VICTORIAN RESPONSE TO 2012 AUSTRALIAN CURRICULUM SENIOR SECONDARY CONSULTATION

Prepared by:
Victorian Curriculum and Assessment Authority

in partnership with and on behalf of:
Department of Education and Early Childhood Development
Catholic Education Commission Victoria
Independent Schools Victoria

September 2012

Contents

1. EXECUTIVE SUMMARY

(a) GENERAL

1. The Victorian Curriculum and Assessment Authority, in partnership with the Victorian Department of Education and Early Childhood Development, the Catholic Education Commission Victoria and Independent Schools Victoria, welcome the opportunity to comment on the draft senior secondary Australian Curriculum.
2. This submission is based on feedback provided by stakeholders through the consultation processes outlined in section 2.
3. A feature of the consultation was the broad lack of engagement from Victorian teachers, especially in contrast to the high level of interest shown in the 2010 consultation. This was in part the result of industrial action commenced by the Victorian Branch of the Australian Education Union. It may also have been a result of varying degrees of 'consultation fatigue', frustration that feedback provided in 2010 appeared not to have been acted on, a sense that the long timelines involved in the development of the senior secondary curriculum meant the consultation lacked an immediate imperative, and a lack of clarity about how the proposed courses might be implemented in Victoria, given that the proposed structure of the content and achievement standards does not have a present equivalent within the Victorian Certificate of Education (VCE) or the Victorian Certificate of Applied Learning (VCAL).
4. Nevertheless, clear views about the documents were expressed by key stakeholders, and these views have informed the development of this response.
5. Victoria welcomes the evolving model of senior secondary curriculum development as part of the Australian Curriculum. We note in particular the following statement made by ACARA in the preamble to the consultation drafts:

   States and territories, through their respective curriculum, assessment and certification authorities, will continue to be responsible for implementation of the senior secondary curriculum, including assessment, certification and the attendant quality assurance mechanisms. Each of these authorities acts in accordance with its respective legislation and the policy framework of its state government and Board. They will determine the assessment and certification specifications for their courses that use the Australian Curriculum content and achievement standards and any additional information, guidelines and rules to satisfy local requirements.

6. We welcome this clear agreement about current arrangements, that is, that senior secondary certification will remain the responsibility of individual states and territories.
7. The understanding and assumption that has therefore informed the approach taken to this consultation exercise in Victoria is that the VCE and VCAL will continue to be provided as the senior secondary qualifications in Victoria for the foreseeable future.
8. However, there is considerable uncertainty about future arrangements. This is in part the result of the Australian government's commitment to the introduction of an Australian Baccalaureate without any accompanying clear statement of

purpose, structure or certification arrangements. It is also the result of the absence of any clear agreement on the impact of the development of common national content for senior secondary courses on the current different policies and practices related to the assessment and reporting of student achievement currently in place in the different states and territories.

9. This current consultation process on the senior secondary curriculum has therefore taken place in a context characterised by an absence of agreement about key features of senior secondary curriculum, assessment and certification, in particular the rationale for any use of generic achievement standards.
10. The same preamble cited earlier notes:

    These draft documents should not, therefore, be read as proposed courses of study. Rather, they are presented as draft content and achievement standards that will provide the basis for senior secondary curriculum in each state and territory in the future. Once approved, the content and achievement standards would subsequently be integrated by states and territories into their courses.
11. Stakeholders have, however, in their reading of the draft documents clearly (and quite reasonably) interpreted the five point achievement scale as a five point reporting scale.
12. At present, Victorian candidates for the VCE receive a grade based on an eleven-point scale for each graded assessment task.
13. In our view, there is at present neither agreement nor a compelling case that the inclusion of a five point achievement scale would be a constructive modification of or addition to existing assessment and reporting arrangements at the senior secondary level in Victoria.
14. There are a number of design problems associated with the inclusion of the proposed five point achievement scale. These include the lack of consistency with the approach taken at F-10, where a single general indication of the expected level of student achievement in relation to the content descriptions is provided.
15. The inclusion of a five point scale design implies, or at least has clearly been taken by respondents to imply, a move to nationally consistent reporting of student achievement at the senior secondary level. Victoria, at this stage, neither supports nor opposes such a move. However, an explicit commitment to such a move has not been made by SCSEEC, and so it is premature to move in a direction that implies an implicit commitment.
16. Given this, Victoria proposes that consideration be given to the removal of the achievement standards in their present form from the draft curriculum documents.
17. Instead, much greater attention should be given to addressing a consistent theme in the feedback which was a lack of clarity about the level of depth and complexity the students would be expected to demonstrate in relation to the draft content.
18. This would mean the content could be rewritten to describe the expected level of demand in a single, integrated statement. This would more clearly leave reporting arrangements to the states and territories and so would be a much

more accurate reflection of the statements cited above from the consultation documents.

19. The key questions addressed in this report, then, are as follows:
    a. On the basis of views obtained from Victorian stakeholders through the consultation process, what aspects of the proposed courses might represent an improvement of or development on Victoria's current courses?
    b. What aspects of the courses might represent a diminution in the level of demand currently made by Victorian courses?
20. We note that, in the event that national agreement on common content for the fifteen subjects currently under development is reached as planned at the end of this year, the process for the review and reaccreditation of VCE subjects in Victoria is a twelve month process. Schools are then provided with twelve months' notice of changes to VCE subjects. This means that the earliest possible date for the introduction of new subjects in Units 1 and 2 would be 2015, with Units 3 and 4 to follow in 2016.
21. It may also be the case that Victoria may determine to introduce some but not all of the proposed senior secondary courses. This applies in each of the four main subject areas.

(b) ENGLISH

22. In the English learning area, the draft curriculum proposes that four subjects are introduced: English, Literature, EAL/D and Essential English.
23. There is no content proposed in the draft documents that is not currently included in the suite of existing senior secondary English courses, with the exception of the proposed Essential English course at Units 3 – 4. We note that Victoria currently offers English Language as a VCE subject, and this does cover content not included in any of the proposed Australian Curriculum subjects. English Language will continue to be offered as a VCE subject.
24. However, the clear view of stakeholders was that the current suite of Victorian English subjects provides greater distinctiveness and clarity of purpose, especially in relation to the distinction between English and Literature.
25. Victoria does not currently offer a course at Units 3 – 4 level equivalent to the proposed Essential English. The purpose of this course, however, remains unclear. It appears to be a course designed to provide access to a senior secondary English subject for students who do not have the level of literacy that would enable them to undertake the English subject. This is implied rather than made explicit in the current course description. If this is indeed the purpose of the course, this should be made clear and explicit.
26. This is an approach that may well have merit, and needs to be considered given the national school completion retention targets.
27. However, it poses clear policy issues in relation to the level of literacy that should be accepted as a minimum requirement for completion of a senior secondary certificate.
28. It may well be that a subject such as the proposed Essential English course provides a *de facto* measure of an agreed minimum literacy level required for successful completion of a senior secondary certificate in Australia.

29. This is an important issue that has been usefully highlighted through the consultation process, and merits considerable further discussion at the national level.
30. It may be that Victoria will revise the current Literacy and Numeracy components of the Victorian Certificate of Applied Learning (VCAL) using the Essential English course as a point of reference rather than introducing this subject as part of the VCE suite.
31. A further issue of significance to emerge through the consultation process was that of provision for EAL/D students.
32. The draft EAL/D subject was generally viewed as a coherent course which develops appropriately across the eight units. It was, however, regarded as a course that primarily meets the needs of students who come to the course with some level of literacy in a language other than English. Careful further consideration needs to be given to the possible introduction in the senior secondary suite of subjects of a subject focussed on the development of English literacy skills for students who have little or no existing literacy in any language (the role of the proposed 'Bridging Units' in the EAL/D in this regard was regarded as unclear).

(c) MATHEMATICS

33. In the Mathematics learning area, it is proposed that four subjects are introduced: Essential Mathematics; General Mathematics; Mathematical Methods and Specialist Mathematics.
34. Similarly to the case with English, while there are differences in emphases and weighting of content, a substantial majority of content in the proposed drafts is currently included in the existing suite of Mathematics in Victoria, with the exception again that Victoria does not at present have an equivalent course to the proposed Essential Mathematics subject at Unit 3 – 4 level.
35. However, the current structure of the Mathematics subjects in Victoria is regarded by stakeholders as providing greater flexibility and more accessible and clearer pathways for students in choosing Mathematics programs most suitable to individual aptitude and aspirations.
36. The proposed Essential Mathematics course appears to be designed as a subject that provides access to the study of mathematics as part of senior secondary schooling for students who do not have the ability to undertake one of the other three more demanding Mathematics subjects.
37. Currently in Victoria, 92% of students include at least one unit of Mathematics in their senior secondary program of study, and 78% of students include at least one unit 3-4 sequence in their senior secondary program.
38. The current three Mathematics subjects in Victoria (Further Mathematics, Mathematical Methods and Specialist Mathematics) are all subjects that demand a high level of mathematical competence, and yet students are undeterred from including mathematics in their senior secondary programs.
39. A clear risk for Victoria in introducing a less demanding Mathematics subject is that the current pattern of students enrolling in more demanding levels of Mathematics would shift to students enrolling in the less demanding level of Mathematics.

40. This would run counter to current policy settings in Victoria, and indeed nationally, which are designed to produce exactly the opposite impact, that is, encouraging and enabling greater numbers of students to undertaken more difficult and demanding levels of Mathematics and Science.
41. Nevertheless, the inclusion of this kind of subject at the senior secondary level may provide access to further learning in Mathematics for students who have not developed the skills and knowledge that would enable them to undertake one of the three more demanding subjects. As with Essential English, an Essential Mathematics course may provide a *de facto* measure of an agreed minimum numeracy level required for successful completion of a senior secondary certificate in Australia.
42. This in turn would raise a further policy issue for Victoria and other states where the study of English (or literacy) is a compulsory component of senior secondary programs but the study of Mathematics (or numeracy) is not.
43. As with the questions raised by the proposed Essential English subject, this is an important issue usefully highlighted through the consultation process that merits considerable further discussion at the national level.
44. It may be that Victoria will revise the current Literacy and Numeracy components of the Victorian Certificate of Applied Learning (VCAL) using the Essential Mathematics course as a point of reference rather than introducing this subject as part of the VCE suite.

(d) HISTORY

45. In the History learning area, two subjects are proposed: Ancient History and Modern History.
46. Stakeholder response to the proposed Ancient History course was relatively positive.
47. The content covered by the proposed Modern History course is currently covered variously in the VCE through Australian History, Revolutions and Australian and Global Politics.
48. Responses from Victorian stakeholders to the draft Modern History curriculum were overwhelmingly negative. It was viewed as a course lacking in coherence, providing none of the opportunity for depth of study that the current Revolutions course offers, the opportunity for a survey course provided by the current Australian History subject or engagement with Australia's place in contemporary global affairs offered by the current Australian and Global Politics course.
49. The changes proposed in this response, if adopted, would provide a nationally-agreed basis from which courses that provided students with the opportunity to engage in the sustained study of a key aspect of modern history (for example, revolutions) or of Australian history or other options could be developed.
50. As part of this process, the VCAA will consult with stakeholders about the continuing viability of the current Renaissance History subject.

(e) SCIENCE

51. In the Science learning area, four subjects are proposed: Biology, Chemistry, Earth and Environmental Science and Physics.

52. The overwhelming response from Victorian stakeholders to all four subjects was negative. Stakeholders argued that the proposed drafts either did not provide the depth or complexity of subject matter nor the contemporary understandings and applications as offered by the current Victorian courses, or occasionally included content that in almost all international jurisdictions is included at tertiary rather than secondary level. In other words, the content pitch was regarded generally as below that currently in place in Victoria or, on a few occasions, so far above that it is almost universally included in tertiary studies. Further, content overload, the repetitive and narrow focus of the *Science as a Human Endeavour* strand and lack of a conceptually cohesive framework were seen as significant issues by stakeholders.
53. The current VCE Biology, Chemistry and Physics subjects have all been recently reviewed and are all regarded as providing cohesive and engaging courses of appropriately challenging demand that include contemporary developments in each field (for example, genomics and proteomics in Biology, nanotechnologies in Chemistry, and photonics in Physics). The proposed changes, that would both lower the level of cognitive demand and eliminate the study of these contemporary applications of each discipline, were widely regarded as regressive by Victorian stakeholders.
54. Victoria will consider reviewing the current VCE Biology, Chemistry and Physics courses in the light of the equivalent final agreed national subjects, but the current high level of demand in these subjects, and the current focus on contemporary science within these subjects, will not be modified simply for the sake of reaching national agreement.
55. The Earth and Environmental Science course was criticised by Victorian stakeholders for giving too much attention to Earth science at the expense of the inclusion of important environmental concepts including biodiversity and sustainability. Victoria is likely to review the current VCE Environmental Science subject in order to develop a subject with an appropriate balance of attention given to fundamental concepts that underpin both Earth science and environmental science. Victorian stakeholders were also concerned about an overlap between the proposed Earth and Environmental Science course and the proposed Geography senior secondary course, and the overrepresentation of ecology in the proposed Biology course with very little included in the proposed Earth and Environmental Science course.
56. Nevertheless, the consultation process highlighted the issue that Victoria has not, for some years, offered Geology as a senior secondary course or a course focussed on Earth Science. Addressing this apparent gap in our current offerings will be the focus of further consultation in Victoria.

2. VICTORIAN CONSULTATION PROCESS

The consultation on the draft senior secondary documents in 2012 took three forms:

(a) Statewide consultation forums – both face-to-face and online
(b) Expert reference groups
(c) Web-based survey

(a) CONSULTATION FORUMS

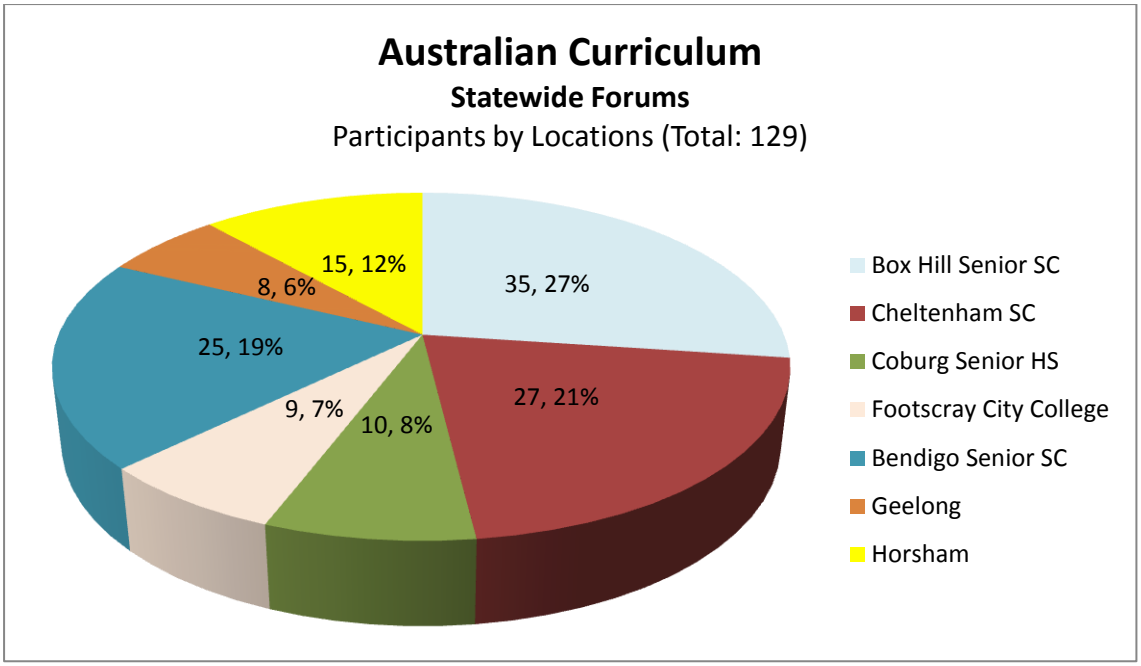
129 participants attended regional consultation forums held in June 2012. Nearly half of the registrations were received from the Government sector (49.4%), although other sectors were represented (Independent 27.3%, Catholic 17%). Other non-sector related registrations (6.3%) came from the tertiary sector, DEECD staff, publishers, union representatives and subject associations.

