions of temperature and pressure. They should be encouraged to explain these phenomena in terms of their developing ideas of the particulate model of matter. Their study should extend to an investigation of the temperature changes that occur during changes of state and to other changes, such as expansion, that occur during heating and cooling. They should be introduced to atoms, ions and molecules as types of particle and should develop models to explain the properties of some substances. Pupils should be introduced to radioactivity and radioactive substances through demonstration experiments. They should also be made aware that radioactive substances emit ionising radiations of different types, some of which are present naturally as background radiation.

3) Pupils should be made aware of the range of sources of raw materials, including those derived from the air, rocks, fossil fuels and living things. They should become aware of the role of oxygen in combustion. They should investigate examples of different types of reactions, such as combustion, thermal decomposition, salt formation, oxidation and reduction, neutralisation, electrolysis and fermentation; recognising that in chemical reactions energy changes may be evident. Pupils should construct word equations to describe chemical reactions. They should investigate factors such as temperature, concentration, particle size and catalysts which influence the rate of a chemical reaction, and, where possible, attempt simple quantitative relationships and explanations. The work should illustrate ways in which chemical reactions lead to the formation of new materials and relate to everyday processes such as corrosion and food oxidation. They should relate reactions to information about manufacturing processes involved in metal extraction, the petrochemical industry and fermentation.

4) Pupils should investigate practically, and by use of secondary sources, the properties of water, the water cycle, conservation of water resources and the effect of water on the Earth's surface. They should study the factors influencing the weather, including how different airstreams give different conditions. They should be acquainted with meteorological symbols. Pupils should investigate, by observation, experiment and fieldwork, the properties and formation of igneous, metamorphic and sedimentary rocks, and link these to major features and changes on the Earth's surface. They should be aware of the time-scales involved in the operation of geological processes, and be able to evaluate earlier ideas about the age of the Earth. They should investigate some natural material (rock or soil) and link the properties of minerals and rocks to their uses as raw materials in construction. They should appreciate the effects of weather on buildings and on rocks and examine the soil forming processes.

Key Stage 4

1) Pupils should carry out a more detailed study of selected elements and their compounds, covering metals and non-metals, in order to understand the limitations and different ways in which elements can be classified and ordered in the periodic table. They should recognise patterns in the properties of elements in groups and periods and relate these to the electronic structures. Pupils should be able to make predictions from the reactivity series of metals. They should investigate the process of neutralisation. Pupils should study the properties, structure and uses of materials, including metals, ceramics, glass, plastic and fibres. Pupils should have the opportunity to separate and purify the components of mixtures and to make different types of mixtures which have important everyday applications, such as emulsions, foams, gels and solutions. They should be introduced to the idea of composite materials, illustrated by some common examples including reinforced concrete, glass-reinforced plastic, bone and synthetic fibres.

2) Pupils should investigate the quantitative relationships between the volume, temperature and pressure of a gas, and use the kinetic theory to explain changes of state and other phenomena. They should develop models to explain the difference between elements and compounds in terms of atoms, molecules, ions and ionic and covalent bonds. They should use their knowledge of the structure of the atom to explain the existence of isotopes and radioactivity. Through demonstration experiments pupils should become aware of the characteristics of radioactive emission and determine the half-life of a nuclide. Pupils should study the different methods of detecting ionising radiation and its effects on matter and

living organisms, developing an understanding of the beneficial and harmful effects.

3) Pupils should investigate a range of types of reaction including thermal and electrolytic decomposition, ionic reactions in solution, salt formation, oxidation and reduction, fermentation and polymerisation and, where possible, relate these to models and to everyday processes such as corrosion and the manufacture of new materials. They should investigate the different factors affecting the rate of chemical reactions and relate these to the practical problems associated with the manufacture of new materials and to everyday biochemical change. Chemical and electrolytic reactions should be represented first in word and later in symbolic equations and these should be used as a way of describing and understanding reactions. Pupils should begin to explore through experiment and the use of data the quantitative aspects of chemical equations, including masses of solids and volumes of gases. The work should involve determination of formulae and, subsequently, quantitative electrolysis. Pupils should study chemical reactions in which there is energy transfer to and from the surroundings. At a later stage they should become aware that the energy transfer is associated with the making and reforming of chemical bonds and can be determined quantitatively by experiment and the use of data. Pupils should study the energy requirements and the social, economic, environmental and health and safety factors associated with the manufacture of materials. This should involve studying the processes involved in metal extraction, cracking oil, the chlor-alkali industry and the production of plastics and fertilisers. Pupils should relate this research to experimental methods used in the laboratory. During the work they should be made aware that some reactions are significantly reversible and may reach an equilibrium, and that this may be a major consideration in some manufacturing processes.

4) Pupils should study, through measurement and by other means, the principles which govern the behaviour of gases in the atmosphere, and the nature of the energy transfers which drive their motion. They should study atmospheric circulation, including the qualitative relationship between pressure, winds and weather patterns. They should study the origins of the atmosphere and the oceans, and be aware of the chemical and biological factors which maintain atmospheric composition. Pupils should study, through laboratory and field work, the evidence which reveals the mode of formation and later deformation of rocks, and the sources of energy that drive such processes. Pupils should study the scientific processes involved in the weathering of rocks, transport of sediments and soil formation. Pupils should understand how geological time scales are

measured. They should examine data which suggest that the Earth has a layered structure, including contrasting densities between surface rocks and the whole Earth, transmission of earthquake waves and magnetic evidence. They should investigate the evidence that favours the theory of plate tectonics including the nature of the rock record. They should consider how plate movements are involved in the recycling of rocks and the global distribution of the Earth's physical resources. They should consider theories from earlier times concerning movements of the Earth's crust, and how these were changed through advances in several fields of science and technology.

