International Review of Curriculum and Assessment Frameworks

Thematic Probe: Science for the 21st Century

Queensland (Australia), Ontario (Canada), France, the Netherlands and Sweden

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Preface

The probe which follows provides information regarding science education in Queensland (Australia), Ontario (Canada), France, the Netherlands and Sweden. The data, collated in June 2000, was in response to five specific questions received by the National Foundation for Educational Research (NFER) from the Qualifications and Curriculum Authority (QCA) to inform thinking on science education in compulsory level education in England (students aged five to 16 years). The questions were:

1. **Do all 14- to 16-year-olds (or those in the final phase of compulsory secondary level education) follow science courses including biology, chemistry and physics? If not, what do they study in terms of science subjects?**
2. **Do all 5- to 11-year-olds (or those in compulsory primary level education) follow science courses?**
3. **Is there a recognition of a problem regarding the relevance of the science curriculum? If so, is this regarded as a particular problem for certain groups of pupils (for example, certain age ranges, boys or girls at a particular age?), and are there any plans to deal with this?**
4. **With particular reference to science, are there current changes to the assessment of pupils between the ages of five and 16 (compulsory education)? If so, what are the reasons for the changes and are there any issues/problems regarding the introduction of new methods?**
5. **Are there any good examples of the teaching of contemporary science?**

The data was sourced initially from the International Review of Curriculum and Assessment Frameworks (*INCA*) Archive (www.inca.org.uk), complemented by additional information from Ministries, agencies and our contacts in the countries or states concerned.

Please note that, as stated previously, the data was sourced in June 2000. Changes may have taken place since that date which are not reflected in the information which follows.

Should you have any comments on the thematic probe which follows or on the *INCA* website in general, please contact us via the 'Contact *INCA'* button on the *INCA* homepage (www.inca.org.uk) or directly via s.odonnell@nfer.ac.uk

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Thematic Probe - Science for the 21st Century
Science education in Queensland (Australia), Ontario (Canada), France, the Netherlands and Sweden

6. Do all 14- to 16-year-olds (in the final phase of compulsory secondary level education) follow science courses including biology, chemistry and physics? If not, what do they study in terms of science subjects?	
Australia [i] - Queensland	All students aged 14 to 16 usually study science. Students in Years 9 and 10 (aged 14-16) generally study, as compulsory core subjects: English, mathematics, **science**, science of society and environment (SOSE) and languages other than English (LOTE), as well as sport and recreation studies, lifeskills/health and physical education. They also choose two elective subjects, as outlined below. Years 9 and 10 students (aged 14-16) have more opportunities than those in earlier years of compulsory education to specialise in particular subject and discipline areas according to their needs, interests and abilities. The three (obligatory) elective subjects may be chosen from: mathematics, **science**, science of society and environment (SOSE), languages other than English (LOTE), the arts, technology, and health and physical education. This is to allow students to explore the traditional academic areas of the curriculum in more depth. The science course incorporates biology (including some physiology), chemistry, physics, geology and astronomy, as well as a focus on the societal aspects of science. A new Year 1-10 science syllabus was published in 1999; this is made up of the following strands: life and living; energy and change; natural and processed materials; earth and beyond; and science and society. Working scientifically is embedded in all strands. According to the 1999 Queensland science syllabus for Years 1-10, indicative time allocations are provided for science education in Queensland. These are based on an estimate of the minimum time needed to provide students with opportunities to demonstrate the core learning outcomes. The 1999 science syllabus was developed on the assumption that the average minimum time allocation for science education across Years 1-10 (ages 6-16) should be 1.5 hours per week. More specifically, for pupils in Years 8, 9 and 10 (aged 13-16), 180 hours is the recommended minimum across these three years. The science syllabus for Years 1-10 is available online at http://www.qscc.qld.edu.au/kla/science/syllabus.html