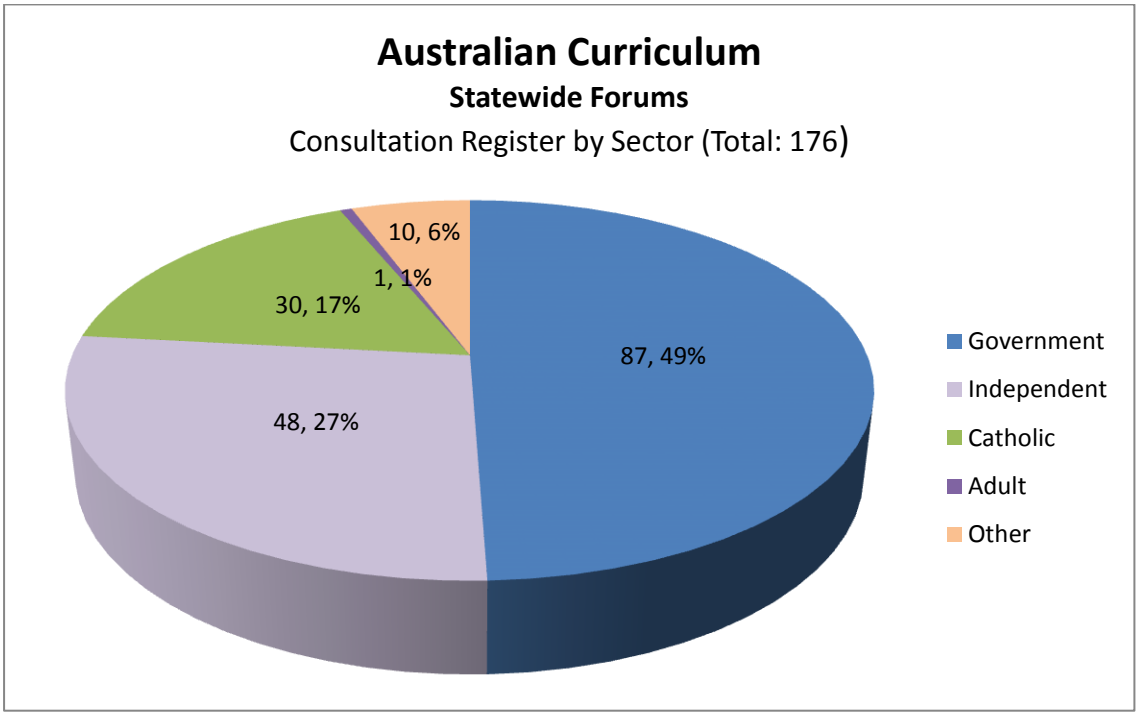
Australian Curriculum Statewide Forums

Venue	No. of Registrations	No. of participants
Box Hill Senior SC	50	35
Cheltenham SC	36	27
Coburg Senior HS	17	10
Footscray City College	12	9
Bendigo Senior SC	29	25
Geelong	14	8
Sale	6	cancelled
Wangaratta	3	cancelled
Horsham	9	15
Total	**176**	**129**

Australian Curriculum Statewide Forums

Sector	No. of Registrations	
Government	87	49.4%
Independent	48	27.3%
Catholic	30	17.0%
Adult	1	0.6%
Other	10	5.7%
Total	**176**	**100.0%**





Attendance levels at the regional forums were relatively low, which is not surprising given the consultation period coincided with senior secondary examination periods and the end of Term 2 (the lead up to which generally entails parent/teacher evenings and the main reporting period at schools). In some cases, regional forums were cancelled due to low registrations.

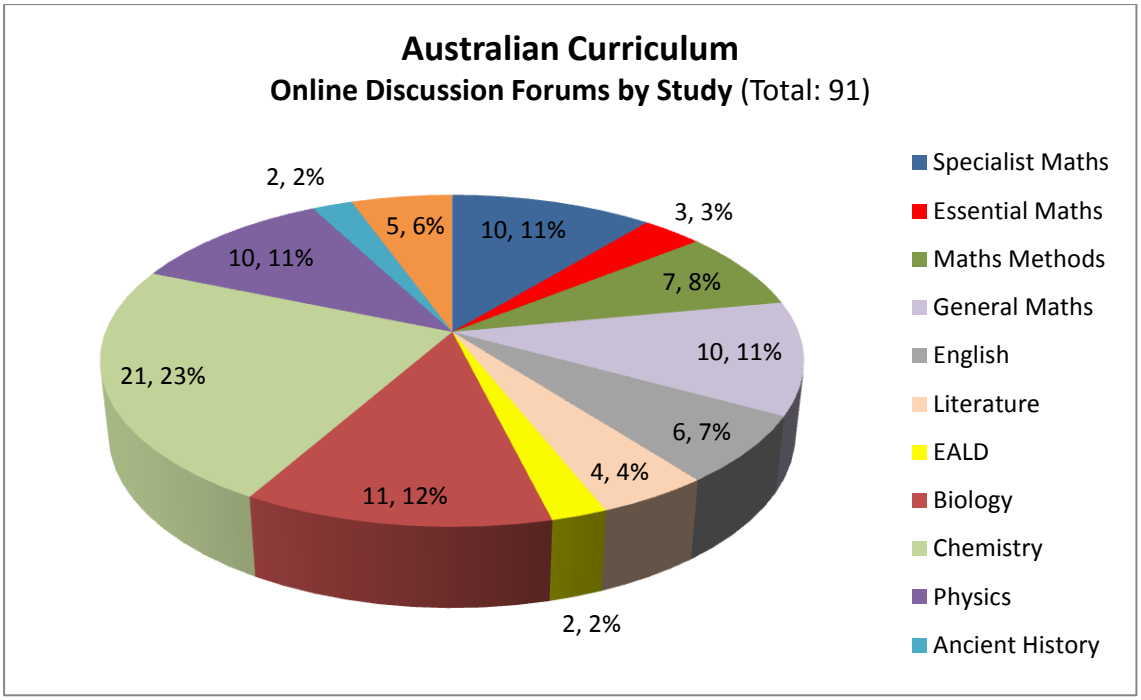
Online study specific consultation forums were held. These were attended by a total of 91 participants.

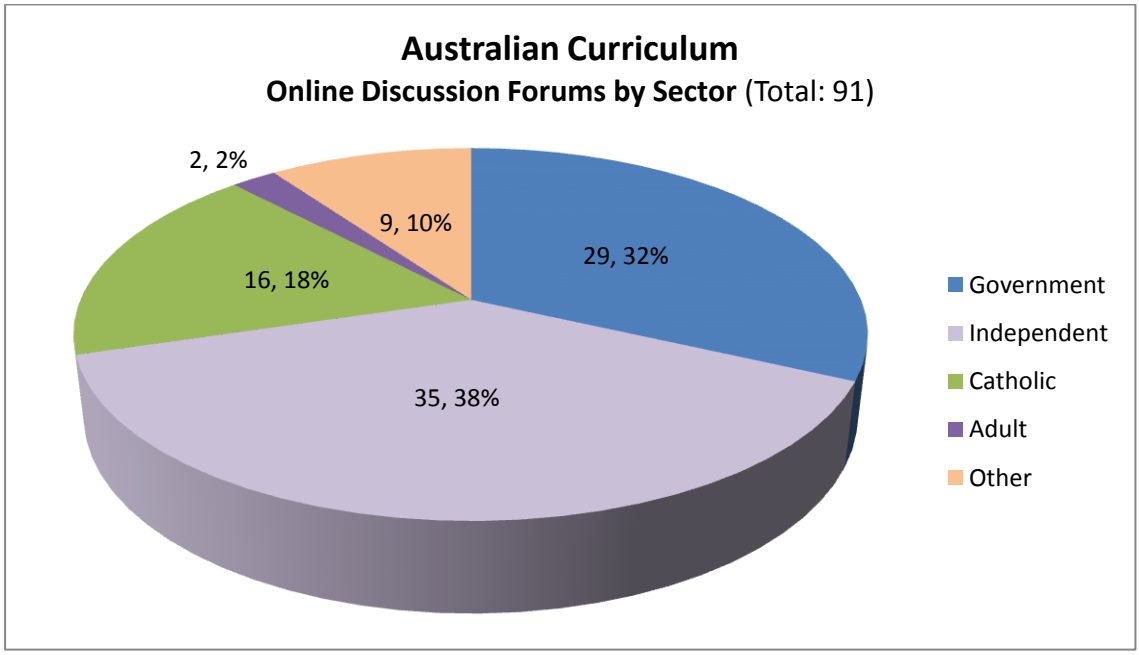
Australian Curriculum Online Discussion Forums

Study	No. of Registrations	
Specialist Maths	10	11.0%
Essential Maths	3	3.3%
Maths Methods	7	7.7%
General Maths	10	11.0%
English	6	6.6%
Literature	4	4.4%
EALD	2	2.2%
Biology	11	12.1%
Chemistry	21	23.1%
Physics	10	11.0%
Ancient History	2	2.2%
Modern History	5	5.5%
Total	**91**	**100.0%**

Australian Curriculum Online Discussion Forums

Sector	No. of Registrations	
Government	29	31.9%
Independent	35	38.5%
Catholic	16	17.6%
Adult	2	2.2%
Other	9	9.9%
Total	**91**	**100.0%**


Australian Curriculum
Online Discussion Forums by Study (Total: 91)
2, 2%
5, 6%
10, 11%
3, 3%
10, 11%
7, 8%
21, 23%
10, 11%
6, 7%
4, 4%
11, 12%
2, 2%
Specialist Maths
Essential Maths
Maths Methods
General Maths
English
Literature
EALD
Biology
Chemistry
Physics
Ancient History


Australian Curriculum
Online Discussion Forums by Sector (Total: 91)
2, 2%
9, 10%
29, 32%
16, 18%
35, 38%
Government
Independent
Catholic
Adult
Other

(b) EXPERT REFERENCE GROUPS

The respective expert reference groups for each subject met together at least once to provide expert advice on the draft documents. The membership of each subject group is detailed in Appendix 1.

In addition, meetings were held with a range of tertiary educators, some of whom served on the expert reference groups, and key interest groups including Engineers Australia. Two subject associations supported the work of the VCAA in collecting feedback about the draft Senior Secondary Australian Curriculum in the sciences:

- The Chemistry Education Association Inc. held two after-school consultations and conducted an on-line survey with respect to the draft Senior Secondary Australian Curriculum for Chemistry. Twenty educators attended the consultations whilst twenty completed the online survey.
- The Australian Institute of Physics (Victorian Branch) Education Committee held 16 after-school and holiday consultation forums across Victoria in metropolitan and regional areas which were facilitated by 18 experienced teachers and attended by about 120 teachers.

Study	**Meeting**		**No. of Attendees**
	Date	**Time**	
English	Tues 29 May	3-5pm	8
Essential English	Wed 30 May	3-5pm	5
Literature	Tues 5 June	3-5pm	9
EAL/D	Wed 6 June	3-5pm	8
Modern History	Mon 18 June	3-5pm	16
Ancient History	Mon 25 June	3-5pm	8
Mathematics Specialists	Wed 27 June	9 am-2:30 pm	12
Biology	Fri 22 June	1-4 pm	11
Chemistry	Mon 25 June	10 am-1pm	11
Earth and Environmental Science	Thurs 21 June	10 am-1pm	13
Physics	Fri 29 June	9 am-12 noon	14

(c) WEB-BASED SURVEY

Quantitative and qualitative data collected via the web-based survey has informed the study specific responses to the senior secondary curriculum in this document.

Area of Interest	Number of Responses
English	13
Mathematics	50
Science	60
History	18

3. LEARNING AREAS

3.1 ENGLISH

General

It was noted that there has been significant improvement across the suite of subjects since the original draft and an attempt to better differentiate them. While is acknowledged that each of the subjects will have similar characteristics, there is still some work to be done to ensure each of the subjects is sufficiently distinct. English and Literature have areas of inappropriate overlap, and Essential English is confused about its purpose and audience. These issues are discussed further below. Additionally, many stakeholders expressed concern that the four subjects did not provide for the full range of students to study English at the senior secondary level; this is due to the absence of a linguistics study. The current VCE English Language study will continue to be offered for this reason.

The representation of General capabilities and Cross-curriculum priorities is nominal and does not represent a genuine approach to the potential of the field to authentically address a range of them, for example through the selection of texts and contexts.

It is not immediately apparent how the skills and understanding, as articulated as Content Descriptions, develop across the four units. A scope and sequence document would be a useful addition in each subject.

The Sample text list provides some focus and context for the subject and includes appropriate texts. The VCAA will continue to publish a prescribed text list to accompany the VCE English and Literature studies.

The Glossary definitions across the four draft subjects are useful, however, it is important to note that they do not necessarily cover the full range of concepts and metalanguage necessary for a course of study in each subject.

Achievement Standards

It is difficult in many cases to see the alignment between the content descriptions and the achievement standards.

Further, the use of a hierarchy of cognitive processes in the responding dimension does not capture the differences between levels of achievement That is, the demonstration of increasing accuracy and complexity of knowledge and understanding, and sophistication and subtlety in the application of skills. This represents the most significant issue across the draft subjects. The following examples highlight this.

English

- There is no meaningful difference between 'represented' and 'presented' in the following statements.

Achievement standards Units 1 and 2	A	• *evaluates how effectively ideas, attitudes, values and voices are represented in texts*
	B	• *analyses how ideas, attitudes, values and voices are presented in texts*
		(English, p.8 of 15, 2012)

Additionally, the distinction between 'evaluation' and 'analysis' is inappropriate; they are distinct processes and one is not more challenging than the other. It is the quality of the evaluation or analysis that distinguishes between levels of achievement. In fact, some stakeholders thought they may suggest different assessment tasks; did the task require students to analyse or evaluate?

- The following statements actually describe rather different skills rather than describing the development of a particular skill.

Achievement standards Units 1 and 2	B	• *analyses how ideas, attitudes, values and voices are presented in texts*
	C	• *analyses the ideas, attitudes, values and voices presented in texts*
		(English, p.8 of 15, 2012)

- The following two statements fail to distinguish between levels of achievement; evaluating and analysing are two distinct cognitive processes.

Achievement standards Units 1 and 2	A	• *evaluates how choices of text structures, language features, stylistic features and types of texts influence or persuade audiences*
	B	• *analyses texts structures, language features, stylistic features and types of texts that influence or persuade audiences*
		(English, p.8 of 15, 2012)

Additionally, it is unclear why persuasion is given preference.

Literature

- The numeric approach to standards used in the following statements is inappropriate. In reference to the below standard descriptors, students could compare only two interpretations at the A standard, dependent on the task set. Equally, at the B standard, students could compare a range of interpretations. Rather it is the quality of the interpretation which discriminates between the standards.

Achievement standards	A	• *compare a range of personal and critical interpretations of texts*
Units 3 and 4	B	• *compares different personal critical interpretations of texts*
		(Literature, p.13 of 14, 2012)

The creating dimension of the Achievement Standards is generally more successful at capturing increasing accuracy and complexity of knowledge and understanding, and sophistication and subtlety in the application of skills, through the judicious use of meaningful adjectives and adverbs. There are, however, many issues across the draft subjects. The following examples highlight these.

English

- There is no meaningful difference between 'pertinent' and 'relevant' in the following statements.

Achievement standards Units 1 and 2	A	• *creates sustained imaginative, persuasive and interpretive texts that synthesise ideas and information from varied sources and are pertinent to purpose, context and audience*
	B	• *creates imaginative, persuasive and interpretive texts that adapt ideas and information from varied sources and are relevant to purpose, context and audience*
		(English, p.8 of 15, 2012)

- Imaginative texts are missing from the Achievement Standards for Units 3 and 4 and should be included. This will provide an essential balance.

EAL/D

- There is no meaningful difference between the following two statements. The use of a numeric approach is inappropriate. Students could create a text for a particular purpose, context and audience that is at the A standard without using any sources, dependent on the task set. Equally so at the B standard.

Achievement standards Units 1 and 2	A	• *creates texts for particular purposes, contexts and audiences using varied sources of information*
	B	• *creates texts for different purposes, contexts and audiences using information from several sources*
		(EAL/D, p.8 of 31, 2012)

3.1.1 ENGLISH

The new organising framework is clear and does represent key aspects of learning in English. The sophisticated approach to genres, as shaped by cultural and social contexts, audience and purpose is positive, although it is worth noting that stakeholders expressed concern about a limited or prescriptive approach to genre. The explicit focus on digital and multi-modal texts is positive and future-focused. The content was generally seen as appropriate to the senior secondary level and would allow for the demonstration of a broad range of student achievement.

However, the central focus of learning in English is the text and how it creates meaning, and the focus of this draft on audience interpretation creates a significant distraction from this. While interpretation is a key procedural aspect of students responding to texts, and creating their own texts, the separation of interpretation as a distinct area of content suggests an explicit teaching and analysis of others' interpretations, especially in Units 3 and 4, rather than exposure to alternate

viewpoints and perspectives about texts to challenge or confirm students' views about how texts create meaning.

The following Content description stems should be re-worked with a focus on creating meaning.

Unit 1 Content descriptions (English p. 3 of 15, 2012)	*Identify and explain how audiences interpretations are influenced by:*
Unit 2 Content descriptions (English p. 6 of 15, 2012)	*Analyse and explain why texts are interpreted by audiences in a variety of ways including:*
Unit 3 Content descriptions (English p. 11 of 15, 2012)	*Analyse and explain how the conventions of texts influence audiences including:*
Unit 4 Content descriptions (English p. 13 of 15, 2012)	*Analyse and evaluate how texts can influence audiences' perspectives through:*

The use of 'interpretive' to describe texts whose primary purpose is to explain and interpret personalities, events, ideas, representations and concepts adds further confusion.

Unit 3 has the clearest focus of all units. The focus on transformation could result in rich learning. In contrast, the focus of Units 1 and 2 is not clear and they are not distinct from each other.

While the Unit 4 focus on close study of texts provides a distinction from Unit 3, it is not appropriate for the English subject. It is too similar to Literature, and implies that close study of texts, indicative of study in Literature, is more challenging. It is not clear whether this unit intends a study of one or multiple texts.