Attainment Target 4: Physical Processes

Key Stage 1

1) Pupils should be made aware of some uses of electricity in the classroom and in the home and the dangers of misuse. They should explore the effect of magnets on a variety of magnetic and non-magnetic materials and consider their uses. They should experience simple activities using bulbs, buzzers, batteries and wires and investigate materials to discover those which conduct electricity and those which do not.

2) Pupils should find out about the fuels used in their home and school. They should talk about when and why they feel hot or cold, and link the sensations of hot and cold with thermometer measurements, for example, in water and air.

3) Pupils should have early experience of devices which move. They should experience the natural force of gravity pulling things down and manufactured forces such as those produced in wind-up toys, elastic or electrically driven toys and by the movement of their bodies. These forces should be experienced in the way they push, pull, make things move, stop things and change the shape of objects. Such experiences should include, for example, road safety activities. They should explore floating and sinking and relate their experiences to water safety.

4) Pupils should have the opportunity to experience the range of sounds in their immediate environment and to find out about their causes and uses. They should experience the production of echoes resulting from the reflection of sound from distant surfaces. They should explore how to make and experience sounds by speaking and singing, striking, plucking, shaking, scraping and blowing, using

familiar objects and simple musical instruments from a variety of cultural traditions.

Pupils should have opportunities to explore light sources and the effects related to shadow, reflection and colour.

5) Pupils should observe closely the local natural environment to detect seasonal changes, including length of daylight, weather and changes in plants and animals and relate these to the passage of time. They should observe, over a period of time, the length of daylight, the position of the Sun and when possible the position of the Moon in the sky and its changing appearance.

Key Stage 2

1) Pupils should have the opportunity to construct simple circuits. They should investigate the effects of using different components, of varying the flow of electricity in a circuit and the heating and magnetic effects. They should plan and record construction details of a circuit using drawing and diagrams. They should learn about the dangers associated with the use of mains electricity and appropriate safety measures. They should investigate the properties of magnetic and non-magnetic materials. They should begin to explore simple circuits for sensing, switching and control, including the use of logic gates.

2) Pupils should investigate movement using a variety of devices, for example, toys and models, which are self-propelled or driven and use motors, belts, levers and gears. Pupils should investigate changes that occur when familiar substances are heated and cooled, and the concepts of 'hot' and 'cold' in relation to their body temperature. They should survey, including the use of secondary sources, the range of fuels used in the home and at school, their efficient use and their origins. They should be introduced to the idea that energy sources may be renewable or non-renewable and consider the implications of limited global energy resources. They should be introduced to the idea of energy transfer.

3) Pupils should explore different types of forces including gravity and use measurements to compare their effects in, for example, moving things and bridge building. They should investigate the strength of a simple structure. They should be introduced to the idea that forces act in opposition to each other, that one force may be bigger than another, or equal to it, and that the relative sizes and directions of the forces can affect the movement of an object. They should investigate the factors involved in floating and sinking. They should explore

friction and investigate the way in which the speed of a moving object can be changed by the application of forces. This work should be set in everyday situations, for example, road safety, transport (including cycling and sailing), balancing systems and hydraulic mechanisms in model making.

4) Pupils should learn that sounds are heard because they travel to the ear and they can do so via a variety of materials. They should learn that sounds are made when objects vibrate and investigate how sounds are changed in pitch, loudness and timbre, by changing the characteristics of the vibrating objects, for example, by changing length, tension, thickness of material of the vibrating object or the way it is made to vibrate, as exemplified by using musical instruments. They should be made aware of the obtrusive nature of some sounds in the environment. Pupils should learn about the reflection of both light and sound and relate this to everyday effects (mirrors, echoes). Pupils should learn that light travels faster than sound by considering natural events such as thunderstorms. They should explore the effects produced by shining light through such objects as lenses, colour filters, water, prisms. They should also investigate the formation of shadows and represent in drawings their ideas about how light varies in terms of brightness, colour and shade.

5) Pupils should track the path of the Sun using safe procedures such as a shadow stick or a sundial. They should study, using direct observations where possible, the night sky including the position and appearance of bright planets and the Moon. They should learn about the motions of the Earth, Moon and Sun in order to explain day and night, day length, year length, phases of the Moon, eclipses and the seasons. They should be introduced to the order and general movements of the planets around the Sun.

Key Stage 3

1) Pupils should investigate a wider range of components in electrical circuits and appreciate the means of controlling electricity using a variety of components such as variable resistors, delays, switches, diodes, capacitors, transistors and logic gates. They should make simple electrical measurements to develop understanding of the relationship between current, potential difference and resistance. They should be introduced to an interpretation of common electrostatic effects. They should develop a model of electric current in terms of the flow of charge in conducting materials. Pupils should investigate qualitatively the properties of magnets, electromagnets and the nature of magnetic fields. Their investigation should be in the context of everyday applications and devices

including electric motors, electromagnets, dynamos, transformers, loudspeakers and circuit breakers. They should measure and calculate the cost of energy used by domestic appliances. Using a systems approach, pupils should have an opportunity to use logic gates together with input sensors and output devices in simple decision making and control circuits to solve problems.