Canada [ii] - Ontario	All students aged 14-16 in Ontario study science. Prior to September 1999, there were generally three types of courses available in the curriculum for students in Grades/Years 9 and 10 (aged 14-16). These were academic, applied and open courses, and there was a common core curriculum for the academic and applied courses, which included: English; French as a second language; mathematics; **science**; geography; and history. Students had to successfully complete their selected course in Grade 9 to proceed to take the same subject (either as an academic or applied course) in Grade 10. A new four-year programme was introduced for students in high schools (Grades 9-12, aged around 14-18) in September 1999. Pupils in Grades 9 and 10 (aged 14-16) still select either an applied or academic study programme, but this now provides an increased emphasis on mathematics, language and **science**, as well as promoting responsible citizenship. The high school programme is based on a credit system, where students must earn a total of 30 credits, 18 of which are compulsory and 12 optional. The compulsory credit system is as follows: 4 credits in English; 1 credit in French as a second language; 3 credits in mathematics; **2 credits in science**; 1 credit in Canadian history; 1 credit in Canadian geography; 1 credit in the arts (music, art, drama or dance); 1 credit in health and physical education; and ½ credit in civics and ½ credit in career studies. High school graduates are expected to have knowledge and skills in English, maths and **science**, and also to have some experience and knowledge and skills in contributing to their communities. A **new science syllabus**, linked to the new four-year programme detailed above, was introduced in September 1999 for students in Grade 9 (aged 14-15); and will be introduced for students in Grade 10 (aged 15-16) in September 2000. This comprises four strands: **biology**, **chemistry**, **earth and space science**, **and physics**. The revised science curriculum for students in Grades 9 and 10 (aged 14-16) in Ontario is available online at: http://www.edu.gov.on.ca/eng/document/curricul/seccurric.html (A revised curriculum for science education in Grades 11-12 (students aged 16-18) has also recently been published. This will be introduced in September 2001 for students in Grade 11 and in September 2002 for students in Grade 12. This is also available at: http://www.edu.gov.on.ca/eng/document/curricul/seccurric.html) In addition, the *Pan-Canadian Protocol for Collaboration on School Curriculum: Common Framework of Science Learning Outcomes*, published in 1997, is available online at http://www.cmec.ca/science/framework/index.htm
France	All students aged 14-16 in France study science in some form. In France, students aged 14-15 are in the final year of the compulsory lower secondary school - the 'troisieme' class or year in the collège; those aged 15-16 are usually in the 'seconde' class of the 'lycée'. In the final year of compulsory lower secondary education in the collège, students aged 14-15 study: French; mathematics; first modern foreign

	language; history and geography; economics; civic education; technology; **physics and chemistry**; **biology or biology and geology**; art education; and sport and physical education. The time spent on the study of the different science subject areas varies dependent on the specific branch of study the student has selected to follow during this year (the language branch or the technology branch). All students aged 15-16 (in the 'seconde', the final year of compulsory education in an upper secondary lycée) study the same compulsory subjects (core curriculum), in accordance with a common timetable. Courses usually comprise the core subjects, two compulsory optional subjects, and a choice of subjects at the student's discretion or practical workshops. The compulsory core subjects for the seconde are: French; mathematics; **physics and chemistry**; **life and earth sciences** (or **biology and geology**); technology of automated systems; first modern foreign language; history and geography; and physical education and sport, plus civics. For information, in the earlier years of compulsory secondary education, pupils aged 11+ study the following subjects: In the first year of compulsory lower secondary education in the collège, students aged 11-12 study French; mathematics; history, geography and civic education; **life and earth sciences**; technology; artistic education; a modern foreign language; and sport and PE. The **life and earth sciences** syllabus covers the following areas at this level: introduction to the environment; understanding nature; and nature in use by man. It is recommended that 1.5 hours per week is spent on the study of **life and earth sciences**. In the second and third years of compulsory lower secondary education in the collège, students aged 12-14 study: French; mathematics; a modern foreign language; history, geography and civics education; **life and earth sciences**; **physics and chemistry**; technology; art education; and PE and sport. The **life and earth sciences** curriculum follows on from that studied in the first year of the collège, but includes more biological content. The **physics and chemistry** curriculum covers: discovering the environment; matter (water, air, etc.); light; and electricity. It is recommended that 1.5-2 hours per week each is spent on the study of **life and earth sciences** and **physics and chemistry**. The syllabuses for **life and earth sciences** (sciences de la vie et de la terre) for pupils aged 11-12 and for **physics and chemistry** (physique et chemie) for pupils aged 12-14 are available online, in French, at http://www.cndp.fr/college/textoff/bprg_6.html and http://www.cndp.fr/college/textoff/bprg_54.html respectively.
Netherlands	In general, all students aged 14-16 study science in some form. Dutch secondary education, for pupils aged 12+, consists of two main cycles. During the first cycle, all students aged 12-15 follow a common core curriculum (basisvorming). The length of the second cycle (pupils aged 15+) and the specific subjects studied depend on the educational route/type of course the pupil has previously selected. Some are following what are known as VBO or MAVO courses which finish when they reach the age of 16; others are following HAVO courses until the age of 17; and others finish at age 18, having followed a VWO course. The main difference between the various types of secondary education is the level at which the subjects are studied, and the number of lessons devoted to different subjects over the whole period of a particular type of education.