The following Content description, consistent across all units, should not be included as essential content for the study of English; it implies the method used to reflect across all learning areas rather than a skill. If the intent of this Content Description however, is that collaborating and negotiating are important skills in the English subject, then development across the four units would be expected rather than a cut and paste repetition.

Unit 1-4 Content descriptions (English, 2012)	• *collaborating and negotiating in real and virtual environments*

The following Content Description does not link to the stem 'Reflect on their own and others' work'. If anywhere, 'using ethical scholarship practices' belongs in the Creating texts content organiser, where it is already covered by Content Descriptions such as 'using appropriate quotation and referencing protocols'.

Unit 1-4 Content descriptions	• *using ethical scholarship practices and appropriate online behaviours*

(English, 2012)

The following Learning outcome requires re-wording for clarification.

Unit Learning Outcomes	**1**	• *understand the relationships between language, text, purpose, context and audience*

(English, p.2 of 15, 2012)

Suggest the following better articulates the relationship:

- *understand the way decisions about language and text are influenced/shaped by purpose, context and audience*

3.1.2 ENGLISH AS AN ADDITIONAL LANGUAGE OR DIALECT

The draft EAL/D subject is generally viewed a coherent course which develops appropriately across the eight units. It is, however, regarded as a course that primarily meets the needs of students who come to the course with a level of literacy in a language other than English. Careful consideration needs to be given to the possible place in the senior secondary suite of subjects for a subject focussed on the development of English literacy skills for students who have little or no existing literacy in any language. Respondents were unclear about the role of the proposed "Bridging Units" in this regard.

The draft EAL/D subject broadly aligns with the draft English subject, albeit providing a subject that more explicitly scaffolds language development, however some parts of the draft subject under-represent the complexity of the overall course. The Content Descriptions are appropriate and represent a challenging course, while other aspects of the document appear to reduce this complexity. For example, the content organiser 'Comprehension strategies' does not adequately reflect the nature of the skills listed. A more appropriate organiser would be 'Skills and strategies for engaging with texts'.

The Key language skills table is a generally positive addition to the document. The language skills included in the table should not be seen as additional to those explicitly outlined in the Content Descriptions, rather as a useful reference of those across the subject, especially if students should be proficient in these skills by the time they complete Unit 4. The headings used across the table are appropriate although the skills in some instances seem to exclude what might be expected to appear. Bachman's Model of Communicative Competencies may provide a useful reference for refining the table.

The following outlines further detailed feedback.

- The following amendments to the description of the EAL/D subject may provide better clarity about the focus of study.

EAL/D	***English as an Additional Language or Dialect*** **(EAL/D)** is designed to develop students' knowledge, understanding and skills in Standard Australian English (SAE*) including the development of oral language skills.* Students studying this subject will benefit in all curriculum areas from explicit teaching of the structure, linguistic

features and sociolinguistic and sociocultural aspects of SAE. The EAL/D curriculum *also* provides a variety of language, literature and literacy experiences to accommodate the diverse range of starting points for students learning English as an additional language or dialect. EAL/D focuses on how language and texts can vary in structure and usage depending on cultural and social context, and how language can change according to audience and purpose. ~~One of the key focuses of units EAL/D is the development of students' oral language skills.~~

(EAL/D p.2 of 10, 2012)

- There needs to be greater clarity about the intended or possible order and combination of the Bridging units 1-4 with Units 1-4.
- Dialect is not defined within the draft. This has the potential to cause significant confusion so a definition should be provided.
- The following content description is incorrect and needs amending.

Bridging Unit 2
- *modal ~~adjectives~~* adverbs *such as always, never, sometimes, often*

(EAL/D p.22 of 31, 2012)

3.1.3 ESSENTIAL ENGLISH

There are significant problems with the Essential English subject, which roughly fall into the following areas:

- Purpose: what is the intended purpose of this subject?
- Theory of language: which approach to language is taken and is it applied consistently?
- Contexts for learning: which contexts for learning will allow for student success?

This draft assumes that students have a base level of literacy that enables them to engage in senior secondary education but the purpose of the course appears to be to support the development of functional literacy. There is an apparent contradiction here that needs to be resolved.

Further, the use of Research as a content organiser is inappropriate. It foregrounds research as a product, rather than a possible process for creating texts for specific purposes, audiences and contexts. The EAL/D subject has a much more appropriate approach to research.

Unit 1 Content descriptions

Create a range of texts using:
- *research skills and strategies…*

(EAL/D p.4 of 31, 2012)

Further, there are several instances where the research stem does not match the dot point. For example:

Unit 1 Content descriptions

Conduct research for specific purposes and contexts by:
- *using appropriate referencing…*

(Essential English p.3 of 15, 2012)

The lack of clarity about the theory of language used in the draft Essential English subject provides considerable confusion about how the content is to be interpreted. As in the draft English subject, there is a genre approach to language which sees texts as shaped by the context, audience and purpose. The draft Essential English subject goes further, adding the register continuum of language choices. However, the use of register is confusing and not defined. For example, consider the following:

Unit 1 Content descriptions	•	*the use and effect of different styles, vocabulary choices, registers and tone.*

(Essential English p.3 of 15, 2012)

The items listed above are not hyponymous; decisions about register, including the ideational, interpersonal and textual functions of language, impact on style, vocabulary and tone.

Additionally, an understanding of register and the decisions that can be made about register, would be a very useful way for students studying this subject to navigate the variety of contexts which may be presented to them.

The confusion about the articulated contexts for learning is the key reason that the draft Essential English subject is not a coherent course that is sufficiently distinct from the draft English and Literature subjects.

The Unit 1 Description articulates 'everyday, community, social and workplace' contexts for students' interactions. Later in the same paragraph, 'real or imagined' contexts are identified for students' creation of texts. A more appropriate rendering of these concepts might be that students 'learn to create texts for a range of purposes in everyday, community, social and workplace contexts'.

In Unit 2, students' skills are 'consolidated and demonstrated through the analysis and creation of a range of texts for different purposes, selected from real or imagined contexts.' In this instance, it seems that the different purposes are selected from real or imagined contexts, for example students may write a letter to the editor on real community issue and send it into a real newspaper, or students may create a poster for an imagined school event. If this is the distinction being made, it is unnecessary as it suggests pedagogy.

Alternatively, if it is suggesting that texts created by students include both imaginative and analytical, this is not clear.

3.1.4 LITERATURE

Generally, the new organising framework is clear and does represent key aspects of learning in Literature. Sentences such as the following capture the nature of learning in this area:

Rationale	*Literature explores how literary texts in all language modes shape perceptions of the world and enable us to enter other worlds of the imagination.*

(Literature, p.1 of 14, 2012)

The Content descriptions are generally rigorous and the subject will allow for wide reading of a broad range of texts. Unit 1 provides an appropriate introduction to the subject, and the reworking of Unit 4 has improved the sense of development of knowledge and skills across the subject. It is acknowledged that an inclusion of critical and aesthetic approaches will constitute a minor shift in emphasis although is not in direct conflict with current practice.

However, some elements of the previous draft of the Literature subject better articulated the nature and complexity of the study of literature; the framing of units, learning outcomes and content descriptions generally provide less clarity than the previous draft, for example the following phrase is not represented in the latest draft.

Unit 1 Learning outcomes *Develop knowledge and understanding of complex literary conventions and techniques*
(Literature p.10 of 17, 2011)

The focus on analysing similarities and differences in Unit 2 is too simplistic and misses opportunities for the examination of intertextuality and allusion.

The study of rhetoric and rhetorical skills in Literature needs clarification to avoid a lack of distinction with the proposed English subject. In Literature, students identify and analyse the use of rhetoric to create meaning as appropriate to texts being studied. They may also manipulate language to clearly articulate an analysis of language, which may include, as appropriate, persuasive techniques. The explicit study of persuasion and rhetoric is appropriate in the English study. Content descriptions such as the following may overemphasise the place of rhetoric in the Literature subject:

Rationale *Students establish and articulate their views through creative response, logical argument and rhetoric.*
(Literature p.1 of 14, 2012)
Unit 2 Unit description *…responses that are evidence-based and persuasive in tone and argument.*
(Literature p.5 of 14, 2012)
Unit 3 Unit description *Students inquire into the power of language to represent ideas, events and people…*
(Literature p.9 of 14, 2012)

The focus of Unit 3 on identity continues the emphasis on concepts resting outside of the text, which are more appropriate in the proposed English subject. A focus on 'Values and attitudes' would be more appropriate.

There is a false dichotomy generated between students' creation of analytical responses and imaginative texts. Analytical texts may also be imaginatively crafted, or further, the creation of imaginative texts may be a way into or stem from close

textual analysis. As analytical texts constitute a significant part of the study of literature, a broad and dynamic approach to them would be favourable.

The balance between text response and text creation is positive, however there is a concern that this implies every unit would require at least one of each, not allowing for a flexible approach.

The following outlines further detailed feedback.

- The following phrase from the Rationale is ambiguous and required clarification.

Rationale	*…in order to reflect on what these texts offer them as individuals, as members of Australian society, and as world citizens.*

(Literature p.1 of 14, 2012)

- 'Personal preference' may be expressed better as 'interpretation' in the following phrase.

Rationale	*…inquire into the relationship between personal preference and texts, authors, audience and contexts….*

(Literature p.1 of 14, 2012)

- The fourth Aim could be re-worded for clarity. Suggest:

Aims	• *capacity to respond personally, critically and imaginatively to a range of literary texts*

(Literature p.1 of 14, 2012)

The remainder is already expressed in the Rationale.

- The final Aim could be re-worded for clarity. Suggest:

Aims	• *capacity to articulate and evaluate interpretations, using appropriate metalanguage, informed by a range of critical perspectives.*

(Literature p.1 of 14, 2012)

- Fiction and non-fiction are the appropriate terms for describing texts.

Unit 1 Unit description	*A range of literary forms is considered, for example oral, written, verse, prose, film, ~~factual~~ non-fiction and fiction~~al~~ texts.*

(Literature p.2 of 14, 2012)

The forms listed are also not of the same order.

- The following phrase provides a good platform for creative responses.

Unit 1 Unit description	*…students explore and experiment with aspects of style and form.*

(Literature p.2 of 14, 2012)

- There is no apparent difference between the following two content descriptions. Suggest that they be combined or the difference clarified.

Unit 1 Content descriptions	• *how responses can range from empathic to critical* • *the differences between initial personal responses and more studied and complex responses*

(Literature p.3 of 14, 2012)

- There is no apparent difference between the following two content descriptions. Suggest that they be combined or the difference clarified.

Unit 1 Content descriptions	• *how text structures, language features and stylistic elements shape meaning and create particular effects and nuances, for example, allusions, paradoxes and ambiguities*

- *the significance of complex literary conventions and techniques*

(Literature p.3 of 14, 2012)

- The following Content description could be re-worded for clarification. Suggest:

Unit 1 Content descriptions

- *the ~~significance~~ effect of complex literary conventions and techniques on different audiences*

(Literature p.3 of 14, 2012)

- The Content descriptions for Unit 2 suggest a much more sophisticated, and appropriate, approach than the Unit description.

3.2 MATHEMATICS

Consistent feedback across all the draft Mathematics subjects was that the courses were not sufficiently cognisant of the *active* role of technology for *doing* mathematics (and not just as a pedagogical tool) in particular technology including numerical, graphical and symbolic computation capability, as has been incorporated in current Victorian mathematics courses. The preamble still seems to assert a deficit view of technology, rather than an assertion that students are expected to have strong mathematical skills with and without the use of technology. It is also framed as a pedagogical tool (for teaching and learning) rather than a tool for working mathematically, despite the fact that technology such as CAS are used extensively by mathematicians and researchers in mathematics based disciplines around the world.

3.2.1 ESSENTIAL MATHEMATICS

The purpose of this subject is unclear, that is, whether it is intended to operate as an option for students who have not succeeded previously in mathematics (and therefore include content that is not normally at a senior secondary level) or act as a complement to other senior secondary studies at this level through an emphasis on practical applications.

While it was felt that overall there was reasonable distinction between Unit 1 – 4 of Essential Mathematics and Unit 1 – 4 of General Mathematics, in some instances this was not clear.

Unit 1

Topic 1: Calculations, percentages and rates

- There is repetition between this topic in Unit 1 and Topics 2 (Percentages) and 3 (Rates) in Unit 2.
- Delete reference to 'basic' for number operations, specify the operations, including reciprocals powers and roots as applicable
- Ratio should be included here (with some examples where there is more than one term). Part-Part and Part-Whole ratios should be explicitly covered.

Topic 2: Measurement

- Units, conversions, estimation, measurement and calculation of regular and irregular shapes and objects should be covered (lengths and perimeters, areas and surface areas, volume and capacity)

Topic 3: Algebra

- The title does not reflect the content, and should be changed to *Relations and formulas.*
- The proposed content should be revised to focus on using relations and formulas involving variables relevant to a given context. This should involve both evaluation of an expression/formula by substitution and determining an unknown value (or possibly even a combination of values) in a context where this is relevant to the task/problem at hand.

Topic 4: Graphs

- This should be expanded to include graphs, tables and diagrams, with a focus on both interpreting data/information presented in these forms, and also representing data/ information in these forms (there are quite a variety of representational diagrams used in different contexts).
- The technology application (eg spreadsheet) should not be specified. What should be specified is what is to be done.
- Temperature data is usually shown as a curve not a line.

Unit 2

Topic 1: Representing and comparing data

- Standard deviation is not necessary to include in this unit. The focus should be on being able to use various summary information to describe, compare and the like in a context where the data is relevant and needs to be interpreted. Otherwise, this unit replicates statistics in General Mathematics Units 1 and 2.

Topic 2: Percentages

- As a topic the depth and breadth is out of balance with the rest.

Topic 3: Ratios and rates

- The whole treatment of ratio, proportion, percentage and rates should be revised to provide more effective sequencing (ratio is the more fundamental concept, rates the more complex).

Unit 3

Topic 1: Measurement

- There is significant overlap with Units 1 and 2. Surface area should be covered at Units 1 and 2. The relationship between surface area and volume for various shapes, and calculation of surface area and volume (capacity) for semi-regular and irregular shapes (not only the standard formulas for pyramids and spheres) should be included.

Topic 2: Scales, plans and models

- This topic should include cross sections, projections and isometric representations.

Topic 3: Graphs

- The focus of this topic should be on interpreting a broad range of graphs of functions of real data not necessarily determined by a rule, for example, daily temperature variation over a month, water storage levels. The characteristics of these functions (graphs) such as when they are increasing, decreasing, constant, have maximum or minimum values and the like can then be investigated and related equations and inequalities solved.
- Gradient, average rate of change and linearity over a short interval should be used to assist in analysis of such graphs.

Topic 4: Data collection

- The treatment of bivariate data should be informal. There is no need to introduce correlation coefficient – even by technology, the key idea is to have a qualitative sense of the association (direction, strength, linearity) by informal consideration of scatter-plots. An informal line of good fit by eye and graphical treatment will suffice for most practical purposes. Otherwise, it replicates

General Mathematics Units 3 and 4 again. Consideration of issues such as, interpolation and extrapolation, causality and so on can reasonably be dealt with informally.

Unit 4

Topic 1: Probability and relative frequencies

- Independence/conditionality of events should be included.

Topic 3: Loans and compound interest

- This replicates content in General Mathematics.
- A broader financial perspective should be taken, not just loans but various types of investments, shares, insurance and the like, with underlying themes of monetary resources, allocations, use for purposes, risk and return.

3.2.2 GENERAL MATHEMATICS

The draft General Mathematics Units 1 – 4 are comparable in intent and broad content to VCE General Mathematics Units 1 and 2 and VCE Further Mathematics Units 3 and 4. However VCE General Mathematics Units 1 and 2 and VCE Further Mathematics Units 3 and 4 have a more flexible combination of required and selected material.

In particular the structure of General Mathematics Units 1 and 2 enables content as preparation for subsequent study of VCE Further Mathematics Units 3 and 4 and/or VCE Specialist Mathematics Units 3 and 4 to be covered in a single course. There was a strong preference from respondents to continue with this flexibility. Indeed, many commented that if the separate structures of the draft General Mathematics Units 1 and 2 and draft Specialist Mathematics Units 1 and 2 were to be put in place, schools would not necessarily be able to offer the latter due to resource limitations and the relative popularity of the former.

It was noted that the current VCE General Mathematics Units 1 and 2 and VCE Further Mathematics Units 3 and 4 structure has been in place for over a decade, and has been very successful in supporting high levels of student engagement and enrolment in a mathematics study. The flexible structure is seen as playing a key role in this process.

The general view of stakeholders was that the proposed General Mathematics content was slightly less demanding than the current VCE content, with less breadth of overall coverage of areas of mathematics.

Unit 1

Topic 1: Financial mathematics 1: basic principles

- Appreciation and depreciation of assets should be included.

Unit 2

- Recursive definition of linear relations and simple applications, informal approaches to lines of good fit for data, and graphs of linear inequalities should be included.

Unit 3

Topic 1: Statistics 2: Associations

- Transformations of data to linearity should be included so that simple but common non-linear relations/trends are considered.

3.2.3 MATHEMATICS METHODS

There was substantial criticism of the proposed statistics content, in part because of the impact of the inclusion of this material on the scope and placement of other important content (functions, algebra and calculus). There was also concern as to whether there was too much content overall (many felt that the current VCE Mathematical Methods (CAS) course is fairly 'full', and the proposed ACARA course would be even 'fuller').