2) Pupils should be introduced to the concept of energy transfer by thermal processes and to the principle of energy conservation. They should have experience of a wide range of processes involving energy transfers in domestic contexts and in familiar devices, such as electric motors and mechanically driven models. The joule should be introduced as a unit for the measurement of energy. They should explore the generation of electricity from different energy sources. They should be introduced to the idea of energy efficiency. Pupils should discuss the use of fuel/oxygen systems as concentrated sources of energy in living things, engines, heating systems and other devices. Pupils should survey national and global sources of energy. They should consider energy from the Sun, nuclear energy, the origin and accumulation of fossil fuels and the use of biomass as a fuel.

3) Pupils should investigate the effectiveness of simple machines and tools such as pulleys and levers and how they can be used to solve everyday problems. Pupils should discover that forces can act to change the shape of things, to begin, move or stop them, and should investigate the factors involved in producing and maintaining motion. This work should make reference to friction and be related to human and vehicular movement with particular reference to road safety. Their investigations should include the measurement of speed and use the relationship between distance, speed and time. They should investigate how stopping distance is affected by speed. Pupils should investigate turning forces and the centre of mass in solid objects, the stability of everyday objects and the action of levers. They should investigate how the effect of a force applied over different areas results in different pressures, and how forces enable floating and sinking. This work should relate to the design and evaluation of structures, for example, bridges and boats. Pupils should appreciate the relationship between force, work and power.

4) Pupils should study the way sound is produced and travels as waves through the air, and how the ear works, common defects of hearing, the effects of loud sounds on the ear and the control of noise and sound levels in the environment. They should have opportunities to investigate their audible range and the

relationships between loudness, amplitude, pitch and frequency. Pupils should investigate the effect on sound of the shape and material used in the home and other buildings. They should understand the use of electronic sound technology, for example, in industrial, medical and social applications. Pupils should explore the nature of vision, leading to an appreciation that vision occurs because light enters the eye and signals are interpreted by the brain. They should learn about the visible region of the electromagnetic spectrum, other main types of electromagnetic radiation, and their uses. Pupils should study the behaviour of light, particularly its transmission, absorption, reflection, refraction and dispersion. They should learn how light is controlled and used in a range of common devices, for example, periscope, simple camera, fibre optics. They should study the function of the eye, common defects, and their correction, for example, long sight and short sight.

5) Pupils should further develop their study of the solar system through observation and secondary sources. They should consider ideas about the position of the Sun and planets in the solar system, and the position of the solar system in the Universe. They should study the extent of human exploration of space and the use of satellites to monitor conditions on the Earth and to observe the wide Universe. They should be introduced to the idea of gravitational force.

Key Stage 4

1) Pupils should study the use of electricity for the transfer of energy, the measurement of energy transferred, and its relation to the costs of using common domestic devices. Such work should also develop an understanding of the dangers of electricity and the standard features and procedures which protect users of electrical equipment. They should develop an understanding of unbalanced charges involving the movement of electrons to interpret common electrostatic phenomena and should consider the dangers and use of electrostatic charge generated in everyday situations. Pupils should study electromagnetic effects in common devices. Pupils should investigate principles of electromagnetic induction as applied to the generation and transmission of electricity and devices such as dynamos and transformers. Pupils should be given opportunities to extend their quantitative study of electrical circuits. They should use measurements of voltage and current to derive measurements of electrical resistance, charge, energy transferred and electrical power. Pupils should continue to investigate the properties of components in controlling simple circuits using switches and relays, variable resistors, capacitors, diodes, transistors and logic gates. They should investigate the behaviour of bistable circuits made from

two logic gates. They should consider the role of bistables in simple memory circuits to perform useful tasks. They should investigate the effects of feedback in a control system and consider the implications of information and control technology for everyday life. They should use knowledge of electronic systems, both analogue and digital, to solve problems. Pupils should develop an understanding of common electrical phenomena in conductors in terms of charge flow, including electrons and ions, and extend this to the study of thermionic emission and the production of X-rays.

2) Pupils should investigate the ways in which energy is transferred in a variety of personal and practical situations, including combustion of fuels. These investigations should include transfer by conduction, convection and radiation, particularly in domestic contexts, including the effects of insulation. They should further develop ideas of energy conservation and efficiency of energy transfer. They should investigate the relationship between potential and kinetic energy and link these to the concept of work. They should be introduced to the idea of power as a rate of energy transfer or doing work. The study should include the idea that although energy is always conserved, it may be dissipated and so it becomes harder to arrange for useful transfers of energy. They should be introduced to the ways electricity is generated in power stations from a range of resources, both renewable and non-renewable. By analysis of data, pupils should understand that some energy resources are limited and consider the longer term implications of the world-wide patterns on distribution and use of energy resources, including the 'greenhouse effect'. They should be given opportunities to discuss how society makes decisions about energy resources.

3) Pupils should investigate the effects of forces on movement and the relationship between force, mass and acceleration. They should explore examples of motion including free-fall, circular motion and the movement of projectiles and be aware of the effect of friction. They should consider the use of ideas of momentum and energy in relation to motion in systems, for example, in collisions, rockets and jet propulsion. They should investigate pressure and everyday applications of hydraulics. Pupils should investigate the relationship between forces and their effects in relation to the properties of common materials and how these determine the design, testing and strength of relevant artefacts and structures. They should apply their knowledge of the turning effect of forces and develop their understanding of centre of mass.