	The common core (basisvorming) curriculum for all pupils aged 12-15 comprises the following compulsory subjects: Dutch; English language; second foreign language (French or German); mathematics; **biology**; **chemistry and physics**; IT studies; history and politics/civics; geography; economics/commerce; technology; social and life skills; at least two of visual arts, music, dance or drama; and physical education. The recommended number of teaching periods (lasting 50 minutes each) is 120 for **biology** and 200 for **physics and chemistry**. This common core curriculum, although followed by all pupils in secondary education, is modified and added to in light of the particular secondary education route (see above) the pupil has selected. The general objectives and attainment targets for **biology** and **chemistry and physics** for the first cycle of secondary education in the Netherlands are set out in the publication - *Attainment Targets 1998-2003: Basic Secondary Education in the Netherlands*. This document is available online - in pdf format - at http://www.minocw.nl/english/index.htm The study of science for pupils aged 15+ (in the second cycle) depends very much on the specific course the pupil has selected to follow. Following recent reforms, pupils in the second cycle of VBO and MAVO courses (aged 15-16) will have already selected six examination subjects (for their certificate), comprising a common component, a sector-specific component and an optional component. The common component is compulsory and includes Dutch and English as examination subjects, plus social studies, physical education and one arts subject as non-examination subjects. Under the sector-specific component, two or three compulsory examination subjects are taken relating to the sector chosen. The optional component comprises two further examination subjects depending on the pathway chosen. Since August 1999, students on MAVO and VBO courses have selected subjects from four sectors: engineering and technology; care and welfare; economics; and agriculture, and four pathways: theoretical; middle-management vocational; vocational; or combined. Whether or not specific science subjects are studied during this final year will therefore depend on the sector and pathway chosen by the pupil. Following reforms introduced in 1998, pupils following HAVO courses (until age 17) and VWO courses (to age 18) follow a common core of subjects, plus four 'profiles' or specialist routes in addition. The route is selected from: science and technology (comprising combinations of **physics**, **chemistry** and **biology**); nature and health; economics and society; and culture and society. These four streams are linked to higher education disciplines. In addition, the common core curriculum for all pupils in the second cycle of HAVO and VWO courses includes **general science**.

Sweden	All students aged 14-16 study science. In Sweden, compulsory education is provided in one all-through school, the 'grundskola', for pupils usually aged 7-16. Some variations are permitted, that is, some children may start at age 6, others may defer entry to age 8. Compulsory education must, however, last nine years. The curriculum for the nine years of compulsory education comprises: art; craft; domestic science; English; language options; mathematics; music; sport and health; Swedish; Swedish as a second language; geography; history; religious studies; social studies; **biology**; **physics**; **chemistry**; and technology. The **science** curriculum is organised in subject-related (cross-disciplinary) blocks (known as 'subject blocks' in Sweden), and comprises **biology**, **physics** and **chemistry**. The total minimum teaching time for the whole nine compulsory years for **science** is 800 hours. This refers to **biology**, **physics**, **chemistry** *and* **technology**. Individual schools determine how these hours are allocated. Some schools, for example, allocate more hours to the teaching of Swedish and mathematics in the early years of the grundskola. (All students in post-compulsory upper secondary education, age 16-19, regardless of which specific one of the 16 national three-year programmes they have selected, follow a common core curriculum. This comprises eight subjects, which account for approximately one third of teaching time. Science is one of these eight core curriculum subjects.)

2. Do all 5- to 11-year-olds (compulsory primary level education) follow science courses?	
Australia [iii] - Queensland	All children in compulsory primary level education in Queensland, age 6+, usually study science. According to our contacts in the Queensland Department of Education (Education Queensland), "they are expected to undertake studies across a range of **science** subjects similar to those in secondary schools; that is, **biology**, **astronomy** and **geology**, **physics** and **chemistry**". More specifically, the core curriculum for children in Years 1-8 (ages 6-13) in Queensland covers the eight, nationally agreed 'Key Learning Areas', namely the arts, English, health and physical education (HPE), languages other than English (LOTE), mathematics, **science**, studies of society and the environment (SOSE), and technology. 'Lifeskills' is also mandatory. The **science** and technology Key Learning Areas are often combined in primary level education to form one curriculum area. A new Year 1-10 science syllabus for Queensland was published in 1999; this is made up of the following strands: **life and living**; **energy and change**; **natural and processed materials**; **earth and beyond**; and **science and society**. Working scientifically is embedded in all strands. Implementation of the new science syllabus is being phased in over three years (1999-2001). According to the 1999 Queensland science syllabus for Years 1-10, indicative time allocations are provided for science education in Queensland. These are based on an estimate of the minimum time needed to provide students with opportunities to demonstrate the core learning outcomes. The 1999 science syllabus was developed on the assumption that the average minimum time allocation for science education across Years 1-10 (ages 6-16) should be 1.5 hours per week. More specifically, for pupils in Years 1-3 (aged 6-9), 180 hours is the recommended minimum across these three years; for those in Years 4-7 (aged 9-13), the recommended minimum is 240 hours across the four years. The science syllabus for Years 1-10 is available online at http://www.qscc.qld.edu.au/kla/science/syllabus.html