Unit 1

Topic 1: Algebra, functions and graphs 1

- Graphs of relations and functions should include transformation of the basic form by reflection in the axes, dilation from the axes, translation from the axes and simple combinations of these. That is, from $y = f(x)$ to $y = a\,f(b\,x + c) + d$ (also for the function studied in the corresponding topic in Unit 2).
- Matrix representations of transformations should be included.
- Some other simple examples of polynomial functions of low degree should be included, in particular to develop graphical behaviour in terms of odd and even degree.

Topic 2: Calculus 1

- The content of this topic should include the relationship between the graph of the function and the graph of its derivative.
- The first part appears not to be restricted to positive integer power functions, but the last part does – it is not clear if this is intended or an error.

Topic 3: Probability

- Simple two–state Markov sequences should be included, with matrix representation.

Unit 2

Topic 1: Algebra, functions and graphs 2

- Sine and cosine rules should be omitted, explicitly include $\sin^2\theta + \cos^2\theta = 1$.

Topic 2: Calculus 2

- The relationship between the graph of a function and the graph of its derivative should be included.
- Anti-derivatives of polynomial functions and simple power functions (integer values other than -1) should be included

Topic 3: Discrete random variables

- The inclusion of this topic in Unit 1 and 2 was not supported. It was felt that both discrete and continuous random variables and their distributions should be covered together in Units 3 and 4. The removal of this topic would provide opportunity for more thorough and general treatment of the rest of the material.

Unit 3

- A topic on ***Algebra, functions and graphs*** should be included, following on from the corresponding topic in Unit 1 and 2. This should explicitly address the algebra of simple combinations of functions studied in Units 1 and 2 by sum, difference, product and composition, and related equation solving algebraically, numerically and graphically. This should include the modulus function following on from Unit 1.
- The equation solving content is not sufficiently developed – only cases related to $f(x) = k$ where f is a transformed basic function are covered. While this is necessary it is not sufficient. A range of modelling problems are based on solution of equations of the form $f(x) = g(x)$ numerically, graphically or algebraically as applicable. This should be explicitly included. Students should also be able to solve systems of simultaneous linear equations 2 by 2 by hand and simple 3 by 3 by hand, and formulate and solve more complicated systems (eg fitting information about a function and/or its derivative or anti-derivative to determine a simple polynomial rule) using technology. Knowing that there may be unique, no or infinitely many solutions is important.

Topic 1: Calculus 3

- An informal treatment of the series for the exponential function (similar for *sin* and *cos*) should be included).

Topic 2: Calculus 4

- This topic should include using derivatives to find anti-derivatives, for example, differentiate $F(x)$ and hence find an anti-derivative for $f(x)$ where $f(x)$ is part of $F'(x)$.

Topic 3: Continuous random variables

- Exponential distributions should be removed. The binomial distribution should be included instead as a specific example of a distribution of a discrete random variable.

Unit 4

Topic 1: Interval estimates for proportions and means

- The significant majority of feedback did not support inclusion of this material, preferring to include a focus on probability. The consequent negative effect of the inclusion of this material on sequencing and placement of other material, in particular calculus was noted in feedback.
- There was support for the inclusion of two-state Markov sequences, with matrices and consideration of long run (steady-state) behaviour.

Topic 2: Calculus 5

- Most respondents felt that the material on the second derivative should be placed in the Specialist Mathematics course rather than in the Mathematical Methods course.

3.2.4 SPECIALIST MATHEMATICS

Overview

There was strong support for the inclusion of both 'pure' and 'applied' mathematics in this course. However, some educators were concerned that the heavy emphasis on proof in Unit 1 represented an over-emphasis on 'pure' mathematics.

There was substantial opposition to the introduction of the additional and new statistics content (even more so than for the Methods course). A very strong view was that the statistics content should not be included in this course. A complementary argument to this was that if the General and Methods courses both contain aspects of Statistics and probability, then coverage of content from this area of study is covered for the whole cohort (since Methods is a pre- or co-requisite study for Specialist).

The majority of respondents were not in favour of the graph theory content, in particular given that it was only placed at Units 1 and 2 level and did not continue in Units 3 and 4, although a minority did argue for its inclusion as a contemporary area of mathematics with many applications (pure and applied), as providing content from discrete mathematics amenable to constructive proof. If the material on statistics were to be removed from Unit 4, then that on graph theory could be retained and developed across Units 2 and 3 similar to vectors and complex numbers (all three areas of study having geometric aspects related to proof).

There was some concern that content on non-linear relations (in particular ellipses and hyperbolas) currently covered in the relevant Unit 1 – 4 Victorian courses and topics was not included.

Unit 1

Topic 1: Recurrence relations

- This topic could be extended to consider the logistic model for interest.
- Matrix representations of transformations should be included.
- Some other simple examples of polynomial functions of low degree should be included, in particular to develop graphical behaviour in terms of odd and even degree.

Topic 2: Combinatorics

- There is substantial overlap with content in this unit with the Methods course.

Topic 3: Geometry

- Some coordinate geometry proofs to complement and contrast proof techniques should be included.

Topic 4: Vectors in the plane

- It was suggested that this topic could be interchanged with a topic from Unit 2. This would have the advantage of content related to vectors being covered across Units 2 and 3 and the work on transformations potentially more aligned with related work in the Methods course. Alternatively, the topic on real and complex numbers could be moved to Unit 1, as this is accessible material that affords nice opportunities for various proofs.

Unit 2

Topic 2: Matrices

- The matrix material related to transformation of graphs of functions by reflection in, dilation from and translation from (and simple combinations of these) should continue to be placed in the Methods course, as is currently the case in Victoria.
- The use of matrices with respect to 2 by 2 systems of simultaneous linear equations is too restricted when this material can be tackled by hand using direct algebraic manipulation.

Topic 3: Real and complex numbers

- Explicit treatment of the underpinning structure (field) and order properties should be included, See also the earlier suggestion about placement in Unit 1 and interchange with the topic on Vectors.

Topic 4: Graph Theory

- The content of this topic should be omitted or spread across Units 2 and 3.

Unit 3

Topic 2: matrices and systems of equations

- The inclusion of this topic was not broadly supported. It is more suitably dealt with at first year university level (where it is a traditional topic in linear algebra)

Topic 3: Complex numbers

- It is not clear if simple cases with complex coefficients are intended to be covered in the solution of polynomial equations
- The fundamental theorem of algebra should be included.

Topic 4: Functions and calculus

- The first topic (*Functions*) should be placed in the Methods course
- The second topic (*Sketching graphs*) absolute value content should either be relocated to the Methods course or all the material related to absolute value should be removed from the Methods course for consistency.
- Access to symbolic integration using technology should be included.

Unit 4

Topic 1: Further calculus and applications of calculus

- Material on the second derivative should not be included in the Methods course, but in the Specialist course.

Topic 2: Statistical inference for continuous data

- There was no substantive support for the inclusion of this content, with a strong and consistent recommendation for its omission.
- It was felt by many respondents that omitting this topic would create ‘space’ for a more effective coverage, and some additional inclusion, of other content.

3.3 HISTORY

GENERAL

Victorian stakeholders acknowledged the improvements to the draft content made to the content descriptions in Modern History. However, the overwhelming majority of stakeholders' feedback mirrored the concerns of previous Victorian consultation responses in 2010 related to coherence of course design, the opportunity for depth study and the opportunity for an extended coherent study of Australian history.

3.3.1 MODERN HISTORY

The broad concerns with the draft Modern History curriculum were as follows:

1. The amount of content in *Historical knowledge and understanding* is far too great to allow for teaching in depth, teaching historical understandings and historical skills, that is, the opportunity to think and argue historically which constitutes the discipline of history. For example, in Unit 3, students would be required to study 14 key knowledge points, some which in current Victorian courses would individually be the entire focus of an 18 week semester.
2. The draft still lacks coherence, that is, the capacity to build student knowledge in themes and/or chronology across Units 1-2 and Units 3-4. While in some instances a coherent course can be developed though choice of options, in general there are many dead-ends. Coherence should be characteristic of the design of the curriculum, not an *ad hoc* outcome achieved in the implementation of the curriculum
3. While we recognise that there is Australian history content in this draft curriculum, there is not opportunity to teach a coherent sequence through theme or narrative across a year. This is of serious concern, as illustrated by the following extract from a written submission:

   > *There are aspects of Australian History that can be chosen as part of the selection of topics offered under Modern History, but they are disjointed and unrelated to an overall narrative. It has also been argued that the Year 9 and 10 courses offer access to aspects of Australian History, but the nature of the study done at Middle School is very different from that undertaken at Years 11 and 12…..*
   >
   > *The nature of Australian History courses available to senior students has changed over the decades and it is only right that it will change again and again, in response to new knowledge and changing attitudes and values. However, the notion that there should be no opportunity for senior students to study a serious Australian History course is unthinkable. It is highly unlikely that there is any other country in the world that does not offer an examination of its own history, to its students at senior levels.*

4. The content of Units 2 and 4 covers content that in Victoria would be categorised as political and international studies rather than history and is delivered in a more conceptually coherent construct in the current VCE study, *Australian Politics and Global Politics.*

5. There is overlap in content within the four units and between the draft Modern History course and the F-10 curriculum as follows:

Unit 1: The Industrial Revolutions	History – Year 9
Unit 2: Recognition and rights of Indigenous people	History – Year 10 depth study Rights and freedoms 1945 - present
Unit 2: Decolonisation – India option	Unit 3: List 2, India option
Unit 2: Decolonisation – Vietnam option	Unit 4: Engagement with Asia – Vietnam option
Unit 3: List 2 China 1937 - 1976	Unit 4 The Changing World Order
Unit 3: List 2 China 1937 - 1976	Unit 4: Engagement with Asia – China option

6. The key elements of 'Historical understanding' (evidence, continuity and change, cause and effect, significance, empathy, perspectives and contestability) are not sufficiently explicit in the content descriptions and the achievement standards.
7. The proposed options in Unit 4 are not equivalent in scope or complexity. For example, The Changing World Order has arguably far more extensive and difficult content than Movement of peoples.
8. While most stakeholder feedback concentrated on the Knowledge and understanding strand, feedback on the Achievement standards focussed on the lack of qualitative distinctions between grade levels and the lack of alignment between the learning outcomes, the content descriptions and the achievement standards.

Comments on specific units

Unit 1:

While recognising the value of much of the content, the key issues raised in relation to Unit 1 by stakeholders were the extent of the content and the conceptual level of the options. The amount of content in Unit 1 was a key concern for teachers. The view was expressed that this would result in teachers focussing on getting through reams of content rather than teaching and developing the underpinning concepts and disciplines of history, as the following excerpt from a submission illustrates:

> *There is FAR too much in this! Compare this course to the current VCE Units 1 - 4 courses: Revolutions (at Yr 12) expects student to cover ONE revolution in a semester, yet the Unit 1 course here expects it to be done in only half the time!*

A disjunct between the cognitive demands of Units 1 and 2 compared to 3 and 4 was also noted:

> *The content [of Unit 1] is conceptually more difficult for Year 11 students than the Unit 3 course. Because of its conceptual difficulty, the French Revolution is far more suited to Year 12.*

Unit 2

Key issues raised by stakeholders in relation to Unit 2 were:

- The extent of the content
- Overlap with Year 10 history and Unit 3 history
- Issues of coherence between Unit 1 and Unit 2

The amount of content in Unit 2 was (again) considered far too much. For example, it is expected that students would study *Decolonisation* in two countries in the space of about 8 weeks.

The options *Decolonisation* and *Civil Rights in the USA* were considered to be the most interesting and accessible for year 11 students. However, the India and Vietnam options within Decolonisation have overlap with Unit 3 (Unit 3, List 2 India option; Unit 4 engagement with Asia, Vietnam option).

There is substantial overlap between the option, *Recognition and rights of Indigenous peoples* and the Year 10 history curriculum, as illustrated below

> **Year *11 Recognition and Rights of Indigenous People***
>
> The nature of government policies and their impact on indigenous peoples, such as assimilation, the Stolen Generations, and self-determination in Australia
>
> The role of individuals and groups who supported the movement for indigenous recognition and rights, including the methods they used and the resistance they encountered
>
> The achievements of indigenous peoples at the end of the 20th century, including the right to vote, land rights/native title, and reconciliation
>
> **Year 10 *Rights and Freedoms***
>
> The significance of the following for the civil rights of Aboriginal and Torres Strait Islander peoples: 1962 right to vote federally; 1967 Referendum; Reconciliation; Mabo decision; Bringing Them Home Report (the Stolen Generations), the Apology (ACDSEH106)
>
> Methods used by civil rights activists to achieve change for Aboriginal and Torres Strait Islander peoples, and the role of ONE individual or group in the struggle (ACDSEH134)

Units 3 and 4

Given that in Victoria students sit an examination at the end of Units 3 and 4, issues relating to the extent of the content, the links between units and the ability to build understanding across the year were of key concern to stakeholders. There was consistent concern that there was no apparent coherent structure or overarching ideas which hold the 3-4 sequence together, as illustrated by the following excerpt from a written response

> *This proposal is flawed! Students should not be pressured to cover so much material. Fewer options in greater depth must be the way to go.*

The key issue raised in relation to Unit 3 by stakeholders in all forums was the extent of the content and the consequences for the teaching of the discipline of history.

> *I am horrified at the thought of trying to teach two studies in one semester. I currently teach revolutions with a change over in mid-May. It is a frenetic race to cover the content and now it is suggested we teach two topics in 16 weeks! The only way to achieve this is water down the content and do an extremely superficial job! Why? There is NO educational value in such a suggestion. Currently, Russia 1905 -24 takes the class 15 weeks. How can anyone teach Russia 1905 -1948 AND another study of similar scope in that same time frame. This should not be allowed. Students will not develop an understanding of history or historiography under such a model.*

Other issues in relation to Unit 3, included the reasons for dates chosen for particular country choices, for example, why start an Australian history option in the middle of WW1?

For Unit 4, a number of respondents noted that while aspects of the content, including the Cold War, are important for a Modern History course, other more contemporary aspects of the course are more appropriately categorised in the field of political or international studies, as the following excerpts illustrate:

- *Unit 4 – seems to be world politics, it is the same as Global Politics (and some of it looks like Geography).*
- *Globalised economy sounds like an economic subject not humanities.*
- *Where is the historiography in all of this? What idea do they have of the discipline of history?*
- *Unit 4 is framed as politics rather than history*

Other concerns related to the broad descriptive language used in the key knowledge, which does not make clear what is to be taught and will encourage superficial coverage of the content rather than teaching in depth.

3.3.2 ANCIENT HISTORY

The draft Ancient History curriculum has undergone significant revision since its first draft and improvements were noted and welcomed, including the removal of Classical Studies literature, the consistency of language used in presenting options, the removal of some trivial examples and the sound historical approaches of Units 2 and 3.

Several issues still remain, particularly for Units 1 and 4. However, the underlying issue is about the nature of history teaching and learning and this mirrors the concerns expressed about the Modern History course, that is, the lack of sequence and coherence of units that provide opportunities to build student knowledge and understanding across Units 1 and 2 and across Units 3 and 4.

Unit 1: Investigating the Ancient World

This unit does not contain coherent substantive content but rather unrelated fragments of the past. While the title implies that students will be looking at the ancient World, there is no notion of 'world' in the unit. There is no narrative or chronology and no sense of the significance of the content of the unit.

The unit focuses on the present rather than the past, that is, the ways that the past can and has been interpreted in other times. In the content of the unit, presenting students with a chronological or coherent view of the past does not seem to matter. The overwhelming focus of the unit is on evidence, sources, representation and documentation.

The substantive content of the history unit does matter and this should be presented in a coherent fashion. This view was put this way in one submission:

> *The overwhelming bulk of research in history education in terms of fostering historical thought would argue that we need to engage with substantive knowledge ie knowledge of the particular period, particular place and particular point in time and the student as historian – procedural knowledge. … If we want a world-leading curriculum we should take note of contemporary research and this doesn't. The unit picks bits of the past and then two issues. What holds it together?*

Unit 2: Ancient societies

Unit 2 is far stronger than Unit 1 in that it offers the possibilities for coherent study, a narrative of an ancient society, although this would depend on choosing options judiciously. There is also the opportunity to engage in a comparative study provided by this unit.

However, the array of options would make it difficult to provide appropriate professional support for teachers and there are particular options that do not link to any material which has come before or after.

The Roman options are strongest in that they offer the opportunity for a history of the early empire. But Sparta has no obvious 'partner' and the sources for study are sparse.

Unit 3: People, Power and Authority

Unit 3 offers the opportunity to study a society in some depth and the philosophy of the individual and socio historical context is interesting. Cleopatra should be included as a woman of historical significance, especially since there is only one other woman in the list.

However, it is essential for depth that individual studied should be from the same society as the society studied, otherwise the unit will lack coherence.

There are too many options for examination assessment (seven societies and 17 individuals) and some options would need to be removed. Date ranges would also need to be modified.

Unit 4: The Ancient World: Sites and Development

Unit 4 lacks coherence with options that are not comparable. The approach is evidence and the use of evidence rather than the past itself or creating a coherent narrative of the past.