4) Pupils should explore the fundamental characteristics of sound, including loudness, amplitude, pitch and frequency. They should have opportunities to improve their understanding of the properties and behaviour of sound by developing a wave model, for example, through observations of waves in ropes, in springs and on water. This should be related to pupils' experience of sounds and musical instruments, acoustics, electronic instruments and recording. They should be given the opportunity to investigate devices, for example microphones and loudspeakers, which acts as transducers. They should understand the importance of noise control in the environment. Pupils should investigate the characteristics and effects of vibration, including resonance, in a range of mechanical systems. They should extend this study to include some uses of electronic technology in, for example, industry (cleaning and quality control), medicine (prenatal scanning), and social contexts (musical instruments). Pupils should investigate the fundamental characteristics of light, such as reflection, refraction, diffraction, interference and polarisation. They should relate these characteristics to the wave model. They should investigate the types of electromagnetic radiation, their uses and their potential dangers in: domestic situations (microwaves, infra-red, ultra violet); communication (radio, microwaves, light); and medicine (X-rays, gamma rays). They should study the process of transmission of waves through different media, including the relationship between speed, frequency and wavelength. They should understand the working of a range of optical devices.

5) Pupils should have opportunities to use the idea of gravitational force to explain the movement and positions of the Earth, Moon, Sun, planets and other bodes in the universe. The idea of gravitational force should also be applied to tides, comets and satellites. Pupils should consider the possibilities and limitations of space travel and the use of the data gained. Pupils should know that other planets are geologically active and that their present composition is related to their distance from the Sun. Pupils should understand that the Sun is powered by nuclear fusion processes. Pupils should examine ideas that have been used in the past and more recently, to explain the character and origin of the Earth, other planets, stars and the Universe. They should study the 'life cycle' of stars.

The Science National Curriculum for Scotland

The Science curriculum for Scotland is incorporated into the Environmental Studies 5-14 non-statutory guidelines. This was introduced in March 1993, and is currently being adopted across Scotland.

The science content of the curriculum is divided into three Attainment Outcomes:

1) Understanding living things and the processes of life;

2) Understanding energy and forces;

3) Understanding Earth and space.

Within the Attainment Outcomes there are six strands, known as Attainment Targets. These are:

1) Knowledge and understanding;

2) Planning;

3) Collecting evidence;

4) Recording and presenting;

5) Interpreting and evaluating;

6) Developing informed attitudes.

The curriculum covers three age ranges, stages P1 to P3, stages P4 to P6 and stages P7 to S2 (total age range 5 to 14 years).

The curriculum is based on programmes of study around which teachers are encouraged to design work schemes and lesson plans. The programmes of study for the three age ranges are detailed below.

Programmes of Study

Understanding living things and the processes of life

In developing a progressively deeper knowledge and understanding of living things and the processes of life, pupils should be given opportunities to observe and investigate plants and animals in the classroom, school and community. In addition they should carry out fieldwork in the immediate vicinity of the school and pay visits to nearby locations such as the seashore, woodlands, part or pond or to suitable industries. Studies should provide pupils with experience of living material, artefacts and scientific equipment, complemented by the use of audiovisual and reference materials, with firsthand experience predominating at all stages but especially at the early stages. Examples are provided at some points to give an indication of the depth of treatment but are not intended to be restrictive and additional examples can be included where appropriate. Studied should focus on:

Stages Pl to P3

Variety and characteristic features

- sorting things into broad groups according to easily observable characteristics e.g. birds, insects, flowers, evergreen/deciduous trees;
- recognising and naming common plants and animals in the classroom and local environment;
- similarities and differences between themselves and other pupils.

The processes of life

- changes which occur in plants and animals, including humans, which are indicative of growth and maturation, e.g. seeds germinating, buds bursting, milk/adult teeth;
- use of all the senses (smell, sight, taste, touch, hearing, balance, pain, heat/cold) to detect information and to keep the body safe;
- simple life cycles of plants and animals to illustrate stages of development e.g. seeds to plants, caterpillar, pupa to moth, spawn and tadpole to frog.

Interaction of living things with their environment

- animals and plants in a variety of habitats to demonstrate variety and to show how living things depend on each other;
- caring for living things in the classroom and the home e.g. houseplants, bulbs, pets;
- seasonal changes which take place in the appearance or behaviour of animals and plants e.g. leaf fall, hibernation, migration, colour changes.

Stage P4 to P6

Variety and characteristic features

- the main distinguishing features of vertebrates (fish, amphibians, reptiles, birds and mammals), major invertebrate groups (worms, molluscs, arthropods such as insects, spiders and crabs), flowering and non-flowering plants;

- recognising and naming some members of these groups using simple keys;
- similarities and differences between plants and animals of the same species, e.g. leaf shape, breeds of dog.

The processes of life

- the structure and functions of the major parts of the body as they relate to the processes of movement (muscles, bones and joints) and nutrition (teeth and digestive system);
- the structure and functions of the parts of flowering plants (roots, stem, leaves, flowers) and factors which affect germination and growth;
- dispersal of fruits and seeds by animals (externally/internally), by wind and by self.

Interaction of living things which their environment

- the interaction between humans and their environment in relation to aspects such as farming, fishing and other local industries;
- simple food chains based on energy from the sun;
- the importance of conservation and of the value of recycling materials;
- living things which are very rare or which have become extinct, e.g. protected species, dinosaurs;
- how plants and animals are affected by environmental conditions such as light/shade, dry/moist, hot/cold.

Stages P7 to S2

Variety and characteristic features

- the main distinguishing features of flowering (monocotyledons, dicotyledons) and non-flowering plants (algae, mosses, lichens, ferns, fungi, conifers) and micro-organisms (bacteria and viruses);
- similarities and differences within a group leading to the concept of a species;
- creating and using classification keys to identify living things;
- continuous and discontinuous variation;
- introduction to how information is passed from one generation to the next.

