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Australia

Basic Structure of the Educational System

The Commonwealth of Australia with a population of about 20.7 million based on the 2006 census data [1] comprises six States [New South Wales (NSW), Queensland QLD), South Australia (SA), Tasmania (TAS), Victoria (VIC) and Western Australia (WA)] and two Territories [Australian Capital Territory (ACT) and Northern Territory (NT)]. There are about 3.4 million pupils and about 240,000 teachers in 9,217 schools throughout Australia [1]. School education is compulsory between the ages of 6 and 16 (Year 1 to 10) and comprises 13 years with slight variations between States and Territories. It includes:

- a preparatory period of 1–2 years before Year 1: not compulsory but almost universally undertaken
- primary schooling: 6 or 7 years – Years 1–6 or 1–7
- secondary schooling: 5 or 6 years – Years 7–12 or 8–12

Details of each category of schooling years are summarized in table 2 [2]. In addition to the end of schooling qualifications shown in table 2, at the end of Year 12, pupils in all States and Territories sit for university entrance examination prepared independently of the school system.

A summary of school enrolments and staffing is provided in table 1 based on the 2006 census data [1].

Table 1: Total number of schools, pupils and teachers in Australia in 2006

School level	**Number of Schools**	**Number of pupils**	**Number of Teachers**
Primary	6,558	1, 938.8	121,215
Primary & Secondary combined	1,181	--*	--*
Secondary	1,478	1,453.8	118,424
Total	**9,217**	**3,392.6**	**239,639**

Note: * The number of teachers has been included in the relevant sections for primary and secondary; similarly for the number of pupils.

The six States and two Territories in Australia and the Federal Government (Commonwealth of Australia) have joint responsibility for implementing educational initiatives in the respective States and Territories. The school year comprises four terms, each of 10 weeks interspersed by breaks, the longest from December to January during the Australian summer.

Table 2: Schooling years in the six States and two Territories in Australia

States/ Territories	**Pre-primary**	**Primary school**	**Secondary school (including senior secondary school)**	**Qualification**
ACT	Pre-school Kindergarten	Years 1-6	Years 7-12	ACT Year 12 Certificate
NSW	Pre-school Kindergarten	Years 1-6	Years 7-12	Higher School Certificate (HSC)
NT	Pre-school	Years 1-6	Years 7-12	NT Certificate of Education (NTCE)
QLD	Kindergarten	Years 1-7	Years 8-12	QLD Certificate of Education Senior Statement QLD Certificate of Individual Achievement
SA	Pre-school Reception	Years 1-7	Years 8-12	South Australian Certificate of Education
TAS	Pre-school Reception	Years 1-6	Years 7-12	Tasmanian Certificate of Education
VIC	Pre-school Reception	Years 1-6	Years 7-12	Victorian Certificate of Education (VCE) Victorian Certificate of Applied Learning
WA	Kindergarten Pre-Primary	Years 1-7	Years 8-12	Western Australian Certificate of Education

Science in the Compulsory Schooling Years (Years 1–10)

A major national educational initiative was commissioned by the Australian Education Council (AEC) in 1989 to develop national statements and profiles in eight broad curriculum areas, one of which was science. The AEC comprised the education ministers from the States, Territories and the Commonwealth of Australia. The result was the publication of two documents by the Curriculum Corporation in 1994 [3, 4]. These documents provided a framework for curriculum development with emphasis on a pupil-centred social-constructivist approach to teaching and learning. The statements for the science learning area were structured in four strands, 'Earth and Beyond', 'Energy and Change', 'Natural and Processed Materials', and 'Working Scientifically'. The first three strands are concept-based while the fourth strand is process-based.

Since pupils learning progressed at different rates, eight levels of achievement were described for each strand, and pupils' achievement was described by learning outcomes in place of a rigid syllabus content that teachers were expected to implement. Chemistry (as well as other science disciplines) is not taught as a separate subject in the compulsory schooling years from Years 1–10. Instead, several topics relating to chemistry that involve understanding of chemical phenomena and concepts to varying degrees, are incorporated in the science curriculum on a term-by-term basis within the four strands referred to above.