While the event is the basic building block of history, there is too much emphasis here on how the past is studied: sources about the past, who studies it, archaeology and the like. For example, the option on the Athenian Agora is not about what happened there but the archaeology and issues of conservation.

The amount of Thucydides and Tacitus in makes these options far weightier than the rest.

3.4 SCIENCE

Victorian stakeholders noted an improvement in the senior secondary science courses when compared to the earlier drafts. Few issues, apart from lack of differentiation across Units 1 & 2 and Units 3 & 4 were nominated in the *Science Inquiry Skills* strand. The explicit recognition that states and territories could include an extended scientific investigation as part of the courses was welcomed by stakeholders. Investigation is an existing and valued component of both the content and assessment of senior science studies in Victoria.

However, there was an overwhelmingly negative response to the question of whether these courses represented engaging, cohesive, futures-oriented senior science courses. Significant issues were raised in relation to a perceived lack of clarity and depth, inappropriate content selection and lack of content cohesion.

A particular area of concern, common across all the science subjects, was the achievement standards. In each subject, the achievement standards were heavily criticised on almost identical grounds:

- lack of differentiation of the achievement standards between Units 1 & 2 and Units 3 & 4. It is expected that students undertaking Units 3 & 4 would demonstrate greater proficiency in their demonstration of scientific skills, and increased capacity to undertake more complex skills, when compared with Units 1 & 2 independent of the increasing complexity of content
- the distinction between grade levels (A to E) should be based on how well students perform a particular task or skill rather than assuming that only 'A' students can evaluate rather than that 'A' students can evaluate (or explain/describe etc) better than other students
- the 'disappearance' of some assessment measures as one moves down the scale from 'A' to 'E' is inappropriate. Representation of data, for example, is expected of all students – how well it is done is the variant that distinguishes an 'A' from a 'B', 'C', 'D' or 'E' student
- the expectations for standards related to the *Science as a Human Endeavour* strand are unrealistic in terms of depth and proportion of time that would be required for students to demonstrate expected levels
- some parts of the 'A' descriptors are unrealistic both in terms of expectation and opportunity specified in the curriculum. This was illustrated in the following comment by a former VCE Chemistry State Reviewer:

  > *An achievement standard in Units 1 and 2 related to the Science Understanding strand states that to achieve an A standard, the student 'evaluates the theories and models used to describe chemical systems and processes, the supporting evidence and the aspects of the system they include'. Senior secondary students do not have the theoretical background that would be required to evaluate most of the theories and models they study, or to evaluate the supporting evidence, such as new emerging technologies! Indeed, I would venture to say that the majority of chemistry teachers would not have this advanced background knowledge either, and would therefore not be in a position to assess their students on this criterion*.

3.4.1 BIOLOGY

The overwhelming response from stakeholders was that the proposed content of the senior Biology course does not adequately reflect the contemporary discipline of biology and does not represent an advance on what is currently offered in Victoria through the *VCE Biology Study Design*. Stakeholders reported that content selection and sequencing require significant revision, there is a lack of clarity about expected content depth, there is too much content in some units with little consideration of practical work, the *Science as a Human Endeavour* strand adds content load and is too limited in scope, there is a need for inclusion of more biochemistry and molecular genetics to make this a more contemporary course, and the achievement standards as written are not useful. Significant stakeholder concern was also expressed at the omission of human evolution from the draft.

The major concerns are detailed below:

(a) Scientific errors in the draft

A number of scientific errors are apparent in the current draft:

- *Science Understanding*, Unit 3: The statement that 'Sequences of DNA can be 'coding' or 'non-coding'; coding sequences are genes that contain information for protein production…' is incorrect since genes can contain 'non-coding' regions – introns - that are cut out during RNA processing.
- *Science Understanding,* Unit 3: The statement that 'Frequencies of genotypes and phenotypes of offspring can be predicted using probability models…and by taking into consideration patterns of inheritance, including dominant genes…' is incorrect since genes are not dominant or recessive. The term 'allele' should be referred to, but it is actually the phenotype which is dominant or recessive.
- Uncertainty (in data) is defined as 'a range of measured values in collected data'. This is incorrect since uncertainty relates to the quantitative estimation of error present in data, rather than the range of measurements. It would also be appropriate to indicate that uncertainty is generated through systematic and/or random errors.
- The definition of 'validity' includes reference to accuracy. These are two separate concepts, with validity (either internal or external) referring to the reasonableness of the data. Data can be valid without being accurate.
- The glossary term 'Respiration (cellular)' should be replaced with 'Cellular respiration', and should be more precisely and usefully defined to indicate expected coverage at a senior secondary level. The provided definition of 'the series of biochemical reactions and processes … to convert biochemical energy from nutrients into …ATP…' is inaccurate since the nutrients must be organic-based and should exclude inorganic nutrients. Hence, 'nutrients' could be amended to 'organic compounds', but at this level it would be expected that students consider glucose as the starting organic material, so that 'glucose' may be specified in the definition instead of 'nutrients'. The overall equation for cellular respiration should be provided:

  $C_6H_{12}O_6 + 6O_2 \rightarrow 6\ CO_2 + 6H_2O$ + energy (36 ATP)

- The definition of 'variable' should recognize that all variables can be measured. At this level, it would also be useful to distinguish between 'dependent', 'independent' and 'extraneous' variables.

(b) Alignment of aims, rationale, content descriptions and achievement standards

There is not always a clear connection between the rationale and the rest of the document. The rationale, for example, states that 'Australian and global communities rely on the biological sciences to understand, address and successfully manage environmental, health and sustainability challenges facing society in the twenty-first century' and that the draft curriculum provides '…a foundation for students to give critical consideration and to make informed decisions on contemporary biological issues in their everyday life'. This is not reflected adequately in the content descriptions or in the achievement standards, since the capacity to critically evaluate and make decisions about contemporary biology-related issues requires a deeper understanding of biochemistry, cellular biology, immunology and molecular genetics than is evident in the draft. As one submission stated:

> *The 'Science strand descriptions' include the statements regarding the SHE, SU and SIS strands in the draft that 'In the practice of science, the three strands are closely integrated; the work of scientists reflects the nature and development of science, is built around scientific inquiry and seeks to respond to and influence society's needs. Students' experiences of school science should mirror and connect to this multifaceted view of science.' If this is acted on in the curriculum, then the content descriptions should include the most up-to-date research and ideas like molecular biology and rational drug design as an example of applying molecular biology to solve real world problems such as targeting cancerous cells using nanoparticles.*

(c) Contemporary curriculum

The molecular basis of life is not only the focus of much of contemporary biological research but also reflects the interdisciplinary nature of contemporary biology, which is included as a fundamental design principle in the development of many current national - including Victoria - and international senior biology courses. This is not sufficiently evident in the draft curriculum, as evidenced by the following comment:

> *Movement to the Australian Curriculum for Biology is a retrograde step – it is putting Biology teaching in Victoria back at least a decade. Although the current Study Design in Biology has far too much content, at least it is 'modern' and up-to-date. The Australian Curriculum syllabus is archaic and an 'old' traditional course. Surely we should be teaching students Biology that is current (not what was taught twenty years ago)?*

(d) Content selection

Stakeholder feedback notes a number of significant issues regarding content selection including: lack of sufficient progression in a number of areas from the *Year 7-10 Australian Curriculum: Science;* inclusion of content that may be better suited to the *Draft Senior Secondary Curriculum – Earth and Environmental Science, May 2012;*

lack of contemporary biological content and applications; and lack of sufficient academic rigour.

Examples where progression from junior secondary to senior secondary is not evident, particularly when the suggested *Year 7-10 Australian Curriculum: Science* elaborations are also considered, are identified in the table below:

Draft Senior Secondary Curriculum - Biology		***F-10 Australian Curriculum: Science***	
Unit	*Content description*	*Year*	*Content description*
1	The biotic components of the ecosystem transfer and transform energy originating primarily from the sun'	9	Ecosystems consist of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems
1	Organisms survive in areas where their behavioural, structural and physiological adaptations are suited to the environmental conditions	5	Living things have structural features and adaptations that help them to survive in their environment
		8	Multi-cellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce
		9	Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment
1	The biosphere is composed of all the Earth's ecosystems; processes and interactions within the biosphere are interconnected with processes and interactions in the hydrosphere, atmosphere and/or geosphere	10	Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere
2	Multicellular organisms have a hierarchical structural organisation of cells, tissues, organs and systems	8	Multi-cellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce
		9	Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment
3	The theory of evolution by natural selection is supported by evidence from comparative anatomy, molecular homology, comparative genomics, and contemporary	10	The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence

	plant and animal breeding programs		
4	Animals' responses to variations in their internal and external environments involve the nervous and endocrine systems	9	Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment

Many stakeholders were concerned about placement of ecology in the draft biology course rather than in the draft Earth and environmental science course, as reflected in the following submission:

> *My strong feeling…I do not like this Draft. This Biology draft looks so much like Environmental Science. I think we in Victoria should continue to keep our existing Biology. We do it so well and students are better prepared for university. The 'Dynamic biosphere: models of change and resilience' is absolutely not necessary in Unit 4…too much Ecology. When there is Environmental Science already existing then why throw ecology into Biology?*

Inclusion of contemporary concepts and applications was identified by stakeholders as being an area requiring improvement in the draft. A consideration of biological concepts at the cellular, rather than 'whole organism', level not only reflects current biological thinking and research but provides the depth and rigour that Victorian stakeholders see in the current VCE Biology Study Design, as illustrated by the following survey comment:

> *There appears to be no reference to the chemistry of the cell in the Units 3 & 4 course. Although conceptually difficult (though it is included in the VCE Biology Study Design in Unit 3), signal transduction involving how signals are detected and the way the cell responds is current biology. We now focus more on the cell rather than the whole organism.*

Further content inclusions expected of a contemporary biology curriculum include: a study of disease; microbiology; a significantly greater in-depth treatment of cell biology, molecular genetics, immunology and biochemistry than is seen in the current draft; biomarkers; rational drug design; bioinformatics; a stronger link between current research and the curriculum strands; and opportunities for investigating current local and global biology-related issues in society.

(e) Content sequencing and cohesion

Related to content selection is the issue of content sequencing, with many stakeholders reporting dissatisfaction with the proposed sequencing in the draft. The following comment highlights this issue:

> *If our aim as educators is to facilitate the learning of our students then I query whether the order of the proposed course optimally fulfils this goal. If learning occurs through the construction of meaning then the sequence in which ideas are introduced needs to best aid this construction. In the proposed course, there has been a reordering of content from traditional biology courses, but I think the new order lacks pedagogical reason.*
>
> *I am not convinced that starting with biodiversity and the other content outlined for Unit 1 is the best place to start; in spite of the fact that biology as*

a discipline grew in a similar way. The sequence may have some sound biological/historical basis but not so educationally. We should therefore look for a way to introduce students to the most fundamental biological concepts in the simplest ways and then progressively build towards increasing complexity. With this in mind, starting with the cell theory, or the nature of life or the common requirements for life would be much better.

One submission proposed an alternative sequencing of content:

Unit	***Theme/'story'***	***Sub-units***	***Concepts***
1	Who am I?	• Biodiversity within ecosystems • Biodiversity and ecosystems	• Classification (also includes cells and genetics review) • Biomolecules • Biodiversity • Ecosystems
2	How do I function?	• Functioning organisms • Surviving and functioning	• Cells • Biomolecules • Energy processes (e.g. Cellular Respiration and Photosynthesis) • Systems (and links to adaptations) • Linking it all together: Homeostasis
3	Why am I who I am?	• Genetics • Evolution	• Genetics • Natural selection • Evolution (including theories of human evolution)
4	How do/can I influence my world?	• From within and beyond… • Linking our biological understanding to survival	• Big emphasis on science as a human endeavour • Links to specific biotechnologies such as genetic biotechnology, immunology, bioinformatics, rational drug design, etc. • Links to technologies related to 'who we are', 'how we function' and 'why we are what we are'… 'what/how we could be…? • Implications of technologies/humans on biodiversity and ecosystems

There was almost unanimous support for a conflation of the existing content of Units 1 and 4. Even for those teachers who supported the revisiting of ecology in Unit 4 after studying it in Unit 1, the practicalities of implementation favoured a single-unit study of ecology, appropriately placed in Unit 1, as the following comments illustrate:

- *Unit 1 is an exceedingly dry unit focusing on classification and ecosystems – a good way to turn students off Biology. Despite this comment I suggest the Dynamic biosphere part of Unit 4 go into Unit 1. In Unit 1 you are dealing with interactions within ecosystems, it seems logical to include the Unit 4 material here. Also, why end a student's study of*

Biology (i.e. Unit 4) with ecosystem interactions as it is conceptually easy (not that engaging for most students) and can be covered easily in Unit 1?

- *Being trained in Environmental Science and Biology, I think that it is logical, on one level, to compare the way an organism responds to changes in its environment with the way an ecosystem responds. In another sense, one could question the validity of the comparison; it is quite challenging. The dynamic biosphere may relate better to natural selection and evolution i.e. humans out-compete other organisms and so many are being displaced. The competitive exclusion principle and a reference to fundamental and realized niche would be helpful here. However, I can see that the ever-burgeoning human population can be likened to a disease of the biosphere i.e. an explosion of one population causes dysfunction in its host (think of the biosphere as the host), by its competitive use of the host's resources or by toxins affecting areas of the host. I can see validity in this perspective. The only resistance mechanism that ecosystems have is biodiversity. This is an important message to get across to students before they leave school. As responsible citizens and future voters, they need to know the most effective ways to conserve biodiversity. I certainly believe it is important to study changes in ecosystems and the biosphere, particularly with regard to human impact, but it may be more practical to do it at the end of Unit 1 after studying ecosystems in detail. There also seems to be some conceptual overlap with Unit 1 with respect to the idea of changing ecosystems. I appreciate that different examples can be used, human impact appears to be emphasized more and the perspective is different (i.e. comparing it with an organism's response) but all the same it does overlap with the end of Unit 1.*
- *To give Unit 4 'Dynamic biosphere' a fair treatment, a field trip investigation would be beneficial. Theoretically I am in agreement with this but in practice, I feel it is unlikely to happen. Funding, supplying staff and being allocated time for a second field trip in a two-year course may prove difficult. Second semester in Year 12 is relatively short, also. This would reduce further the probability of a field trip. I suspect that for practicality, if a field investigation is required, it would be more sensible in a school to link 'Dynamic biosphere' to the earlier study of 'Changing ecosystems' in Unit 1, due to budgetary and time considerations.*

(f) The 'Science as a Human Endeavour' strand

The inclusion of a *Science as a Human Endeavour* strand was, in principle, seen by stakeholders as being a valuable curriculum element. However, significant issues have been identified related to content selection with the subsequent consequences for content loading and assessment, as illustrated in the following comment:

> *Human endeavour is great and in most cases is already an integrated part of our teaching practice that engages students, but if students are to be assessed on it as well that is a massive workload and amount of content to cover.*

Content descriptions in this strand range from statements of fact through to specific examples of contexts which can be used. There is also a narrow focus of some statements, often with little direct relevance to the *Science Understanding* and/or the *Science Inquiry Skills* strands, and which would require further conceptual understandings. There is an over-focus on the history of the development of biological understanding - it is unnecessary that students are required to consider, for example: mid-19th century models of membranes; microscopy developments; the work of Levene, Astbury, Avery, Chargaff, Franklin, Wilkins and Pauling in developing understanding of the structure of DNA; and 19th century evolutionary theories.

Persistent references to development of technologies would also be time-consuming and could be beyond the scope of a biology course dependent on how the statements are interpreted. In the sub-unit 'Multicellular organisms', for example, students are expected to consider that 'Discoveries made through the use of modern technology (for example, scanning electron microscope, use of radioisotopes, chemical monitoring and CAT and MRI scans) have increased understanding of organ and system functions' and that 'Advances in medicine and technology have enabled organ transplantation and the development of artificial replacement organs, which significantly affect peoples' lives'. Although some content is listed as a contextual 'for example', at Units 3 and 4 where Victoria has external examinations, assessment of optional content can be difficult. In the examples above, content creep is clear: are the technologies to be treated as 'black boxes' (in which case, why mention them?) or should there be some understanding of how they work and what they detect? Organ transplantation involves understanding of immunological reactions, which is not studied until later units (and even then, in this draft, the necessary background understanding is not developed). What is expected of an investigation of '…the development of artificial limbs'? Reproductive systems are not included in this unit – could they still be used as a context? What time should be spent considering impact of artificial replacement organs on peoples' lives, and how will the information be collected?

Stakeholder feedback advocates for a revision of the *Science as a Human Endeavour* strand such that it includes a strong focus on 21st century developments in, contemporary applications of and issues related to biology, and that it more closely links to the *Science Understanding* and *Science Inquiry Skills* strands. Opportunities to introduce local content in this strand have been missed by including descriptions that provide specific examples rather than general conceptual statements.