The processes of life

- the basic structure and function of plant and animal cells;
- the structure and function of the major parts of the body as they relate to the processes of respiration, excretion, sensitivity and reproduction;
- development, birth and parental care;
- changes in the physical and emotional development of human beings at puberty;
- the process of reproduction in flowering plants with reference to cross-(wind and insect) and self-pollination;
- photosynthesis, explaining the significance of this process to green plants, to the energy requirements of all animals and to the maintenance of the earth's atmosphere.

Interaction of living things with their environment

- food webs and food pyramids;
- competition between living things with respect to food and space;
- birth rate, death rate and factors which limit the growth of populations;
- the various ways in which humans can act on the environment, whether to its benefit or detriment e.g. forestation, dealing with pollutants, farming methods, chemical processing plants;
- adaptation to the environment over a period of time, leading to an understanding of the process of evolution and the survival or extinction of species;
- responses of plants and animals to environmental stimuli, including growth responses in plants and behaviour in animals.

Understanding Energy and Forces

In developing a progressively deeper knowledge and understanding of energy and forces, pupils should be given the opportunity to observe and investigate different forms of energy and forces and their properties and applications, in the classroom, school and community.

Stages P1 to P3

Pupils will be concerned with the forms of energy and forces which they can observe and experience directly in their immediate environment, through play and every day life. Studies should focus on:

<u>Forms and sources of energy</u>

- heat, light and sound which pupils can detect with their own senses;
- recognition that heat, light and sound are forms of energy.

<u>Properties and uses of energy</u>

- everyday uses of these forms of energy in common devices, e.g. cooker, candle, bell.
- safe use of energy providers.

<u>Forces and their effects</u>

- the effects of pushing, pulling, floating, leading to the idea of a force;
- moving and stopping effects, e.g. pulling or pushing a toy;
- the force of friction and its effects;
- the turning effect of a force, e.g. turning a door handle, twisting an elastic band.

Stages P4 to P6

Pupils will continue to deal with topics covered earlier, but practical investigations will lead to a greater depth of understanding of scientific ideas and principles. Studies should focus on:

<u>Forms and sources of energy</u>

- the Sun as the main source of light and heat;
- sound from a variety of vibrating sources, e.g. tuning fork, violin string, radio and TV speaker;
- electricity as a form of energy;
- sources of electrical energy e.g. mains, power station, battery.

Properties and uses of energy

- use of thermometers to measure 'hotness', leading to distinction between heat and temperature;
- sunlight and shadows (no direct viewing of the sun!);
- mirrors and reflections, including curved mirrors;
- lenses;
- colours in sunlight, visible spectrum formed by a prism;
- simple applications of mirror and lenses, e.g. car mirrors, spectacles, magnifying glass, telescope;
- pitch and volume of sounds including applications, e.g. speech, musical instruments, alarms;
- electrical conductors and insulators;
- construction of battery operated circuits to operate, e.g. bells, buzzers, lamps, warning lights;
- electrical safety.

Conversion and transfer of energy

- simple introduction to the idea that one form of energy can be converted to another, e.g. electrical to heat, light and sound.

Forces and their effects

- friction forces on different surfaces, reducing friction;
- air resistance, streamlining;
- force of gravity;
- magnetic materials, forces of attraction and repulsion;
- motion down a slope under gravity;
- Earth's magnetic field and the compass;
- magnetic materials in everyday use.

Stages P7 to S2

Pupils will grow in sophistication of understanding of the phenomena of energy and forces. They will learn more about the conversion of energy and forces. They will learn more about the conversion of one form of energy to another and of some of the environmental implications. They will begin to understand the need for units of measurement. Studies should focus on:

<u>Forms and sources of energy</u>

- the range of available energy sources, e.g. fossil fuels, solar energy, hydro-power, nuclear energy;
- renewable and non-renewable sources of energy;
- energy options issues;
- potential and kinetic energy;
- how energy is defined.

<u>Properties and uses of energy</u>

- measurement of energy, need for units, unit of energy - the kilojoule (kJ);
- basic electrical circuit components;
- voltage, current and resistance in simple d.c. circuits;
- microelectronics components;
- electrical power;
- magnetic effect of a current;
- many applications of different forms of energy, e.g. heating systems - radiators, insulation, cameras to lasers, control and alarm systems.

<u>Conversion and transfer of energy</u>

- more detailed treatment of conversion from one form of energy to another, e.g. fossil fuel or nuclear energy to electrical, wave energy to electrical energy, electrical energy to heat.
- conduction, convection and radiation of energy;
- ways and means of making the best use of energy.

Forces and their effects

- the lever as a force magnifier;
- simple pulley systems;
- simple gear systems;
- measurement of forces, spring balance;
- unit of force - the newton (N);
- weight; 1 kg weight is approximately 10N.

Understanding Earth and Space

In developing a progressively deeper knowledge and understanding of Earth and space, pupils should be given the opportunity to observe and investigate, in the classroom, school and community, including industrial settings. Throughout, emphasis should be laid on the finite nature of many of the Earth's resources and the need to use them sensibly.

Stages P1 to P3

Pupils will be concerned mainly with the features which they meet in everyday life. Studies should focus on:

Earth in space

- the Sun, Moon and stars as seen from the Earth;
- patterns of day and night;
- seasons.

On planet Earth

- changes in the environment related to seasons;
- simple features of the weather, with particular reference to water as rain, snow, ice.

Materials from Earth

- common materials with straightforward uses from living and non-living sources, e.g. stone, sand, wood for building, wool for clothes, coal as fuel, water;

- easily observable differences in properties of common materials, such as wood and stone, e.g. hard/soft, rough/smooth, warm/cold.