Canada [iv] - Ontario	All children in compulsory primary level education in Ontario, age 6+, usually study science. **This is taught as a combined subject area: science and technology.** More specifically, a new provincial curriculum for elementary (primary) school education (Grades 1 through to 8, pupils aged 6/7 - 13/14) was introduced in 1998. This concentrates on literacy and numeracy (the 'back to basics' curriculum). The elementary school curriculum is divided into: the arts, comprising three strands: music, visual arts, and drama and dance (Grades/Years 1-8); French as a second language (Grades 4-8, students aged 9-14); language, comprising writing, reading, and oral and visual communication (Grades 1-8); mathematics (Grades 1-8); **science and technology** (Grades 1-8); social studies (Grades 1-8); and history and geography (Grades 7-8, students aged 12-14). Within the **science and technology** curriculum area, students study five strands: **life systems** (which incorporates traditional topics studied for biology); **matter and materials**; **energy and control**; **structures and mechanisms**; and **earth and space systems**. The full version of the science and technology curriculum for elementary education in Ontario is available online at: http://www.edu.gov.on.ca/eng/document/curricul/elemcurric.html In addition, the *Pan-Canadian Protocol for Collaboration on School Curriculum: Common Framework of Science Learning Outcomes*, published in 1997, is also available online at http://www.cmec.ca/science/framework/index.htm
France	All children in elementary/primary level education in France, aged 6-11, study science in some form. Children aged 6 to 8 study: **the sciences**, technology, history and geography as one combined subject area entitled **'discovering the world'** (découverte du monde). Children aged 8 to 11 study: **the sciences** and technology as one combined subject (**science and technology**). For children aged 6-8, it is recommended that four hours per week is spent on 'discovering the world' and, for those aged 8-11, that four hours per week is devoted to the study of history/geography, civics, and science and technology combined. The amount of time devoted to each individual aspect of **science** during elementary level education (for example, the percentage of time devoted to the study of physics as compared with the study of chemistry) is influenced very much by teacher preference and the availability of teaching material. Health education is usually also taught in **biology** (**science**) education during elementary phase education in France (children aged 6-11). Information on nursery and primary level science education and links to curricula/programmes of study are available, in French, at www.inrp.fr/lamap/accueil.html

Netherlands	All children in compulsory primary level education in the Netherlands usually study science. More specifically, the Primary Education Act advocates a 'well-balanced curriculum' geared to children's development and the diversity of the demands of the society to which they belong. Since August 1993, a set of core objectives has determined the formal content of primary education. All primary school children (aged around 4+-12) must be taught the following subjects, if possible in an interdisciplinary form: sensory coordination and physical education; Dutch; arithmetic and mathematics; English (compulsory for students aged 10-12); a number of factual subject areas, including geography, history, **science** (including **biology**), social studies (including politics studies), and ideological and religious movements; expressive activities, including developing the use of language, drawing, music, handicrafts, play and movement; self-reliance, including social and life skills; and healthy living. The **study of nature** (natuuronderwijs), which is part of the science curriculum, is available online, in Dutch, at http://www.dds.nl/~pdc/9221000/n/f5jf4tik.htm Although the subjects are compulsory, schools are free to decide how much time they devote to each subject. The school plan, drawn up biennially by the school, sets out the distribution of teaching over the (generally) eight years of primary education.
Sweden	In Sweden, all students in compulsory education, aged 6/7+, usually study science. More specifically, compulsory education is provided in one all-through school, the 'grundskola', for pupils usually aged 7-16. Some variations are permitted, that is, some children may start at age 6, others may defer entry to age 8. Compulsory education must, however, last nine years. The curriculum for the nine years of compulsory education comprises: art; craft; domestic science; English; language options; mathematics; music; sport and health; Swedish; Swedish as a second language; geography; history; religious studies; social studies; **biology**; **physics**; **chemistry**; and technology. The **science** curriculum is organised in subject-related (cross-disciplinary) blocks (known as 'subject blocks' in Sweden), and comprises **biology**, **physics** and **chemistry**. The total minimum teaching time for the whole nine compulsory years for **science** is 800 hours. This refers to **biology**, **physics**, **chemistry** *and* **technology**. Individual schools determine how these hours are allocated. Some schools, for example, allocate more hours to the teaching of Swedish and mathematics in the early years of the grundskola. Although the curriculum for the grundskola does not specify at what age certain subjects are to be studied, there are goals for science which pupils are expected to reach by the end of Years 5 and 9 of the grundskola (aged 11-12 and 15-16 respectively).

3. Is there a recognition of a problem regarding the relevance of the science curriculum? If so, is this regarded as a particular problem for certain groups of pupils (eg. certain age ranges, boys or girls at a particular age etc?) and are there any plans to deal with this?	
Australia - Queensland	According to our contacts in Queensland, the new (1999) science syllabus for Years 1-10 in Queensland (pupils aged 6-16) has attempted to address issues of relevancy and was widely accepted in the trial/pilot schools. It is conceptually based and the specific content of units of work can be selected by schools to be relevant to local contexts. The strand 'science and society' also enables an exploration of current issues. No particular group was identified as having particular needs in terms of relevance; it was seen as being an issue for the entire student group. Our contacts "suppose this issue is always of concern to curriculum specialists….but the very fact that Queensland has a newly developed Years 1-10 syllabus means that it is as up-to-date as the Queensland School Curriculum Council (the independent statutory authority responsible for curriculum development) can make it". It is perhaps significant that the science syllabus is the first of the new syllabuses in all of the eight nationally agreed Key Learning Areas (the arts, English, health and physical education (HPE), languages other than English (LOTE), mathematics, science**,** studies of society and the environment (SOSE), and technology) to be revised. (It is intended that reviews of the remaining seven will be completed within the next five years.)