(g) Content clarity

Clarity of the written content descriptions was seen as a major issue by Victorian stakeholders since scope and depth of concepts cannot be determined accurately from the draft as written. In Victoria, content clarity is particularly important at Units 3 and 4 where student assessment includes an external end-of-year single examination. For educational equity, it is important that teachers and students have a clear understanding of the extent to which concepts are examined. It is not sufficient, for example, to state as a *Science Understanding* content description that 'Animals' responses to variations in their internal and external environments involve the nervous and endocrine systems' (Unit 4), since to what extent should nervous systems, for example, be considered? Does this mean simply the organisation of the nervous system? Transmission of nerve impulses and generation of action potentials? Synaptic transmission? At cellular and membrane levels? Voltage-gated ion transport? The corresponding detail in the *VCE Biology Study Design* related to nervous systems (in Unit 3) specifies the role of the nervous system in homeostasis, stimulus-response model and negative feedback model; signalling molecules (neurotransmitters), and signal transduction (signals, membrane receptors and responses).

Similarly, to state that 'When pathogens cross the surface physical and chemical barriers of animals and enter the body, they can cause changes to the internal environment and stimulate immune system responses' (Unit 4), to what extent is this to be considered? A general definition only of pathogens? The main groups of pathogens and their characteristics? The *VCE Biology Study Design* for Unit 3, for example, specifies non-cellular agents and cellular agents.

The *Science Inquiry Skills* strand in Units 3 and 4 includes 'represent data in meaningful and useful ways, including the use of statistical analysis….' Does this mean that students calculate means? Or standard deviations? Are t-tests required? Stakeholders reported numerous other points in all units throughout the document that require further explication, some of which will be included in the discussion below relating to comments on specific units.

(h) Field, experimental and practical work

While field work is universally regarded as an important part of the study of Biology, it should not be a mandated component of the curriculum. The knowledge and skills that students will best develop through fieldwork should be set out in the curriculum. The decision about when, how and how often to engage students in fieldwork is a pedagogic decision that should be made at the school level.

Comments on specific units

Unit 1

Concerns were expressed that there is considerable overlap in this unit with material covered in Years 7-10 of the *Australian Curriculum: Science*. While some of the biodiversity content in the draft may provide an opportunity for students to build on concepts introduced in previous years, as the current draft Unit 1 stands, many students may find the limited extension of the material boring and may soon lose interest. In order to modify this unit so that an appropriate level of academic rigour is achieved, it is suggested that photosynthesis, respiration and biomolecules vs inorganic matter from Unit 2 be included. These concepts would relate well to energy flow through ecosystems and cycling of matter, and would give more scope for classroom investigations and student-designed experiments. Strong stakeholder response also advocates incorporation of the current draft Unit 4 '*Dynamic biosphere: models of change and resilience*' sub-unit. It would also be appropriate to include diffusion and surface area to volume ratio to assist understanding of adaptations to particular environments.

Further suggestions for developing an introductory unit that will engage students are included in the submission below:

> *To consolidate students' understanding of the structure and function of organisms and the unity and diversity of life, they should have time to study the comparative anatomy and physiology of a range of organisms; studying how they obtain energy and nutrients, exchange gases, remove wastes and respond to the environment. My experience suggests that students find this*

very interesting and informative compared with the relative dryness of the content suggested for the first unit.

Unit 2

Stakeholders consistently expressed the view that this unit contained too much content:

- *This is a really BIG unit with a lot of content in it. Without seeing the elaborations that are suggested to unpack each of the dot points in the Science Understanding it is difficult to anticipate the depth that students are required to understand. This is especially the case, given the statement in the Unit description regarding the 'chemical nature' of cellular systems… For example, to what detail are the students required to understand:*
    - *the chemical nature of biomolecules?*
    - *molecular structure of cell membranes?*
    - *nature and arrangement of internal membranes and enzymes in biochemical processes?*
    - *primary, secondary and tertiary structure of proteins (e.g. enzymes)?*
    - *inputs, outputs, locations and stages of photosynthesis and cellular respiration?*
- *Unit 2 is a large conceptual leap from Unit 1 with many key biology principles introduced. In order to teach these important principles effectively and make them simple for a Year 11 student, much practical work and hands-on activities are required, and these take time. There is plenty of scope (almost too much) for experimental investigation and practical work, including student-designed ones. I feel Unit 2 is too heavy in content; the risk is that if taught in a rush, it will be given a superficial treatment; it could overload and confuse students. In fact, depending on how you interpret the content descriptions and to what extent each point is covered, Unit 2 presents our current VCE Unit 1 plus half of our current Unit 3 material!*

A judicious placement of some Unit 2 content into Unit 1, deletion of content previously covered in the *F-10 Australian Curriculum: Science* and rationalisation of essential content is required to enable manageable content including opportunity for practical work in Unit 2. Significant omissions in this unit identified by stakeholders include: detecting, responding, coordination and regulation (from Unit 4 in the draft) which link appropriately to concepts in this unit; reproduction (both plants and animals); and pathogens and disease, given that this includes a focus on multicellular organisms, cells and systems. This concept can then be further developed in Unit 3 with a focus on medical technologies that currently assist (or could assist) humans in dealing with pathogens and combating disease.

Unit 3

Content scope has overwhelmingly been identified as a significant issue in this unit. Other concerns include the omission of human evolution and the lack of opportunity for students to undertake student-designed investigations.

The following submission indicates the nature of uncertainty about the scope of the content included in this unit:

- *Each dot point in the Science Understanding learning outcomes needs an indication of the depth that should be covered e.g.:*
    - *'mitosis and meiosis'- is a simple definition sufficient, or are names and stages and structures and behaviours at each stage required?*

- *'proteins, including enzymes, are essential to cell structures and functioning' – this could be covered in one slide of a PowerPoint or it could take several lessons, including practical work. I assume enzyme function is not to be given as extensive treatment as in Unit 2. Therefore, should other proteins, besides enzymes, be given as examples in this dot point?*
- *'patterns of inheritance' – are dihybrid crosses expected, as well as monohybrid ones?*

Stakeholders strongly argued for the inclusion of human evolution, as represented by the following comments:

- *I am concerned that human evolution does not appear explicitly anywhere in the learning outcomes or content descriptions. It should be included as a separate dot point or at least as an example, perhaps in the 'theory of evolution' dot point. I feel very strongly that all Biology students should be exposed to and consider phylogenetic models of human evolution.*
- *There is no dot point that is related to our own hominin biological evolution that has brought us to where we are (few senior biology courses ignore our own biological evolution and the cultural and technological consequences of that biology).*

For conceptual cohesion, changes in the global biosphere over time, which are currently in Unit 4 draft content, could be incorporated into the natural selection/evolution section in Unit 3.

There is sufficient scope in this unit for practical work, but it is questionable as to whether students can design their own investigations. The *Science Inquiry Skills* strand should be better tailored to suit the content. Although students could propose some designs, for example, suggest possible crosses to determine parental genotypes, the draft content does not lend itself to student-designed investigations.

Unit 4

There was strong stakeholder feedback for a reconceptualisation of this unit, with the recommendation that concepts be appropriately distributed in other units to provide stronger links with major biological concepts, and that concepts already included in the *F-10 Australian Curriculum: Science* course be deleted. It was noted that the level of demand in the immunology section was well below the expectations in the current *VCE Biology Study Design*.

The following comments summarise the widespread concern about the lack of cohesion in this unit:

- *Unit 4 is based on a theme of responding to change but the theme results more in a manufactured set of links than logical biological ones. This can be seen in the grouping of concepts from diverse areas of biology such as ecology with physiology and immunology. As a result Unit 4 is a miscellany of ideas from different sub-disciplines of biology. Such a random collection of ideas does not aid learning.*
- *This content is 'mumbo-jumbo'. It is all over the place! Homeostasis fits best with multicellular systems in Unit 2 and the ecosystem/biosphere should be woven into where it is appropriate throughout the other units (such as Unit 1, 2 and 3).*

- *Unit 4 is just a grab bag of stuff that the writers forgot to include in the other units.*

3.4.2 CHEMISTRY

The draft Chemistry curriculum covers most chemical concepts that have traditionally been part of senior secondary school chemistry courses. However, feedback from most Victorian educators was that the draft is not as rigorous or as contemporary a curriculum as the current *VCE Chemistry Study Design*. In summary, stakeholders reported the following concerns: superficial understanding expected of too many topics; incoherent sequencing of a number of concepts; lack of specificity in content descriptions; overemphasis in the *Science as a Human Endeavour* strand of the impact of technology on, and the historical development of, chemical theories, and a lack of emphasis on current and future applications of chemistry; tokenistic inclusion of emerging technologies, nanochemistry and green chemistry; lack of contemporary knowledge and applications; minimal focus on problem solving; and disconnection across strands.

The major concerns with the draft Chemistry curriculum are elaborated below:

(a) Scientific errors in the draft

A number of scientific errors appear throughout the document. Examples across all three strands include:

- *Science Understanding*, Unit 1: reference to metals having high melting points is incorrect, since the alkali metals and mercury are examples of metals that have low melting points.
- *Science Understanding*, Unit 1: 'The magnitude of heat absorbed or evolved for a reaction is directly proportional to the quantities of reactants involved…' This is only true in situations where there is a stoichiometric proportionality between reactants according to balanced chemical reactions. If one of the reactants is in excess, then the limiting reagent will be the determinant of the heat absorbed or evolved.
- *Science Understanding,* Unit 2: 'The pH value of a solution is used to compare the levels of acidity or alkalinity of solutions; the pH is dependent on the concentration of hydrogen ions in the solution." pH is dependent on temperature, and is defined by the concentration of hydrogen (or hydronium) ions in solution: pH = $-\log[H_3O^+]$. H_30^+ and H^+ can be considered as interchangeable from a mathematical perspective. It is worth noting that it is only at 25^oC, in pure water, that the concentrations of hydrogen/hydronium ions and hydroxide ions are equal and that they are 1.0×10^{-7} M each, thus having a pH of 7. At other temperatures, although pure water will have equal concentrations of hydrogen/hydronium ions and hydroxide ions, the pH will not be 7.
- *Science as a Human Endeavour*, Unit 1: X-ray crystallography, first used in 1914, has been identified in the draft as an 'emerging technology'.
- *Science Understanding*, Unit 3: 'The effect of changes of concentration and pressure on chemical systems at equilibrium can be explained and predicted by the application of collision theory to the forward and reverse reactions.' More

correctly, this requires the application of collision theory to a consideration of the effect of changes to the relative rates of the forwards and backwards reactions. Alternatively, explanations and predictions can be made through consideration of the molar ratios in the balanced chemical equation, the reaction quotient and the application of Le Chatelier's Principle.

- *Science Understanding*, Unit 4: The statement that 'Fuels (for example, biodiesel, ethanol, hydrogen) can be synthesized from a range of organic or inorganic sources using addition, oxidation and condensation reactions' is inaccurate. The synthesis of biodiesel from plant or animal sources, for example, actually involves transesterification reactions rather than any of the three reaction types listed in the draft.
- *Science Understanding*, Unit 4: the statement that 'polymers are synthesised through condensation and addition reactions' should be modified to read 'polymers are synthesised through condensation polymerisation and addition polymerisation reactions'.
- *Science Understanding*, Unit 4: the statement that analytical techniques including chromatography and spectroscopy rely on specific properties…including solubility, mass…' Spectroscopic analysis is not dependent on solubility or mass.
- *Science Inquiry Skills,* Unit 4: 'Select, construct and use appropriate representations, including…chemical equations (using IUPAC conventions), systematic nomenclature…' IUPAC conventions relate to nomenclature rather than chemical equations.
- *Science Understanding*, Unit 2: 'the pH of a solution is used to compare levels of acidity or alkalinity…' Levels of acidity can be calculated by measuring hydrogen ion concentration. The alkalinity is then deduced through application of a mathematical relationship linking $[H_3O^+]$ and $[OH^-]$. 'Levels of alkalinity' is not an accepted chemical term.
- *Science Inquiry Skills, (*Units 1 to 4*):* "…recognise uncertainty…" Uncertainty is a quantitative rather than qualitative measure.

(b) Alignment of aims, rationale, content descriptions and achievement standards

Stakeholders reported general satisfaction with the rationale, although too wordy, but note that there is not always a clear connection to the rest of the document. For example, the statement included in the rationale that '…Some of the major challenges and opportunities facing Australia at the beginning of the twenty-first century are inextricably associated with chemistry…' is not apparent in the actual curriculum outline.

(c) Content selection, contemporary curriculum and student engagement

Stakeholder feedback includes references to lost opportunities for the course to be forward thinking. It is not possible that a course of this nature can cover all possible chemical concepts, but the omission of a number of major chemistry topics that are the focus of much current research and development and are within the conceptual capabilities and interests of students have been identified, for example, a more detailed consideration of biochemistry could be included in the organic reactions component of Unit 4 without significant increase in content. A consideration of the

chemistry of fuel cells could similarly be included in the electrochemistry component of Unit 3. In particular, the tokenistic treatment of contemporary aspects of chemistry, including green chemistry and technologies, was an area of concern. There is concern that this draft, in comparison with the current *VCE Chemistry Study Design*, provides fewer opportunities for problem-solving and deep understanding of contemporary chemistry-related issues in society.

Twelve principles of green chemistry are well articulated in the chemistry literature, namely: prevention of waste; atom economy; less hazardous chemical syntheses; design of safer chemicals; use of safer solvents and auxiliaries; design for energy efficiency; use of renewable feedstocks; reduction of derivatives; catalysis; design for degradation; real-time analysis for pollution prevention; and inherently safer chemistry for accident prevention. These listed principles are underpinned by chemical concepts that take green chemistry beyond a simple ethical behaviour capacity. Reference to 'green chemistry' occurs in the draft as only a few scattered examples in the *Science as a Human Endeavour* strand without a serious effort to include the relevant underlying principles in the *Science Understanding* strand. This leads to a superficial consideration of these principles. 'Green chemistry' is mentioned specifically in Unit 1 only as, 'Green chemistry aims to design products and processes that minimise environmental impacts (for example, reducing the use and generation of hazardous substances, increasing energy efficiency), decrease the cost of these products and processes and develop sustainable practices'. The concept of energy efficiency is not included in the *Science Understanding* strand, nor are there associated content statements that unpack ideas such as the chemical nature of hazardous substances, sustainability, atom efficiencies, the nature of solvents or degradability. If students are expected to do more than simply recall the statement and actually understand how green chemistry principles can be applied in both familiar and unfamiliar situations to minimise environmental impacts and develop sustainable practices, then it is essential that relevant concepts are included in the *Science Understanding* strand. Further, an aim of green chemistry is not economics-based, as suggested in the content description. Importantly, serious treatment of green chemistry requires a consideration of the nature of wastes; this is not included in the course. Numerous opportunities exist throughout the course to incorporate green chemistry in meaningful ways.

Nanotechnology is a contemporary area of research and application in today's world, but is given minimal representation in Units 1 and 4. Although fullerenes are specified in Unit 1 as an example of a carbon-based material, the four general classes of nanomaterials and their properties should be investigated, namely carbon-based materials (including fullerenes and nanotubes), metal-based nanocrystallinematerials (quantum dots, nanogold, nanosilver, metal oxides), dendrimers (organic, branched nanoparticles) and nanocomposites (multi-layer structures and inorganic/organic composites). Nanotechnlogy provides opportunities as a context for the consideration of a number of green chemistry principles.

The focus of Unit 2 is on 'environmental chemistry', but few links are made that connect chemical concepts to environmental issues. For example, the 'atmosphere'

sub-unit does not refer to the nature of the greenhouse effect and how an enhanced greenhouse effect has occurred on Earth. Except for combustion, no other consideration of the anthropogenic production of the six specific gases monitored/controlled under the United Nations Framework Convention on Climate Change: carbon dioxide, methane and nitrous oxide (generated through fuel combustion, agriculture and deforestation); and sulfur hexafluoride, perfluorocarbons and hydrofluorocarbons (generated though industrial processes) has been included in the draft.

In Unit 4 a consideration of only two chromatographic and two spectroscopic techniques is limiting and does not provide a true reflection of the application of multiple instrumental analytical techniques in contemporary analysis. One written submission made this comment:

> *The omission of HPLC as a chromatographic technique reduces the relevance of the course to current analytical laboratory techniques. This method is widely used and would be simple to include. Similarly the omission of NMR and Mass Spectrometry makes this part of the course quite backward and old fashioned and does not reflect the practices in modern analytical laboratories. Mass spectrometry is frequently used to identify and determine structure. Omission of this technique limits the extent to which dot point 5 (p28) can be covered. Mass Spectrometry should be included.*
>
> *In the Science as a Human Endeavour strand, it might even be useful to include reference to the next generation of instrumentation e.g. ICPMS (Integrated Coupled Plasma Mass Spectrometry) which tests for 30 elements at a time and is replacing AAS in industry.*
>
> *From our experience students are able to analyse second hand data from instrumental techniques and enjoy the problem solving aspects of piecing together information from a variety of techniques to elucidate a chemical structure or to determine the amount of analyte.*

In order to enable students to undertake problem-solving tasks involving modern analytical techniques it is recommended that the range of analytical instruments be expanded to include HPLC, UV-Vis spectrophotometry, GC and AAS. In addition, the task of identification of simple unknown organic compounds requires use of a combination of data from low resolution and high resolution H-1 NMR spectroscopy, C-13 NMR spectroscopy, mass spectrometry, IR spectroscopy and percentage composition and molecular mass data.

Other significant omissions in the draft include Periodic Table trends, especially for subsequent understanding of atom reactivities and properties, and organic reaction pathways, which are a fundamental inclusion in most international senior secondary chemistry courses.