When it came to implementing this curriculum initiative, each of the States and Territories decided to develop their own curriculum documents that were broadly based on the Curriculum Corporation documents referred to above [3, 4]. Over the years, however, these curriculum documents have diverged considerably. A study of the key organisational features of the science curriculum in each of the States and Territories was recently undertaken by Dawson and Venville [5]. A summary of these key organisational features has been adapted from their paper and summarized as follows:

Australia

Conceptual strands:

Earth & Beyond, Energy & Change, Life & Living, Natural & Processed Materials

Process strand:

Working Scientifically

Australian Capital Territory

Conceptual strands:

1. The Earth and Beyond – Earth, sky and people; The changing Earth; Our place in space
2. Energy & Change – Energy & us; Transferring energy; Energy sources & receivers
3. Life & Living – Living together; Structure & function; Biodiversity & change
4. Natural & Processed Materials – Materials & their uses; Structures & properties; Reactions & change

Process strand:

1. Working Scientifically – Investigating; Using science; Acting responsibly

New South Wales

Years K – 6 Science & Technology

1. Knowledge & Understanding - Built environments; Information & communication; Living things; Physical phenomena; Products & services; The Earth & its surroundings
2. Skills - Investigating; Designing & making; Using technology
3. Values & Attitudes - Towards themselves; Towards others; Towards science & technology

Years 7–10 Syllabus

1. Knowledge & Understanding – History, nature & practice of science; Applications & uses of science; Implications of science for society and the environment; Current issues; Research & development; Models, theories & laws; Structures & systems; Interactions
2. Skills – Planning investigations; Conducting investigations; Communicating information & understanding; Scientific thinking; Working individually & in teams
3. Values & attitudes

Queensland
Outcomes – Science & Society; Earth & Beyond; Energy & Change; Life & Living; Natural & Processed Materials

Northern Territory
1. Concepts & Contexts – Natural & Processed Materials; Life & Living; Energy & Change; Earth & Beyond 2. Working Scientifically – Planning; Investigating; Evaluating; Acting responsibly; Science in society

South Australia
Science strands – Energy & Space; Energy systems; Life Systems; Matter

Tasmania
1. Essential learning & culminating outcomes – Thinking (inquiring & reflective thinkers); Communicating (effective communication); Personal Futures (self directed & ethical people); Social Responsibility (responsible citizens); World Futures (world contributors) 2. Key element Outcomes – Inquiry; Investigating the natural & constructed world; Understanding systems

Victoria
1. Biological Science – Living together, past, present & future; Structure & function 2. Physical Science – Energy & its uses; Forces & their effects 3. Chemical Science – Substances: structure, properties & uses; Chemical reactions 4. Earth & Space Sciences – The changing Earth; Our place in space

Western Australia
1. Working Scientifically – Investigating; Communicating scientifically; Science in daily life; Acting responsibly; Science in society 2. Understanding Concepts – Earth & Beyond; Energy & Change; Life & Living; Natural & Processed Materials

In the curriculum framework for primary schools that was developed in Western Australia, for example, ‘pupils learn to investigate, understand and communicate about the physical, biological and technological world and value the processes that support life on our planet. Science helps pupils to become critical thinkers, by encouraging them to use evidence to evaluate the use of science in society and the application of science in daily life’ [6].

As an example of the chemistry content in the science curriculum we provide an overview of the Western Australia curriculum for the compulsory schooling years. In the ‘Working Scientifically’ strand pupils plan and conduct investigations, collate and analyse data, and evaluate their findings. Pupils have opportunities to use apparatus and chemicals commonly encountered in the chemistry laboratory in order to carry out chemical reactions, make observations and deductions relating to their investigations. In the ‘Earth and Beyond’ strand pupils are introduced to minerals and ores and the chemical principles involved in the extraction of metals. The ‘Energy and Change’ strand introduces pupils to energy changes in chemical reactions. The ‘Natural and Processed Materials’ strand is the most significant in terms of coverage in chemistry. It involves understanding that the structure of materials determines their properties and that the processing of raw materials results in the production of new materials with different properties and uses. The chemistry curriculum relating to this strand therefore involves the basics of chemistry beginning with ideas of elements, compounds and mixtures, the atoms, molecules and ions in these substances, chemical symbols, formulas and equations and types of chemical reactions, to name just some of the several areas and concepts in chemistry, understanding of which is essential to be able to appreciate the influence of the structure of materials on their properties and uses.

As a result of the absence of a formal science syllabus (as opposed to a curriculum framework) in all States and Territories (with the exception of NSW), it is only possible to deduce a limited number of chemistry topics that are common to all science curricula. Several of the topics requiring understanding of relevant chemistry concepts that are covered in the compulsory years of schooling are summarised in figure 1.