Stages P4 to P6

Pupils will continue to deal with topics covered earlier, studying them in greater depth, but will extend knowledge and understanding to other areas by investigations and access to printed and audiovisual sources. Studies should focus on:

Earth in space

- the planets of the solar system;
- measuring the passage of time.

On planet Earth

- the Earth's atmosphere and some effects of having air around the planet;
- the water cycle (in simple outline) introducing water as a gas, melting, freezing, evaporation, condensation;
- patterns of weather observed locally.

Materials from Earth

- uses of water, methods of water conservation;
- further properties of common materials, e.g. hardness, rigidity, insulating properties, water resistance; relationship between a material's properties and its use;
- natural and manufactured materials and simple examples of recycling;
- how materials can be changed: by heat, e.g. melting, evaporating, firing of clay; by mixing chemicals, e.g. making fizzy drinks, cement, plaster of Paris; and by a combination of both, e.g. baking a cake.

Stages P7 to S2

In carrying out studies at greater depth, pupils will seek scientific explanations for their observations using evidence drawn from practical activities and a wide variety of print and audio-visual sources. Studies should focus on:

Earth in space

- major features of the universe; further detail of the solar system;
- how knowledge can be gained by space exploration;
- the motions of the Sun, Moon, Earth and planets, and related effects, e.g. day/night, seasons, phases of the Moon.

On planet Earth

- the structure of the Earth, the Earth's crust and processes which led to the formation of main features in it, e.g. formation of different types of rock, fossils;
- the structure and properties of soils;
- the existence of materials such as solids, liquids, gases; properties of solids, liquids, gases, including expansion, density, pressure;
- the particulate nature of matter - atoms, molecules;
- explanations of some of the simpler features of the weather.

Materials from Earth

- materials as elements, compounds; simple chemical reactions which change one material into another, e.g. reactions of metals, acids, making simple gases:
- further aspects of water, e.g. solubility, solutions, treatment of drinking water, waste water, preventing pollution; and simple properties of other common solvents;
- useful materials found in the Earth's crust as mixtures, solutions, e.g. rock salt, oil, sea water, or as compounds, e.g. metal ores;
- methods of extracting these useful materials, including distillation, filtration, break-up of compounds;
- further examples relating use of materials to properties, including corrosion resistance;
- a more detailed consideration of recycling and of conservation of finite mineral resources;
- the gases of the atmosphere - properties and uses;

- fossil fuels, occurrence, combustion and effect of emission of 'greenhouse gases'; methods of avoiding or overcoming atmospheric pollution; other uses (outline only).

The Science National Curriculum for Northern Ireland

The Northern Ireland Curriculum Council is currently revising the science National Curriculum. Science and technology are compulsory subjects through all Key Stages, and are taught as separate subjects.

The latest consultation document (NICC, 1994) indicates the areas of study within the curriculum. These are:

- living things, their variety and processes;
- materials, their properties and uses, they way they behave, and how new materials are made;
- the nature of energy, its transfer and control;
- aspects of the physical world, such as forces, sound, light, electricity and magnetic;
- the earth, its atmosphere, its place within the universe and the impact of human influences on it.

Further debate is due to take place before the full curriculum is released for all four Key Stages.

Appendix 3

Proposed changes to the Science National Curriculum as a result of the Dearing Review

1) Reduction of the Programmes of Study in Key Stage 1, 2 and 3 in order to reduce the percentage of curriculum time devoted to science by 20%. The new recommendations for curriculum time are:

- Key Stage 1: 1.5 hours per week
- Key Stage 2: 2.0 hours per week
- Key Stage 3: 2.5 hours per week

20% of curriculum time is still recommended for Key Stage 4 pupils who are studying Double Award science. The Single Award, to be taken by a minority of pupils (those who are gifted in Arts subjects, and who require additional time in these areas), should occupy 12.5% of curriculum time. The Single Award will not be an acceptable qualification for A-level.

1) Replacement of the Statements of Attainment with Level Descriptions, which are more general statements and are less prescriptive. Teachers are encouraged to use the levels to place pupils on the 1-10 scale. They are designed to be summative rather than formative, and to be used at the end of the Programmes of Study.

2) Teachers are still required to follow the Programmes of Study which specify the content to be taught. These have been radically altered in order to bring about the reduction in content specified in point (1). The changes are:

Key Stage 1:

Reduction in content	**Moved to Key Stage 2:**
Decay	Effects of heating
Effect of human activity	Electricity
Fuels	
Weathering	
Hot and cold	
Observation of the moon	

Key Stage 2:

Reduction in content	**Moved to Key Stage 3:**
Fossils	Acids and alkalis
Waste disposal procedures	Chromatography
Seasonal changes	Competition
Weather	Renewable and non-renewable energy
Seasons of the year	
Heating and magnetic	Sounds as waves
effects of electric current	
Logic gates	
Structures	
Colour	
Study of the night sky	

Key Stage 3:

Reduction in content:	**Moved to Key Stage 4:**
Purification of mixtures	Enzymes and microbes
Water cycle	Excretion
Weather	Effect of human activity on the environment
Soil	
Logic gates	Cycling of materials in biological communities
Stopping distance	
Stability	Behaviour of gases
Structures	Fermentation
Soundproofing	Radioactivity
Defects of the eye	Rates of reaction
	Electrolysis
	Periodic Table
	Electromagnetic spectrum
	Ohm's Law
	Solar system

The Earth Science aspect of the reduced content will be incorporated in the Geography curriculum (not a compulsory subject).

4) The 10-level scale will now be used only to the end of Key Stage 3, so that students approaching GCSE (Key Stage 4) will be assessed only on the subject matter incorporated into the Examination Board syllabi. These are currently in preparation.