(d) Content sequencing and depth

There is significant concern regarding the sequencing of topics, particularly in cases where content is studied which requires pre-requisite knowledge specified in later units. One submission included the following comment:

… the discussion of properties of materials in Unit 1 before learning about intermolecular forces in Unit 2 is not logical. Similarly the reference to properties (p5) in the last dot point reflects an inappropriate sequencing of content, since bonding has not been taught at this stage. Surely the discussion of properties requires an understanding of bonding?

Some concepts covered in the *F-10 Australian Curriculum: Science* which are restated in the draft Chemistry curriculum, for example, rates of reaction and the Periodic Table, and do not show any progression of understanding of the concepts, require revision. To illustrate this point, consider the study of rates of reaction which is specified in the draft in Unit 1. At a senior secondary level, the study of the factors that determine rates requires an understanding of concentration, kinetic theory, behaviour of gases and molecular shape all of which are included in the draft in Unit 2. However, rates of reaction should be linked to equilibrium, a Unit 3 topic in the draft, since production of many useful chemicals involves compromises between rate and equilibrium yield.

Stakeholder feedback reports major concerns with the significantly decreased depth and breadth of stoichiometric applications, and inappropriate sequencing, in the draft when compared with the *VCE Chemistry Study Design*. Calculations involving moles and molar mass require an understanding and application of the concept of relative atomic mass. This concept is fundamental to the chemical calculations that are required throughout the course, but has not been specified. Students are expected to calculate molar mass in Unit 2, but it is not possible to perform the specified stoichiometry calculations in Unit 1 of the draft without this skill. There is minimal coverage of stoichiometry in Units 3 and 4, with a strong view that a full treatment of volumetric analysis (back titration, redox, acid-base), gravimetric analysis and applications of electrochemistry is appropriate, including calculations relating to fuel cells and the use of Faraday's Laws. Although the sub-units of Unit 4 are 'analysis' and 'synthesis', calculations are limited to determining the yield of synthesis reactions. Gravimetric and volumetric analysis should be strong elements that quantify any analyses or syntheses undertaken. Heats of reaction, currently listed in Unit 1, should be extended to include simple calorimetry, the energy content of foods and secondary data from bomb calorimetry. NMR spectroscopy is listed in Unit 2 as a qualitative inclusion in the *Science as a Human Endeavour* strand, but is better placed as a quantitative application with instrumentation in the *Science Understanding* strand.

Some concepts that have been included in the draft curriculum, particularly in the *Science as a Human Endeavour* strand, are regarded as beyond the scope of most senior secondary students, as the following response indicates:

Some of the models and theories that are proposed in this curriculum are too sophisticated for students of this age. These students are only beginning to think in an abstract way, and already they are required to study many models and theories that are not based on anything that is within their experience or that they can see. For example, the detailed study of the Schrodinger model of the atom is already quite a leap for students just entering their senior years.

Molecular orbitals and the involvement of electron pairs in acid-base reactions would also be too great a leap, and for this reason are not usually taught at the senior secondary level. Forcing students to study models that are traditionally taught at the tertiary level can only be counterproductive and rob them of their confidence and interest in chemistry.

(e) Content overload

Stakeholder feedback indicates that the amount of content in the draft is too high, particularly in Unit 1. However, the most significant overload factor was identified as being the content of the *Science as a Human Endeavour* strand. A significant number of the statements in this strand often require addressing concepts that are not included in the other two strands in addition to requiring time to consider economic, technological, social and political factors without direct links to chemical concepts. Further, some of the statements are contestable, for example, the Unit 4 statement: 'The development and acceptance of new materials and processes (for example, molecular self-assembly, conducting polymer materials, biofuels, anti-viral agents) is subject to the scientific community reaching consensus and communicating these findings in ways that make these new materials socially acceptable'.

If there is to be an emphasis on developing deeper conceptual understandings and strong inquiry skills, then curriculum specifications must allow time for them to be fostered. The judicious selection and sequencing of topics, and reconceptualisation of the *Science as a Human Endeavour* strand, should streamline the course.

(f) The Science as a Human Endeavour Strand

The inclusion of a *Science as a Human Endeavour* strand was, in principle, seen by stakeholders as being a valuable curriculum element. However, significant issues have been identified related to content selection, content loading and inter-strand connections which has led to a questioning of the usefulness of this strand both in terms of being taught and being assessed. The range of skills and insights demanded for this strand are seen as being too limited, since many content descriptions across the sub-units are repetitive and narrowly focused. There is concern that too great an emphasis on the historical development of various theories and ideas will result in a loss of student interest and engagement. An expert group concluded that:

The SHE strand is backward looking in that it overemphasizes the historical development of chemical models and the influence of what was then new technology. This is stated in various ways on five occasions in units 1 and 2. A greater emphasis on the application of ideas and concepts listed in the Science Understanding strand would assist to make the subject more relevant and engaging to students. There is a total lack of discussion of possible future developments.

This was supported by the submission:

There seems to be an overemphasis on the historical development of concepts as well as the impact of technology, while there is only a tokenistic reference to nanotechnology and green chemistry. The opportunity for this course to be forward looking has been missed and gives the course an old-fashioned (1950s) feel rather than one which reflects the 21st Century.

This strand would be difficult to assess in its current representation. It is unclear whether everything is meant to be taught that is listed in the SHE strand or are the points just examples? If this is the case, the difficulty of assessment increases further.

Content descriptions in this strand require further conceptual understandings, for example, 'Spectroscopy enables the remote analysis of the chemical composition of celestial objects' (Unit 4) is a very specific application of spectroscopy and does not link to first-hand considerations of the use of spectroscopy to determine structure and bonding, which would be more engaging, provide relevant problem-solving scenarios and better link the strands. A statement about the application of spectroscopy in modern society would be more appropriate. Other content descriptions require that further underpinning concepts and/or processes are required to be taught, thereby adding to the curriculum load, for example 'Claims related to the properties of products…are evaluated by using controlled testing based on accepted and established standards' (Unit 1). Is it expected that actual laboratory testing protocols be studied? Is a discussion required of how protocols can be set up to ensure for accuracy and precision in testing? Or is this simply a statement of fact?

Stakeholder feedback advocates for a reconceptualisation of the *Science as a Human Endeavour* strand such that it includes a strong focus on 21st century, contemporary applications of and issues related to chemistry, that it more closely links to the *Science Understanding* and *Science Inquiry Skills* strands and that it is more relevant to everyday life. The following submission illustrates how this strand could be redeveloped:

As well as the development of ideas, there is a strong need for students to develop skills in critically examining major issues of our time, and hence to analyse and evaluate and respond in a constructive way to the various claims made about these issues in the public arena, many made by people who do not have a science background. This is one area in which students can be assessed for their ability to analyse and evaluate arguments, and to base their case on scientific evidence and their science understanding. This is not only an essential skill but also an area that will be meaningful for students, which can encourage them to become thinking and contributing citizens. Indeed, this is recognised within the statement of the rationale for the curriculum. Therefore it is most disappointing and regrettable that few major contemporary issues are overtly specified in the proposed curriculum. Some could have even been given the status of topic themes, which would be far more meaningful to students than the current topic headings within the curriculum.

(g) Content clarity

It is important that the curriculum provide teachers and students with a clear understanding of the extent to which concepts are to be taught. It is not sufficient, for example, to state as a *Science Understanding* content description that 'Galvanic cells generate an electrical potential difference from a spontaneous redox reaction;

they can be represented as cell diagrams including anode and cathode half equations' (Unit 3), since one could ask a number of questions. Does this include primary and secondary cells? If so, which ones? Are the cell components expected to be known? Is recharging included? Similarly, although 'hydrocarbons' are included in Unit 1, depth of treatment is unclear. Does this include functional groups, polymers and basic organic reaction pathways?

A teacher considering the *Science Understanding* content description that 'Advances in areas such as biochemistry, forensic science and nanoscience have occurred because of developments in analytical techniques (for example, forensic chemical composition analysis, and the discovery of C_{60}) and these areas have ethical, economic and social implications' may ask, 'What are you supposed to teach here? Is it just a statement? To what extent can I give up time to consider economic implications, for example? What level of understanding of economic principles would be required?'

(h) Experiments and practical work

Stakeholders reported disappointment at the lack of emphasis on experimental work and an increase in time which will be devoted to non-hands-on research, as expressed in the following comment:

> *There appears to be an overemphasis on the use of secondary data. Such data would be suitable to investigations conducted using analytical instruments or interpreting spectra that are used to deduce the structures of organic compounds. There is a danger that secondary data could be used at the expense of hands-on laboratory investigations. Teachers must be required to provide laboratory investigations where it is at all possible.*

The current *VCE Chemistry Study Design* includes an extended experimental investigation. Stakeholders have been disappointed with the omission of this curriculum element from the recent draft, as illustrated in following submission:

> *The omission of an extended experimental investigation, even in Units 1 or 2, limits the development of science inquiry skills and of insights into how chemists work. An extended investigation would exemplify how research and applied chemists work, which is one of the aims of the 'Science as a human endeavour' strand. Moreover, with suitable selected topics, such as the industrial production of a key family of chemicals or the analysis of water from different environmental sources, it may well place students in contact with practising chemists and enable them to have site visits, which can help them realise how relevant chemistry is to so many aspects of their lives, and also build their confidence and fascination with chemistry. It also can be an opportunity to learn about chemical issues relevant to that investigation and how they are addressed, and to develop deeper understandings. This in turn can give students the skills and knowledge to be in a position to analyse and evaluate particular chemical models and processes.*

Comments on specific units

Unit 1

Although many traditional introductory chemical concepts are included in the unit, namely mole concept, bonding and chemical reactions, stakeholder feedback is unanimous in concerns about content load, appropriate conceptual sequencing, lack of indication of scope and disconnection between the *Science Understanding, Science Inquiry Skills* and *Science as a Human Endeavour* strands. The following online survey response by a teacher is typical of the general stakeholder view regarding content and sequencing:

> *There is far too much content in this unit for students to develop a solid understanding of the concepts. The apparent level of understanding expected in thermochemistry cannot be supported by the level of background knowledge the students would have in Unit 1.*

The *Science Inquiry Skills* strand contains concepts that should be directly linked to the *Science Understanding* strand, for example, calculations of mass of reactants and products, molar mass, percentage composition by mass, rate of reaction and enthalpy change should all be described in the relevant *Science Understanding* sub-unit since these concepts involve both understanding of the underlying chemical principles as well as the application of this understanding in carrying out the necessary calculations. Further, calculations involving moles and molar mass require an understanding and application of the concept of relative atomic mass. This concept is fundamental to the chemical calculations that are required throughout the course but has not been specified. Although reference in this strand is made to recognising uncertainty and limitations in data, it is unclear as to whether a mathematical treatment of uncertainties will be required, or whether a qualitative treatment will suffice.

In the 'Properties and structures of atoms' subunit, the significant omission of the determination of isotopic masses and the relative abundance of isotopes from mass spectra data is noted. Properties of atoms (ability to form bonds) is included, but not bonding itself, leading to a superficial treatment of the concept. Consideration of alternative forms of the Periodic Table requires a knowledge and understanding of chemistry beyond that expected of students in the first semester of an introductory chemistry course. The draft would be strengthened with the inclusion, in the *Science as a Human Endeavour* strand, of reference to the paradigm shifts involved in the development of atomic theory. This could replace the current inclusion in the draft of alternative Periodic Table formats.

A major concern in the 'Properties and structures of materials' sub-unit is that the properties and structures of materials are discussed without reference to intermolecular forces. The problem is illustrated by considering the statement: 'The type of bonding within substances explains their chemical and physical properties, including melting and boiling point, conductivity of electricity and heat, solubility and reactivity'. Melting point, boiling point and solubility are all explained in terms of intermolecular bonding (included in Unit 2) rather than intramolecular bonding. To quote boiling points of hydrocarbons as a property without understanding why there

are differences is unsound. It is recommended that the Unit 2 'Models of structure and bonding' sub-unit be incorporated into this sub-unit. Further inclusions in this sub-unit should be the properties of ionic substances in terms of the ionic bonding model, as well as properties of covalent bonding in terms of the covalent bonding model. Omission of nanotubes as allotropes of carbon is a significant issue since this is an important aspect of nanotechnology and the basis of much current chemical and biochemical research. It would be appropriate to also include systematic nomenclature of simple hydrocarbons (alkanes and alkenes) in this sub-unit. Understanding of the relationship between structures and properties of carbon compounds involves an application of VSEPR theory and intermolecular forces which are not studied until Unit 2 in the draft.

The treatment of emerging technologies in this unit has been criticised, particularly the statement that: 'Emerging technologies have provided evidence that informs the development of models of chemical structures (for example, X-ray crystallography provides evidence of concentration of electron density in substances that has informed models of the structure of ionic compounds)'. X-ray crystallography was first used in 1914 to elucidate the structure of common salt and so can hardly be described as an emerging technology! At what level are students required to have an understanding of the interpretation of data provided by instrumentation (technology)? In the case of X-ray crystallography interpretations of crystal diffraction patterns and electron density maps is a highly specialised skill including the application of Bragg's Law, $n\lambda = 2d.\sin\theta$, which is well beyond the ability level required in an introductory unit of a senior secondary chemistry course. Also beyond the scope of a course at this level is the consideration of some of the discarded models which require sophisticated levels of understanding, for example, whilst it may be appropriate to consider Pauling's molecular bonding model in terms of overlapping atomic orbitals it would be inappropriate to consider bonding and anti-bonding molecular orbitals and pi- and sigma- bonds.

In the 'Chemical reactions: reactions, products and energy change' sub-unit, the statement about use of the Law of Conservation of Mass requires clarification, particularly since this cannot be used in reactions that involve excess reactants or products. The emphases in the *Science as a Human Endeavour* strand should be changed to enable consideration of how experimental evidence has been interpreted to develop new conceptual models, and how the application of green chemistry principles minimises environmental impact. Detailed study of specific pieces of legislation should not be required.

Unit 2

The environmental chemistry theme of this unit is similar to that included in the current VCE Chemistry Study Design Unit 2 'Environmental Chemistry'. However, the view of all respondents is that the draft is not as conceptually demanding, does not provide comparable depth nor does it have the direct links to current environmental issues when compared with the Victorian course. Lack of inclusion of stoichiometric applications, such as reacting volumes of gases and solutions and introduction of

volumetric titration, was also seen as an issue. The 'Models of structure and bonding' sub-unit was identified as being better placed in Unit 1.

In the 'Chemistry of aqueous solutions' sub-unit an explanation of change in solubility with temperature could be added in order that it can be applied to current issues, for example, global warming implications for oceans. Redox reactions are also important reactions in aqueous environments, for example, metal displacement and metal corrosion. Consideration of pollution often involves small amounts of dissolved substances in water, and it is appropriate that units such as parts per million (ppm) and parts per billion (ppb) are included. Consideration of the Lewis model of acidity is questionable in the current draft since this is relevant to a study of transition metal chemistry and coordination complexes, and acidity of metal chlorides, neither of which are included in the draft. Thus, the application of the Lewis model of acidity to ligands or other instances of non-protonated systems seems to have little relevance and could only lead to student confusion between the protonic model and electron pair acceptor models of acids and bases.

In the 'Chemistry of the atmosphere' sub-unit the emphasis should be on how and why the properties of atmospheric gases affect the atmosphere, and not simply that they do. This sub-unit presents many opportunities for inclusion of relevant concepts that will enable students to apply their understanding to contexts of interest. Combustion is the only anthropogenic source of gas emission included in the document; agricultural and deforestation practices as well as industrial processes should be included as sources of gaseous emissions with the identification of types of gases emitted and the chemistry involved in their environmental and human effects.

Unit 3

The general view of this unit is that it needs significant revision, with important concepts omitted whilst concepts not included in any international chemistry courses at this level due to their complexity have been listed. It is also considered to be more demanding than Unit 4, particularly if essential content currently not contained in this unit is subsequently added, and hence the two units should be reversed. Volumetric analysis is better placed in Unit 2 rather than in this unit.

In the 'Chemical equilibrium systems' sub-unit, it would be appropriate to include a qualitative investigation of a chemical equilibrium system. Whilst the draft specifies calculation of the pH of strong acids and strong bases, calculation of pH in strong acids does not require consideration of equilibrium as strong acids by definition are completely ionized. Calculation of pH of both weak acids and weak bases would be consistent with the statement 'calculation of equilibrium concentrations'. Although it is important for students to be able to apply equilibrium principles to environmental and biological systems, this actually involves an understanding of heterogeneous equilibria, buffer solutions and the chemistry of weak acids and bases, which have not been included in the draft. It is unclear from the draft whether other equilibrium systems other than acid-base equilibria will be studied. A significant omission in this sub-unit is the practical consideration that many industrial processes involve a

compromise between factors that affect rate and factors that affect equilibrium yields.

In the 'Oxidation and reduction' sub-unit, the determination of the amount of product and energy use in electrolytic cells through the application of Faraday's Laws should be included, since it is important to determine efficiencies and undertake cost-benefit analysis. This also provides a practical context in which to consider green chemistry principles. The requirement to calculate cell potentials should be restricted to standard conditions since the calculation of cell potentials in non-standard conditions requires application of the Nernst equation, a logarithmic relationship. Calculations involving electrode potentials to determine cell voltage is also beyond the scope of a senior secondary chemistry course. It is not clear from the draft whether primary and/or secondary galvanic cells are to be considered, nor whether molten and aqueous examples of electrolytic cells are to be studied. This sub-unit provides opportunities for students to investigate contemporary technologies such as energy efficient fuel cells and solar panels, surprising omissions from the draft. Electroplating could be added as a non-mining application of electrolysis.