Canada - Ontario	There appears to be no specific recognition of a problem regarding the relevance of the science curriculum in Canada generally, or Ontario in particular. However, it is perhaps significant that the common framework of science learning outcomes for all Canada was the first joint development programme initiated under the Pan-Canadian Protocol for Collaboration on School Curriculum. As this document states: "Canadian society is experiencing rapid and fundamental economic, social, and cultural changes that affect the way we live. Canadians are also becoming aware of an increasing global interdependence and the need for a sustainable environment, economy, and society. The emergence of a highly competitive and integrated international economy, rapid technological innovation, and a growing knowledge base will continue to have a profound impact on our lives. **Advancements in science and technology play an increasingly significant role in everyday life. Science education will be a key element in developing scientific literacy and in building a strong future for Canada's young people.** Consistent with views expressed in a variety of national and international science education documents, the following goals for Canadian science education have been established for the purposes of this framework. Specifically, science education aims to: • encourage students at all grade levels to develop a critical sense of wonder and curiosity about scientific and technological endeavours • enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives and the lives of others • prepare students to critically address science-related societal, economic, ethical, and environmental issues • provide students with a foundation in science that creates opportunities for them to pursue progressively higher levels of study, prepares them for science-related occupations, and engages them in science-related hobbies appropriate to their interests and abilities • develop in students of varying aptitudes and interests a knowledge of the wide variety of careers related to science, technology, and the environment." The introduction to the Ontario Curriculum for Science and Technology for pupils in Grades 1-8 (aged 6-14) explicitly states that: "occasionally, the fundamental theories, concepts and structures of science change but, for the most part, the basic ideas of science -ideas such as the cellular basis of life, the laws of energy, the particle theory of matter - have proven stable. …." "Science is not only a body of knowledge but 'a way of knowing'. Scientific investigation involves exploration, experimentation, observation and measurement, and analysis and dissemination of data. These activities require specific skills and habits of mind; for example, accuracy, discipline and integrity in the application of scientific principles are fundamental to scientific activity. The science and technology curriculum is designed to develop these skills and habits of mind. Technology is also 'a way of knowing' and a process of exploration and experimentation. Technological investigation involves the application of methods known as design processes, which in turn involve the use of concepts and procedures such as the identification of a need or problem, and the selection of a best solution."

./. **Canada - Ontario**	"Science and technology both exist in a broader social and economic context. They are affected by the values and choices of individuals and governments and, in turn, have a significant impact on society. The world as we know it today has been affected in many important ways by science and technology. For example, science has radically altered and expanded our understanding of earth and space, of the workings of the human body, and of the ways in which living thing interact; technology has revolutionised the way we communicate and made vast changes in our lives through the discovery of new drugs and materials. It is important, therefore, that students see science and technology in this wider context - as endeavours with important consequences for people - and that they learn to relate their knowledge of science and technology to the world beyond the school." Changes which have been introduced in the new (1998) curriculum for science and technology for pupils in Grades 1-8 (aged 6-14) include: • Combining the subject areas of science and technology, with some expectations focussing on science and some on technology, while others deal with relating science and technology to each other and to the world outside school • Introducing some concepts and skills earlier and giving them more rigorous treatment. For example, the particle theory and the distinction between heat and temperature, formerly taught in Grade 10 (pupils aged 15-16), are now introduced in Grade 7 (ages 12-13). • Including a greater number of technology concepts and processes and introducing these earlier. For example, the design process and control systems are now introduced in Grade 1, pupils aged 6-7. • Increasing emphasis on earth and space science, in keeping with expectations in other provinces. For example, the curriculum in Grade 6 (pupils aged 11-12) includes an introduction to astronomy (which has been an optional study topic in Grade 10, ages 15-16, in Ontario since 1987). • Increasing the emphasis on relating science and technology to each other and to the world outside school and on the need for sustainable development. The 1998 curriculum aims to increase pupils' understanding of the concept of sustainability by emphasising this in a variety of contexts. • Increasing emphasis on communication skills and the use of appropriate terminology. For example, pupils are expected to describe what they are doing by using the terminology associated with specific scientific and technological concepts. In a speech announcing the launch of the revised Ontario science curriculum for Grades 1-8 in 1998, the Education and Training Minister highlighted the key change to the curriculum as being the fact that, for the first time in the province's history, the curriculum for each Grade includes not only a theoretical science component, but also a technology component covering practical application of those theories. Indeed, in every Grade, pupils now study both scientific theory and technological applications. For example, in Grade 4, pupils learn about the theory of mechanical systems and they also learn about technologies that use this theory, such as bicycle gears and brakes. In addition, the revised curriculum addresses earth and space science; components which were missing from the previous curriculum.