Elements, compounds and mixtures
Metals, non-metals, alloys
States of matter and changes of state
Kinetic particle theory of matter
Atoms, molecules, ions
Acidic and basic oxides
Separation techniques, e.g. filtration, distillation etc.
Physical changes (e.g. changes of state, dissolution)
Chemical symbols and formulas
The Periodic Table
Chemical bonding and structure
Chemical equations
Chemical changes (e.g. combustion, neutralisation, oxidation, reduction)
Acids and bases
Reversible and irreversible changes
Corrosion of metals
Energy changes in chemical reactions
Rates of chemical reactions and factors affecting the rate
Manufacturing processes (e.g. ammonia, fibres, sewage treatment)
Fuels
Greenhouse effect
Rocks and minerals – extraction of metals
Materials and their properties and uses

Figure 1: Sample of chemistry topics covered in the compulsory schooling years (Years 1–10) in Australian schools

Chemistry in the Post-compulsory Schooling Years (Years 11–12)

Chemistry is taught as a separate subject only in the post-compulsory years (Years 11–12). In a mapping exercise of the content covered in the Years 11–12 chemistry curricula that was conducted by the Australian Council of Educational Research there was found to be considerable consistency with 85–95% of the curriculum content common to all the States and Territories [7]. The same topics are covered in the chemistry curricula of almost all the eight jurisdictions except for ‘Analytical Techniques’ and ‘Gases in the Atmosphere’. The content of the curricula refers to the knowledge, skills and understandings that the pupils are expected to acquire and it is quite likely that the contents of a common topic are interpreted in a similar manner by teachers in general. The common topics that are studied (together with sub-topics or themes, where appropriate) in nearly all States and Territories are listed in figure 2. The analysis was done based on the information provided in the chemistry syllabuses.

1 Atomic structure
- Historic development of the atomic theory
- Periodicity, periodic table
- Chemical bonding

2 Structure of materials
- Properties and uses of substances
- Aqueous chemistry
- Gases and the atmosphere

3 Stoichiometry

4 Quantitative chemistry
- Analytical techniques

5 Reactions and equations
- Acids and bases

6 Equilibrium

7 Thermochemistry
- Energy, enthalpy
- Rates of reactions

8 Electrochemistry
- Oxidation & reduction
- Redox potentials
- Faraday’s Laws
- Metal reactivity

9 Organic chemistry
- Nomenclature
- Functional groups
- Biochemistry

Figure 2: Mapping of chemistry content in Years 11–12 across Australia

The chemistry content covered in Years 11 and 12 is defined in a syllabus issued by the education authorities of the States and Territories. As an example, the rationale of the chemistry programme in the Western Australian chemistry syllabus issued by the Curriculum Council of Western Australia [8] is outlined as follows:

– The subject is intended to enable pupils to understand and interpret the chemistry of their surroundings and appreciate the impact of chemical knowledge and technology on society.
– The subject attempts to provide a balance between useful facts, important concepts and theories in order to facilitate an understanding of the properties of substances, reactions and processes.
– Where appropriate, the physical and chemical properties of substances are related to important uses. Some emphasis is placed on important industrial processes and their impact on society.

– Laboratory work is an essential part of the syllabus with the view to providing opportunities for learning and testing concepts and principles by investigating the properties and reactions of substances.

The objectives of the chemistry curriculum in Years 11 and 12 are geared towards enhancing pupils' (1) knowledge, understanding, and intellectual skills in several areas in chemistry, (2) manipulative skills associated with laboratory work, while at the same time, having confidence in handling safe and dangerous chemicals, and (3) affective attitudes towards chemistry.

Taking Stock of the Australian School System

Overall impressions and outcomes of the Australian school system are generally very positive but there are a number of inequities within the system. Schooling is generally high on the political agenda but there is much room for political action that has so far not been forthcoming.

– As a federation of states, Australians pay their taxes to the federal government which then provides money to the States and Territories for supporting state schools, public hospitals and infrastructure such as roads. Australian States and Territories also have a range of private schools that are supported by federal government grants and fees paid by parents.
– Despite public education being free of tuition fees, around 35% of all pupils in primary and secondary schools attend private schools. These private schools range from elite schools with high fees – typically single sex schools for boys and for girls, to a middle range of fee-paying private schools, a large school system supported by and affiliated with the Catholic Church, and lastly other private schools, most of which have a particular religious orientation. The elite private schools typically have pupils performing well in university entrance examinations. The previous conservative government encouraged the growth of private schools arguing that taxpayers would be overall better off. There is much discussion about the best way to allocate funding for education.
– The current federal government proposes a national curriculum and a consultative document is now available. What form this national curriculum will take is the subject of debate in committees in each of the States and Territories and will most likely be based on three interrelated elements – science understanding, science inquiry skills and science as a human endeavour [9]. As indicated previously, in upper school already there is more than 85% similarity between the curricula of the States and Territories.
– Despite Australian pupils performing comparatively well on international tests such as PISA and TIMSS, there is a large variation within the pupil sample with mean achievement scores being highest in metropolitan areas and correspondingly lower in regional, remote and very remote areas [10]. That the PISA

and TIMSS scores are high is because a very high percentage of schools are in metropolitan areas.