5) Alteration of the Programmes of Study for Attainment Target 1 (Scientific Investigation) to allow for a wider range of practical and experimental work to be included. This should allow more biological and chemical investigations to be included in the assessment of AT1.

Experimental work which has not been carried out as part of a whole investigation can be used as part of the assessment process.

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Revision of the Science National

Curriculum Draft Order, May 1994.

Appendix 4

General National Vocational Qualifications

The General National Vocational Qualifications (GNVQ) in science for intermediate and advanced level were piloted in English schools and colleges in the academic year 1993-1994. The advanced GNVQ has been designed to be of an equivalent standard to two GCE A-levels, and it is anticipated that one GNVQ will provide access to higher education at some institutions. Students study 12 vocational units for the advanced award, eight of which are mandatory and four optional. The intermediate qualification is of a lower standard, and is designed to provide students with a basic grounding in vocational science as preparation either for employment, GNVQ advanced or A-levels in science subjects. Students study six units for the intermediate qualification, four of which are mandatory and two optional.

Within each unit, there are elements which state the aims of each unit. The elements are further sub-divided into Performance Criteria which students are expected to meet to receive accreditation. Units can include, on average, three elements and between 12 to 20 Performance Criteria. The units and elements are listed below.

GNVQ Science Intermediate: Mandatory Units

<u>Unit 1: Working on scientific tasks</u>

Element 1.1: Examine science based employment

Element 1.2: Carry out scientific tasks using standard procedures

Element 1.2: Carry out scientific tasks using adapted procedures

<u>Unit 2: Investigate living things, materials and substances</u>

Element 2.1: Investigate organisms in their environment

Element 2.2: Investigate the properties of solid materials and relate them to their uses

Element 2.3: Determine the composition of substances

Unit 3: Make useful products

Element 3.1: Obtain products from cultivated plants

Element 3.2: Obtain pure substances by chemical reactions

Element 3.3: Make and test devices

Unit 4: Monitor and control systems

Element 4.1: Monitor the performance of tasks by the human body

Element 4.2: Monitor and control chemical reactions

Element 4.3: Monitor and control the performance of physical devices

GNVQ Science Advanced: Mandatory Units

Unit 1: Laboratory safety and analysis of samples

Element 1.1: Investigate health and safety practices in laboratories

Element 1.2: Select analytical strategies

Element 1.3: Carry out analyses and evaluate results

Unit 2: Investigate materials and their use

Element 2.1: Identify the properties of materials for particular uses

Element 2.2: Determine the physical properties of materials

Element 2.3: Modify materials to make them more useful

Unit 3: Obtain new substances

Element 3.1: Plan the preparation of substances

Element 3.2: Prepare quantities of substances

Element 3.3: Extract and determine yield of substances

Unit 4: Obtain products from organisms

Element 4.1: Evaluate organisms as sources of useful products

Element 4.2: Investigate the genetic manipulation of organisms to increase production

Element 4.3: Identify constraints on commercial production from organisms

Unit 5: Control the transfer of energy

Element 5.1: Control transport of objects

Element 5.2: Control fluid flow

Element 5.3: Control thermal energy transfer

Unit 6: Control reactions

Element 6.1: Propose control strategies for reactions

Element 6.2: Monitor and control reactions

Element 6.3: Evaluate industrial processes

Unit 7: Human physiology and healthcare management

Element 7.1: Establish the characteristics of mammalian organ systems in the maintenance of health

Element 7.2: Monitor physiological changes in the human body

Element 7.3: Prepare action plans for healthcare of people

Unit 8: Communicating information

Element 8.1: Gather data for scientific purposes

Element 8.2: Transfer scientific data electronically

Element 8.3: Process, display and evaluate data

In addition to the mandatory scientific units, students are required to study two (for intermediate level) or four (For advanced level) optional units. The subject content of these depends upon the Examination Board used by the institution. Those currently available include pharmacy, electronics and experimental psychology.

Students are also required to study three core skills, Communication, Application of Number and Information Technology. At present, most institutions are assessing these skills within the science units studied.

Glossary

A	Advanced
AS	Advanced Supplementary
ASE	Association for Science Education
AT	Attainment Target
BAYS	British Association for Young Scientists
BEd	Bachelor of Education (degree)
CDT	Craft, Design and Technology
CREST	Creativity in Science and Technology
CSE	Certificate of Secondary Education (Scotland)
CSYS	Certificate of Sixth Year Studies (Scotland)
CTC	City Technology College
DENI	Department of Education Northern Ireland
DES	Department for Education and Science (now DFE)
DFE	Department for Education
DOE	Department of Employment
EA	Education Authority (Scotland)
FAS	Funding Agency for Schools
GCE	General Certificate of Education
GCSE	General Certificate of Secondary Education
GEST	Grants for Educational Support and Training
GMS	Grant Maintained Status
GNVQ	General National Vocational Qualification
GSVQ	General Scottish Vocational Qualification
HMI	Her Majesty's Inspectorate
HMSO	Her Majesty's Stationery Office
INSET	In-service Training
IT	Information Technology
KS	Key Stage
LEA	Local Education Authority
LMS	Local Management of Schools
NACETT	National Advisory Council for Education and Training Targets
NAT	National Assessment Tasks
NC	National Curriculum
NCVQ	National Council for Vocational Qualifications
NICC	Northern Ireland Curriculum Council