./. **Canada - Ontario**	The revised (1999) curriculum for science in Grades 9 and 10 in Ontario (pupils aged 14-16) aims to 'achieve excellence in scientific literacy'. The introduction to the curriculum document for Grades 9 and 10 states that developing "scientific literacy is not the same as becoming a science specialist. The notion of thriving in a science-based world applies as much to a small business person, a lawyer, an elementary school teacher or an office worker as it does to a doctor, an engineer or a research scientist. While the specific knowledge and skills required for each of these occupations vary, the basic goal of thriving in a science-based world remains the same. Achievement of both excellence and equity underlies the goals of the new science programme at the secondary level. Accordingly, science courses have been designed for a wide variety of students, taking into account their interests and possible post-secondary destinations. Some courses have been designed to serve as preparation for specialist studies in science-related fields; others have been designed for students intending to go on to post-secondary education, but not to study science; others have been designed with the needs of the workplace in mind. Launching the revised curriculum for Grades 9 and 10 in 1999, the Minister noted that: "The new science curriculum provides all of Ontario's students with the opportunity to go beyond the science education of the past and aim for true scientific literacy…. These are the fundamental aims of the new curriculum…. And 1999 is none too soon to start teaching science this way". (This press release is available online at http://www.edu.gov.on.ca/eng/document/nr/99.03/second.html
France	According to our contact in the Ministry of Education in France, the national curriculum is updated fairly frequently in an attempt to keep up with fundamental changes occurring in the curriculum subject areas. There are no major differences between the different age groups or different sexes regarding science education, beyond what is recognised worldwide. However, it is observed that boys do slightly better at physics, which is regarded as the most difficult part of the science curriculum for all students.
Netherlands	Reforms of the subjects studied and the assessment procedures for all secondary school qualification courses (VBO and MAVO courses, taken by pupils aged 16; HAVO courses - students aged 17; and VWO courses - students aged 18) have recently taken place. See the responses to questions 1 and 4.
Sweden	Our contact in Sweden informs us that the science curriculum in Sweden has recently been reviewed; one of the reasons for this review was the fact that there was some concern that the curriculum might not be keeping pace with changes in science and technology. The review is very recent and curriculum changes have only recently been formulated. Papers are not yet available in English, but our contact will forward these on to us as soon as they are. On her return from the summer holidays (which take place in June and July in Sweden), she will also provide us with a translated summary of the key changes and concerns. She did highlight the fact that one of the other key concerns in reviewing the science curriculum had been to ensure the integration and inclusion of the various individual aspects of science education (chemistry, biology, physics etc.) in one fully integrated science subject area. Also worthy of note is the fact that the "Development Plan for Pre-schools, Schools and Adult Education 1999-2001" highlights key areas for action. One of these areas is increased investment in teaching training for a number of subjects, including **sciences** and technology.

4. With particular reference to science, are there current changes to the assessment of pupils between the ages of 5 and 16 (compulsory education)? If so, what are the reasons for the changes and are there any issues/problems regarding the introduction of new methods?	
Australia - Queensland	According to our contacts in Queensland, the new (1999) science syllabus for Years 1-10 in Queensland (pupils aged 6-16) is outcomes based. The advantages are seen as being that this sets out clear, public learning outcomes; has high expectations for all students; has a focus on development; is consistent with a learner-centred approach to education; and has assessment that focuses on what students know and can do with what they know. The major challenge for teachers is the change to an outcomes approach to education and assessment and reporting practices that are consistent with it. Assessment during compulsory level education in Queensland is generally school-based and without external examinations, although there are fairly rigorous reviews, monitoring and other checks and balances. Schools are required to develop a curriculum plan that, among other things, outlines the approach being taken to assessment and reporting. The Queensland Department of Education (Education Queensland) is currently working on some broad strategies to assist schools in modifying their assessment and reporting practices so that they respond more effectively to the outcomes-oriented curricula embraced by the new syllabuses such as the 1999 science syllabus. According to our contacts, the output from this work is likely to consist of examples, templates and materials to be included in workshops for school curriculum leaders. In addition, new National Goals for Schooling in the Twenty-First Century were determined and agreed in 1999. These refer to the eight Key Learning Areas (the arts, English, health and physical education, languages other than English, mathematics, **science**, studies of society and the environment, and technology. Commonly known as the Adelaide Declaration, these Goals are available in full at http://www.curriculum.edu.au/mceetya/nationalgoals As part of their commitment to the Adelaide Declaration, Ministers agreed to the following six areas of schooling for initial outcomes reporting: literacy; numeracy; student participation, retention and completion; vocational education and training in schools; **science**; and information technology. A new National Education Performance Monitoring Taskforce (MCETYA) has been established to progress the work on the national reporting of educational outcomes. Ministers have agreed that the Taskforce should: oversee and coordinate the work of any other groups concerned with the reporting of national comparable outcomes of schooling; develop key performance measures as the basis for national reporting in the agreed areas; identify areas where it may be appropriate to establish national targets or benchmarks in relation to the agreed key performance measures, which assist State- and school-level planning and reporting for improvement; and identify and recommend to MCETYA any additional agreed areas for the national reporting of comparable educational outcomes. Of note also is the fact that the States of Victoria, South Australia and Queensland recently set up a joint project - the Consistency Project in 1998. This initial six-month project aimed to support teachers in developing processes to reach consistent judgements about levels of student performance on tasks in English, **science** and mathematics in the middle years of schooling (Years 5-8, ages 10-13/14). Guidance and support materials are provided for this purpose.