– In reading literacy, mathematical literacy and scientific literacy, Australian indigenous pupils performed at a lower level than non-indigenous pupils and were below the OECD mean. Australian female indigenous pupils outperformed indigenous males in reading literacy but there were no differences between Australian indigenous male and female pupils in mathematical literacy and scientific literacy [11].
– All States except Queensland and the ACT have an externally set examination process at the end of Year 12 that serves as university entrance. These examination papers are scored by two or three markers external to the school with overall monitoring by an agency independent of the school system; in WA this agency is called the Curriculum Council.
– There are only small achievement differences between immigrant and Australian pupils who attend schools with similar resources and geographic location [12].

Taking Stock of Current Chemistry Instruction

Decreasing interest in school chemistry

The PISA data show that Australian pupils are among those pupils who have a low general interest in science (which includes chemistry for 15-year-olds) as a subject to be studied, being ranked 54th (the fourth lowest country) [10]. Other research supports these findings of science not being enjoyable [13] and not being presented in an engaging manner, being transmission of content by expert sources – teachers and texts – to relatively passive recipients [14].

Decreasing enrolment in upper school chemistry

One of the four main crises in Australian science education [15] is decreasing participation in post-compulsory science subjects, especially in the enabling sciences of physics, chemistry and higher mathematics. According to longitudinal surveys, in Year 12 [16], the number of Australian pupils selecting science subjects declined in the years to 2001, dropping from 22.6% in 1993 to 17.8% in 2003. However, this change is not consistent across all States and Territories; in Western Australia from 2002 to 2007 pupil numbers enrolling in the chemistry university entrance examinations has remained stable [17].

Only minor changes in the orientation of the subject matter

Chemistry courses in all States and Territories are continually being developed and revised. However these developments largely maintain the structure of a typical chemistry syllabus with more emphasis on differentiating macro and sub-micro properties. There has not been a strong development to a context-based approach.

Training Chemistry Teachers at the University

Most States and Territories require at least four years of university education for prospective primary and secondary school teachers. Teacher education programmes consist of (1) professional studies (theoretical knowledge and skills), (2) curriculum studies (subject knowledge and pedagogical skills), and (3) practical training (supervised professional experience for 12 to 20 weeks) [2]. As teachers in primary schools are generally not subject specialists, the programmes provide a balance of professional and curriculum studies that could help teachers in fostering the intellectual, physical and social development of children. For secondary school chemistry teachers, the programmes provide an integration of professional and curriculum studies in one or two disciplines, one of which would be chemistry. A wide range of chemistry programmes is provided by several universities in Australia. At Curtin University of Technology in Western Australia, for example, a four-year fulltime programme leading to a Bachelor of Education (Primary Education) degree is provided. The course includes core studies, professional practice units and elective units. In the third year pupils are selected for the honours programme or continue with the standard course.

Chemistry teachers in secondary schools generally obtain a Bachelor of Education (Secondary Education) degree with specialisation in chemistry. The four-year course at Curtin University of Technology, for example, prepares teachers to teach pupils aged twelve and above. During the first three years prospective chemistry teachers will study chemistry and at least another secondary science or mathematics school learning area. In the third year pupils are selected for the honours programme (which includes a research project) or continue with the standard course.

Summary and Prospects

The data about science education in Australia and chemistry education in particular, presents a mixed and in some ways hard to interpret picture. Australian pupils at both primary and secondary levels score among the best performing nations in international tests such as PISA and TIMSS. At primary school level, children are reported to enjoy science but at secondary level, data show that the majority of pupils do not enjoy school science. How to explain this situation? One possible answer, as indicated earlier in this chapter, is that for the past 20 years, science teachers have experienced ongoing changes in science curricula, assessment and monitoring of pupils' progress. The implementation of these changes has enabled Australian pupils to maintain high levels of self-efficacy in science (i.e., use their science knowledge in everyday situations to make sense of new information) despite having relatively low levels of interest and enjoyment in school science [10]. The challenge for science educators and chemistry educators in particular, is to provide lessons for learning that address these concerns. The current federal government proposed national curriculum may come some way in addressing this challenge.

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