NICCEA	Northern Ireland Council for Curriculum and Examinations and Assessment
NQT	Newly Qualified Teacher
NVQ	National Vocational Qualification
OFSTED	Office for Standards in Education
PGCE	Post Graduate Certificate in Education
PSE	Personal and Social Education
QTS	Qualified Teacher Status
SAT	Standard Assessment Tasks
SCAA	School Curriculum and Assessment Authority
SCOTVEC	Scottish Vocational Education Council
SEN	Special Educational Needs
SNS	Standard National Scale
SOED	Scottish Office Education Department
STS	Science and Technology in Society
TIMSS	Third International Mathematics and Science Survey
TTA	Teacher Training Agency
WOED	Welsh Office Education Department

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Euroscientia conferences

Information Note

Euroscientia conferences, formerly "The European Science and Technology Forum" were created in 1994 by the European Commission in order to stimulate reflection and debate on science and technology on a European scale. To this aim, they provide a framework for conferences and studies on subjects related to historical, cultural, ethical, social, but also economic and political aspects of science and technology.

The originality of the Euroscientia conferences, when compared with other initiatives in this field, is to address the questions dealt with specifically within their European dimension: attention is concentrated on the particularity of the situation in the field concerned in Europe in comparison with other parts of the world; the differences between European countries and regions; the aspects related to the process of building Europe; the needs and possibilities of collaboration at European level, etc.

Over the years, the European Union has developed its own research policy. Conceived in order to both supplement and support national research efforts, this policy is implemented through large collaborative research programmes co-ordinated within the so-called pluriannual "Research and Technological Development Framework Programmes". The basic principles of these programmes are: stimulating the creation of collaborative networks across Europe; supporting joint research projects associating universities, enterprises and research centres from different European countries; and promoting the mobility of researchers and exchanges.

The main characteristic of the Fifth Framework Programme (1998-2002) is to focus the European research effort on a limited number of subject matters relating to the large social and economic needs, issues and challenges which the European Union is currently facing: employment and industrial competitiveness; problems related to public health, environment, transport and, in general, the quality of life of European citizens.

Together with the European Union policies in the field of education and training and innovation, with which they are regrouped under the authority of a single Commissioner, Mrs Edith Cresson, EU research policy is aimed at promoting the creation and development of a true "knowledge-based" Europe, and helping to make the whole continent a privileged place for investment in research, training and innovation.

The activities of the Euroscientia conferences supplement the European Union research programmes by providing intellectual and conceptual basis for action and helping to strengthen and improve the quality of the relationship between science and society at European level.

The conferences organised in this framework put together a broad spectrum of people from different horizons: historians, sociologists, philosophers, specialists in "science studies", researchers in natural and exact sciences as well as in social sciences and humanities, people in charge of research and policy-decision makers, representatives from the industrial and entrepreneurial world and citizens' associations, etc. Organised by national or European institutions, each conference draws together between 100 and 200 people. The proceedings are systematically published and broadly disseminated.

To stimulate reflection and debate on science and technology far beyond just the participants in these initiatives, the European Commission recently launched a new journal. Called *Euroscientia*, this journal, published in a single multilingual edition, contains articles devoted to subject matters of the same nature as those addressed in Euroscientia conferences' events, sometimes developing views presented in a past conference or preparing the ground for future initiatives.

Agenda of past and future conferences

1994

TITLE	PLACE	DATE	ORGANISATION
"Scientific Expertise in European Public Policy Debate"	London	14-15 September	London School of Economics and Political Science
"Science and Languages in Europe"	Paris	14-16 November	Ecole des Hautes Etudes en Sciences Sociales - Centre Alexandre Koyré
"Science and Power : the Historical Foundations of Research Policies in Europe"	Firenze	8-10 December	Istituto e Museò di Storia della Scienza
"Science, Philosophy and the History of Sciences in Europe"	Paris	9-10 December	Association Diderot
"Science in School and the Future of Scientific Culture in Europe"	Lisboa	14-15 December	Instituto de Prospectiva

1995

TITLE	PLACE	DATE	ORGANISATION
"History of European Scientific and Technological Cooperation"	Firenze	9-11 November	European University Institute
"Science, Law and Ethics in Europe"	Paris	8-9 December	Association Diderot

1996

TITLE	PLACE	DATE	ORGANISATION
"The Future of Postgraduate Education in Europe"	Firenze	17-18 June	European University Institute
"Images and Science Education in Europe"	Paris	3-4 October	CNRS Images/Media FEMIS

1997

TITLE	PLACE	DATE	ORGANISATION
"Industrial History and Technological Development in Europe"	London	20-21 March	The Newcomen Society
"Interdisciplinarity and the Organisation of Knowledge in Europe"	Cambridge	24-26 September	Academia Europaea
"Sciences, Myths and Religions in Europe"	Royaumont	13-14 October	Association Diderot
"Science and Technology Understanding in Europe: New Insights"	Roma	20-21 November	Hypothesis
"European Science and Scientists between Freedom and Responsibility"	Amsterdam	2-3 December	Royal Netherlands Academy of Arts and Sciences/ALLEA

1998

TITLE	PLACE	DATE	ORGANISATION
"Writing and Science in Europe"	Nice	12-14 March	Association Anaïs
"Electronic Communication and Research in Europe"	Darmstadt	15-17 April	Academia Europaea
"History of Science and Technology in Education and Training in Europe"	Strasbourg	25-26 June	Université Louis Pasteur/ALLEA
"Science, Public Policy and Health in Postwar European History"	Barcelona	25-28 November	Maison des Sciences de l'Homme

1999

TITLE	PLACE	DATE	ORGANISATION
"Cultural Identities and Natural Sciences in Europe"	Bologna	16-17 April	Association Transcultura

European Commission

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