Canada - Ontario	In Ontario, there are province-wide tests in maths, **science** and English in certain year groups. Such tests link to the curriculum learning outcomes. However, according to the Ontario Curriculum for Science and Technology in Grades 1-8, whereas previous curricula for science and technology for pupils in these Grades (aged 6-14) in Ontario focussed on outcomes for the end of Grades 3, 6 and 9 (pupils aged 8-9, 11-12 and 14-15 respectively) specifically - when pupils took tests in these subjects - , the current (1998) curriculum for pupils in Grades 1-8 in Ontario identifies knowledge and skills that students are expected to acquire in each Grade.
France	According to our contact in the Ministry of Education, there are no current changes to assessment arrangements for science. However, the national curriculum encourages teachers to evaluate pre-determined competencies (skills) within each subject area, including science.
Netherlands	The National Institute for Curriculum Development in the Netherlands (SLO) has developed new VBO and MAVO examination syllabuses (taken at age 16) which tie in with the 1998-2003 attainment targets for basic secondary education and the new learning pathways in the MAVO (see the response to question 1 in addition). The first examinations based on the new examination syllabuses will be taken in 2003. There has also been a new examination syllabus for every subject in HAVO (to age 17) and VWO (to age 18) courses since the 1998 reforms, which introduced the four specialist routes for HAVO and VWO courses (see the response to question 1 in addition). (In view of the amount of work involved in introducing the new syllabuses, schools were allowed to postpone introducing the new examination until 1 August 1999.) The new HAVO and VWO school-leaving examinations are in two parts: a national examination held in the final year and a component organised by the school, known as the school exam. For some subjects there is a school exam only. The school exam usually takes the form of an examination portfolio comprising various elements as documented in a form decided upon by the school, for example a list of grades/marks or examples of project work. The requirements to be met by the school exam are set out in the examination syllabus and cover all the elements that make up the examination portfolio for each subject. The separate elements of the school exam are not all scheduled for the final year. Each school can decide when the various parts of the exam are to be held. The national examination consists of the same questions - or questions of an equivalent degree of difficulty - for all students and is assessed against national standards. National examinations are held in Dutch, English and all other subjects included in the four fixed subject combinations. Courses in subjects chosen as part of the optional component are concluded, in principle, with an examination portfolio.
Sweden	Please see the response to question 3. Changes may ensue from the recent review of the science curriculum.

5. Are there any good examples of the teaching of contemporary science?	
Australia - Queensland	According to our contacts in the Queensland Department of Education (Education Queensland), a best practice web site for science is currently being developed. It is intended that this will be available by the end of 2000. Access Education - a division of Education Queensland - is developing this part of Education Queensland's web site (http://education.qld.gov.au) Our contacts further comment that the new (1999) science syllabus for Queensland reflects current thinking in science education including a constructivist approach, being socially oriented and embedding the processes of working scientifically. Associated 'science sourcebook modules' - providing teaching and learning ideas, activities, resource materials, information regarding assessment strategies and background and reference material to support the implementation of the Years 1-10 (ages 6-16) science syllabus can be accessed via the Queensland School Curriculum Council web site at http://www.qscc.qld.edu.au/kla/science/
Canada - Ontario	A web site - **Edulinks** - has recently been set up in Ontario with the aim of linking educators to engaging and relevant internet-based resources that correlate directly to the new Ontario Curriculum expectations. Each subject area is assigned an online guide. This guide is a teacher with expertise in that subject area who researches the internet-based resources relevant to their curriculum area on an on-going basis and provides the best sites available through the web-link. The online teacher guide is also available online to answer questions and provide help and suggestions for teaching in the classroom. A conference area for each subject has been created for just this purpose. The science Edulinks site is available at http://www2.tvo.org/edulinks/subject_science.html

France	There are no widely recognised examples of good practice in the teaching of contemporary science. However, the Ministry has recently set up the "La Main a la Pate" scheme, which emphasises the experimental side of science. The mission of the "La Main à la Pâte" web site is to aid science teaching by providing resources and ideas for scientific activities in class and providing examples of best practice. The web site is located at http://www.inrp.fr/lamap The La Main a La Pate scheme was initiated by Nobel Prize winner Georges Charpak. On 20 June 2000, Jack Lang, the Education Minister, in a statement given at a press conference on primary education, encouraged the use of this method of teaching science. He also announced the launch of an initiative to improve the teaching of science to pupils in the final three years of primary education (aged 8-11). This will involve encouraging more 'hands-on' experimentation/discovery for pupils; encouraging pupils to look at science in real life situations; encouraging pupils to learn scientific procedures and processes; and improving pupils' ability to describe the processes they see, to make assumptions/hypothesise and to express their thoughts. A national committee on primary science education is being established; additional government funding is being provided for in-service teacher training and for the provision of scientific equipment/materials; and the Main a la Pate web site is to be further developed. The full text of Monsieur Lang's press conference speech (in French) is available at http://www.education.gouv.fr/discours/2000/primaire.htm
Netherlands	No data on contemporary science teaching methods is available via the *INCA* Archive. Our contacts were unable to supply additional data.
Sweden	There are no obvious examples of widely recognised good practice in the teaching of contemporary science. Our contact in Sweden was unable to provide additional data.

Further information on the revised (1999) science syllabus for Years 1-10 (ages 6-16) in Queensland, Australia, can be obtained from Mr Mark Snartt, Principal Project Officer, Queensland School Curriculum Council (QSCC). His e-mail address is Mark.Snartt@qscc.qld.edu.au

Additional Information

Evaluation of the teaching-learning process	
Netherlands	Our contact in the Netherlands has provided additional information on a recent evaluation of the teaching-learning process. Although this information does not fit specifically into the above questions, it may nevertheless be of interest. In 1999, the Dutch Inspectorate evaluated the teaching-learning process in the first cycle of secondary education (*basisvorming*, students aged 12-16). Reports have been published for each curriculum subject, including **biology** and **chemistry and physics**. The subject reports are available online, in Dutch, at:

	http://www.owinsp.nl/producten/werk-aan-de-basis/home.html?vakrapporten-cont.html http://www.owinsp.nl/producten/werk-aan-de-basis/home.html?downloaden.html One of the evaluation questions was: *To what extent does the actual subject matter cover the subject-specific attainment targets?* Conclusions of the evaluation: in physics/chemistry only 44% of the schools completely covered the attainment targets and 80% coverage was reached by 81% of the schools. In biology only 38% of the schools completely covered the attainment targets and 80% coverage was reached by 67% of the schools. Another of the evaluation questions was: *Is the teaching methodology strategy used by the teacher in agreement with the general objective of the subject and with the other demands that are being placed on the subject?* For physics and chemistry, the indicators which formed the basis of the evaluation were whether: - The teacher encourages students to relate phenomena and events taking place in their every day environment to chemistry principles and contexts. - The teacher encourages students to be able to recognise applications of physics and chemistry in technology. - The teacher encourages students to see those applications in a historic or global context. - The teacher encourages students to be able to relate social or environmental effects to applications of chemistry and physics. - The teacher allows students to do practical laboratory sessions in which the preparation, execution and processing are seen as essential parts of the exercise. - The teacher makes effective use of educational resources (including models, videos and computers). For biology, the indicators which formed the basis of the evaluation were whether: - The teacher encourages students to relate biological principles and contexts to phenomena and events taking place in their every day environment. - The teacher encourages students to learn how they can apply the biological knowledge acquired in their every day lives and how they can recognise this in a social context. - The teacher encourages students to see the relationship between biological processes. - The teacher allows students to do practical laboratory sessions in which the preparation, execution and processing are seen as essential parts of the exercise. - The teacher makes effective use of educational resources (including biological models such as torso, flower and cell, wall posters, videos, felt-boards and computers). The indicators were scored after classroom observation and an interview with the teacher. Conclusions of the evaluation: in 53% of the schools the teachers' subject-related teaching approach has been satisfactory assessed for

	physics/chemistry, and in 56% of the schools the teachers' subject-related teaching approach has been satisfactory assessed in biology.

Authors: Sharon O'Donnell and Catherine Micklethwaite, National Foundation for Educational Research (NFER), June 2000.
Unless otherwise stated, information is sourced from the international review of curriculum and assessment frameworks archive (*INCA*), online at http://www.inca.org.uk

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[i] **Australia**: In 1991, Commonwealth and State Ministers for Education decided that national Statements and Profiles would be developed for eight broad Key Learning Areas. The statements provide a framework for curriculum development which can be used in conjunction with school and system policies. The eight Key Learning Areas, which are applicable throughout the compulsory education phases, are: the arts, English, health and physical education (HPE), languages other than English (LOTE), mathematics, science**,** studies of society and the environment (SOSE), and technology. The above subjects are not compulsory for all Australian schools, but all States and Territories have adopted the eight Key Learning Areas as the basis of curriculum development.

[ii] **Canada**: Throughout Canada, the study of language, mathematics and (general) science is usually compulsory up to Grade/Year 9 or 10 (ages 14/15 or 15/16); in some provinces this requirement includes Grade 11.

[iii] **Australia**: In 1991, Commonwealth and State Ministers for Education decided that national Statements and Profiles would be developed for eight broad Key Learning Areas. The statements provide a framework for curriculum development which can be used in conjunction with school and system policies. The eight Key Learning Areas, which are applicable throughout the compulsory education phases, are: the arts, English, health and physical education (HPE), languages other than English (LOTE), mathematics, science**,** studies of society and the environment (SOSE), and technology. The above subjects are not compulsory for all Australian schools, but all States and Territories have adopted the eight Key Learning Areas as the basis of curriculum development.

[iv] **Canada**: Throughout Canada as a whole, the elementary level curriculum (students usually aged around 6-13+) generally emphasises the basic subjects of: language; mathematics; social studies; introductory arts; and **general science**.