Unit 4

'Analysis' and 'synthesis' are familiar topics to Victorian stakeholders, where they appear in Unit 3. As written, not only is the cognitive demand indicated in the draft significantly lower than that seen in the *VCE Chemistry Study Design* but also the limited specification of functional groups and instrumental techniques does not allow for appropriate analyses and syntheses at this level.

In the 'Synthesis processes' sub-unit, a restricted variety of functional groups have been mandated. This will limit the range of synthesis reactions that students can study. The inclusion of a more extensive range of functional groups, such as haloalkanes, would enhance possibilities for organic reactions including substitution and oxidation reactions. The inclusion of amides, but not amines, seems incongruous. The importance of primary, secondary and tertiary structures has little importance if the reactions that differentiate between these structures are not included, for example substitution reactions of haloalkanes and oxidation of alcohols. The inclusion of aldehydes and ketones would add depth to the later study of analytical techniques. A consideration of a synthesis sequence via organic reaction pathways is not considered in the draft, and nanotechnology has been treated from a social, rather than chemical, perspective. Purification techniques are a notable omission from the draft, since synthesis often involves a sequence of reactions or a reaction pathway and a use of a variety of purification techniques.

In the 'Analytical techniques' sub-unit infrared spectroscopy on its own is of limited value in the identification of a compound. It is most effectively used in combination with other analytical techniques such as mass spectroscopy and NMR. The list of techniques is limiting and should also include AAS, NMR and mass spectroscopy. The use of a combination of techniques and future developments in analytical chemistry should also be considered.

3.4.3 EARTH AND ENVIRONMENTAL SCIENCE

There was strong support for the more explicit inclusion of Earth science in a senior secondary course in Victoria than is the case at present. However, there was significant concern that in the proposed draft there is too much weight given to Earth science at the expense of environmental science. A number of respondents expressed the view that they did not believe a single course could do justice to both Earth Science and Environmental Science. A strong view expressed through the consultation was that Earth science and environmental science each has its own sets of knowledge and skills, and there was concern that, although the combination was justifiable, the practicalities of a combination would result in a dilution of discipline integrity:

> *There would be far too much content, at the expense of skills development, to cover both subjects in a two-year course. 21st century schools need to be places where students can engage with authentic, contemporary issues in ways that allow connections, communication and collaboration. Skills such as data analysis, decision-making, synthesis of information and opinions, evaluation of strategies and communication of ideas are all necessary for successful participation in today's society.*

There was, however, broad support to continue the attempt to develop a single course that does bring together both disciplines without compromising the inherent integrity of the separate disciplines.

There was also concern that the draft duplicates aspects of the proposed senior Geography course, and that the draft Biology course has an overrepresentation of ecology with very little included in the Earth and Environmental Science course.

The Earth Science component in the draft was generally regarded as comprehensive and rigorous, as evidenced by the following comment:

> *This is a well written and well thought through curriculum proposal, which will give students taking this path a good background basic grounding in Earth Sciences of the same level as one semester of first year University Geosciences and Geography. The proposed curriculum of Unit 1 is similar in content to our first-year unit at (University), and the proposed curriculum of Unit 4 is similar to a first-year (University) Geography unit.*

However, key concepts in environmental science were identified as absent, including the following:

- sustainability (ecological; economic; socio-cultural) and the principles of ecologically sustainable development (ESD)
- enhanced greenhouse effect: electromagnetic radiation interacting with atmospheric gases; policies and legislation; management options
- pollution and its effects: air, water and soil pollution; heavy metals, bioaccumulation and endocrine disruptors; management options

- environmental management systems: precautionary principle; environmental effects statements
- biodiversity: habitat fragmentation; wildlife corridors; edge effect; risk assessment; population viability analysis
- environmental policy and legislation
- human population growth
- specific scientific concepts related to energy (e.g. First and Second Laws of Thermodynamics; 'open' and 'closed' systems)
- anthropogenic changes to the environment
- ground water

The following comment demonstrates dissatisfaction with content selection in the draft:

> *I have just finished reading the ACARA 'Earth and Environmental Science' document and I am not impressed. I find it unacceptable that topics like biodiversity, conservation of threatened species, and principles of sustainability have been left out. Please pass on my disappointment with this offering.*

Key concerns with the draft Earth and Environmental Science curriculum are elaborated below.

(a) Errors

- *Learning outcomes*, Unit 1: The phrase 'understand models and evidence for the formation and evolution of Earth…' should be modified to 'understand scientific models…' so that non-scientific models are not included.
- *Science Understanding*, Unit 1: The statement, 'Complex processes lead to the formation of sedimentary, igneous and metamorphic rocks over a range of time scales…', should be re-ordered to reflect both formation order and standard convention i.e. '….igneous, sedimentary and metamorphic rocks…'.
- *Science Understanding*, Unit 1: 'The fossil record...increases in marine animals in the Cambrian, terrestrial vertebrates in the Devonian and mammals in the Tertiary…'. 'Tertiary' as a time period has been replaced by the 'Neogene' and the 'Palaeogene'.
- *Science as a Human Endeavour*, Unit 4: The statement that 'Monitoring and analysis of data, including earthquake location and frequency data and ground motion monitoring, enables the prediction of the location and probability of repeat occurrences of hazardous Earth events, including volcanic eruptions, earthquakes and tsunami' is incorrect. Such prediction is not possible at this time. This statement could be reworded as follows: '…allows the mapping of potentially hazardous zones, and data collection towards the future prediction of the location and probability of repeat occurrences of hazardous Earth events'.

(b) Content selection

Stakeholders expressed the view that a clearer distinction about the learning expectations as a progression from the *Years F-10 Australian Curriculum: Science* to Units 1, 2 and 3 of the draft *Senior Secondary Curriculum: Earth and Environmental Science* are required to assist teachers to structure developmentally appropriate learning programs. It was noted by stakeholders that students cover the topics of 'renewable' and 'non-renewable' resources as part of the Year *7 F-10 Australian Curriculum: Science* in addition to junior studies in geography, so progression should be clear and appropriately challenging concepts should be provided so that students are not bored. Examples of comparative statements are shown in the table below for Units 1 and 2:

F-10 Australian Curriculum: Science	*Draft senior Earth and Environmental Science curriculum*
Year 7 Science: Water is an important resource that cycles through the environment	Unit 1: Water is generally conserved in the global system and changes state through the processes of the hydrologic cycle
Year 8 Science: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales	Unit 1: Complex geological processes lead to the formation of sedimentary, igneous and metamorphic rocks over a range of time scales as part of the rock cycle: rocks are composed of assemblages of mineral crystals or grains
• Year 10 Science: Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere • Year 10 Science: Energy conservation in a system can be explained by describing energy transfers and transformations	Unit 2: Biogeochemical cycling of matter (e.g. carbon, nitrogen, phosphorus) involves transfer and transformation of energy between the biosphere and the geosphere, atmosphere and hydrosphere)
Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within systems	Unit 2: Energy is required to do work; energy can be transformed between multiple forms (e.g. kinetic, gravitational, thermal, light)

(c) Contemporary content

Stakeholder feedback indicates that although the Earth science component of the course is contemporary in its reframing from a systems perspective including recognition of scale, the environmental component lacks connections to the present and future:

> *I think there is some great content related to Earth systems but at the expense of considering how the systems and cycles of the Earth that occur over very long time scales relate to the anthropocene and the intensification of changes over very short time scales. For me then, the environmental science is missing in this respect. In its current form this draft is content focused and less focused on issues and process, which leads the content being*

covered here to be dense and time intensive and not inclusive of critical environmental issues facing humans now and increasingly so in the future – climate, clean water, food production and waste management. In this sense, it is older fashioned and not very contemporary.

(d) Modelling

A significant part of the course requires that students consider various modelling applications, for example:

- Unit 2 SHE: 'Sophisticated physical and computer-based models of the dynamics and mechanics of plate motion and collision enable prediction of future plate tectonic movements and provide evidence for local evidence-based decision making (for example, investment in infrastructure, location of geothermal resources)'
- Unit 3 SHE: 'Models are subject to debate and revision as new data cause scientists to question the underpinning assumptions and limitations of the model (for example, models of maximum sustainable yield for fisheries and agriculture have changed as new data becomes available)'
- Unit 4 SHE: 'Models are subject to debate and revision based on the availability of supporting evidence and review of the underpinning assumptions and limitations (for example, as more data for long term climatic trends become available, this can prompt revision of climate change models'
- Unit 4 SU: 'Climate change models are developed through analysis of past and current climate data and enable prediction of the likelihood of future climate'
- Unit 4 SHE: 'Although forecasting the consequences of environmental change is crucial to society, it involves so many complex phenomena that predictions have inherent uncertainties; this has implications for the willingness of individuals, communities and governments to commit significant resources to mitigation strategies'

What is expected of students with respect to these statements is unclear. The achievement standards for a 'C' state that the student '...describes theories and models...' and 'applies a theory or model...', whilst at an 'A' the student 'evaluates the theories and models/s...' and 'selects and applies theories and models...' Most environmental models are mathematically complex, and to expect manipulation or application, let alone evaluation, of these models by students at a senior secondary level is unrealistic. As an illustrative example, General Circulation Models (GMCs) are the basic tool used to model climate change. GMCs model atmospheric and oceanic interactions by solving equations related to the conservation of mass, momentum and energy (generally studied in Year 12 Physics courses); further, GMCs are applied in three-dimensional grids at selected locations around Earth and their outputs are relevant to global, rather than local or regional, situations.

(e) The Science as a Human Endeavour strand

Implicit or tokenistic content in the *Science as a Human Endeavour* strand that is not supported by articulation of the underlying conceptual principles in the *Science Understanding* strand undermines its importance and adds a 'hidden' content load to the draft. For example, the statement in Unit 4 that 'Social responses to acid rain

and ozone depletion provide examples of the capacity for social change in order to manage a global environmental issue, and reflect the importance of communication of science understanding to individuals, communities and governments' can be considered from a social perspective only, which then compromises the scientific content of the statement and the integrity of the study of environmental science. Most international Earth and/or environmental courses at this level would require an understanding of the chemistry of ozone and acid rain, and to understand why these chemicals have the atmospheric impact that they do. This adds a significant content loading which is not explicitly referred to in the *Science Understanding* strand.

The tokenistic reference to indigenous peoples' management of the land and resources in this strand was also noted.

(f) Content clarity and overload

Judgement of content overload is difficult with this draft due to the generic nature of the content descriptions, particularly in the *Science Understanding* and *Science as a Human Endeavour* strands. In Unit 2, for example, the Science Understanding statement that: 'The net transfer of solar energy to Earth's surface is influenced by its passage through the atmosphere (for example, the greenhouse effect) and the physical characteristics of Earth's surface (for example, albedo)' requires the study of a number of specific scientific concepts that have not been mentioned. Consider the reference to the greenhouse effect: an approach to greenhouse must be based on clear scientific principles which builds knowledge about natural processes (including understanding of atmospheric structure, solar radiation, physics principles related to absorption and reemission, chemical structure of gases, energy) as a starting point and then relates this knowledge to the enhanced effect with accepted data and projections of impacts (based on reliable scientific organisations like CSIRO and IPCC). It cannot be taught as a theory or debate about interpretation of data and models. In this draft, enhanced greenhouse effect is mentioned in Unit 4 but not with respect to any underlying principles. Further, in a study of the greenhouse effect, the nature of the gases involved should be considered. There are six greenhouse gas categories, generated through two general types of human activities, which are monitored/controlled under the United Nations Framework Convention on Climate Change:

- carbon dioxide, methane and nitrous oxide (generated through fuel combustion, agriculture and deforestation); and
- sulfur hexafluoride, perfluorocarbons and hydrofluorocarbons (generated though industrial processes)

None of these gases, nor their anthropogenic origins, have been explicitly mentioned in the draft.

The concept of 'energy' appears throughout the document, and its scientific definition as 'energy is the ability to do work' is included in slightly modified form in Unit 2 as 'energy is required to do work…'. Teachers could rightly ask, 'What am I supposed to do with this?' because there is no other direct connection to it and certainly no application of it to Earth or environmental systems. Additionally,

mathematical requirements regarding relationships are specified – does this mean that students apply the relationship W = F . x, where F is the applied force and x is the distance moved? Do they need to understand the unit for work as being a joule (J) or newton-metre (kg m/s^2)? And what about the added complexity where the above equation does not apply when work is done by a varying force?

Comments on specific units

Unit 1

There was strong stakeholder support expressed for the systems approach adopted in the draft. Stakeholders did, however, identify a significant imbalance in the treatment of the four spheres, with the main focus being on the geosphere, some focus on the atmosphere and lithosphere, but very little focus on the biosphere. It was also recommended that much greater emphasis be placed on the interconnections of the 'spheres'.

The following comments illustrate the perceived lack of connectivity, and provide directions for creating an improved balance between the 'Earth' and 'environmental' aspects of the course:

> *I was surprised when I saw the description of the earth as four 'spheres': lithosphere; hydrosphere; biosphere; and atmosphere. This felt old fashioned, and simplistic. Today we are very aware of the links between these 'spheres' – soil for example, is not just a physical medium, but has a biological aspect as well. To start the course with these artificial distinctions does not bode well, I feel, for the recognition of Earth Science as one which is completely interconnected with life - from soil composition right through to attempts to rehabilitate land which has been disturbed by mining, to water allocations for food crops and to the changing composition of the oceans and the effects of this on marine life.*
>
> *Initially I was excited to see the recognition of Earth as a system, and the sub-systems within, as well as some discussion of the energy and matter flowing into systems and what is coming out of the systems. Linked with this idea of systems was the recognition that there are interactions between the four spheres (where the spheres area a representation of a macro-system), an interdependence of the systems on each other, and that changes in one system will have effects on the other systems. However, this was not appropriately developed in the draft. I was concerned by the actual use of the 4-sphere model. I think it is a simplistic representation of Earth and its sub-systems. The boundaries of these systems are represented as clear and easily defined but in reality are far from this. The importance and weight given to each system can be misleading when the common diagrams are used (often the biosphere is tiny and at the centre, rather than of equal proportion). Certainly this framework does not equally weight the four spheres, as there seems to be a heavier emphasis on the lithosphere and the resources that come from it.*

The theme of 'conservation' was suggested in one response as a way of demonstrating sphere connectedness:

> *Conservation knowledge can be included in this unit by adding more information about different ecosystems of the biosphere and how they relate to other spheres, thereby linking ecosystem type to underlying geology, availability of water, and altitude/latitude.*

Unit 2

Stakeholders were generally supportive of the 'energy' focus of this unit, but the progression from Years 9 and 10 science and geography to this level needs to be further developed, and more explicit links between the 'Earth' and 'environmental' aspects of the course are required. Scientific concepts related to energy need to be included. Greater specification of content is required in order to address the concern that:

> *The energy course (Unit 2) is a little vague. Much of this looks difficult to teach in any meaningful way.*

Clearer distinction about the learning expectations as a progression from the *Years F-10 Australian Curriculum: Science* to Unit 2 of the draft *Senior Secondary Curriculum: Earth and Environmental Science* are required, as indicated in the following survey response:

> *Care needs to be taken with content in Unit 2 relating to weather and plate tectonics; this needs to build on how these topics are covered (F-10) in Geography and Science to ensure they build on these topics (not replicate).*

In any scientific consideration of energy usage and transformation/transfer, both the First and Second Laws of Thermodynamics must be included in a senior Earth and Environmental Science curriculum:

- First Law of Thermodynamics – in essence, that matter is neither created nor destroyed but is only modified in form, should underpin any considerations of transformation/transfer.
- Second Law of Thermodynamics – concept of 'entropy' relates to energy efficiencies.

These laws are also important when considering the development of new/alternate energy technologies as a solution to current global energy issues.

Following from the First and Second Laws of Thermodynamics, the concept of Earth as a closed system with respect to matter (Second Law) but an open system with respect to energy is important, given that disorder increases in closed systems.

There are opportunities to make stronger links in this unit between the 'Earth' and 'environmental' aspects of this topic, as illustrated in the following suggestion:

> *Unit 2 makes a gallant attempt to bring the spheres together through the prism of energy…and I think this works quite well. However in my view the*

opportunity is missed here to link the energy so brilliantly locked up by plants, to the large amount therefore stored in fossil fuels, thereby explaining why we have been using them. In contrast, the more feeble, but clean and renewable energy sources available from the other spheres such as solar, wind, wave and geothermal require more clever thinking to harness their energy into the future as we seek to replace fossil fuels. I think it would make most sense to locate this here and would clearly ground the unit in something students can relate to directly.

Unit 3

Stakeholder feedback identifies this unit as requiring a significant change of focus, including the need to show progression from associated content in the *F-10 Australian Curriculum: Science*. Most of the content actually covers methods of location and extraction of renewable and non-renewable energy resources with scant coverage of the environmental consequences of these activities. It is not concerned with how humans use these resources as suggested in the title.

The use and management of all resources, present and future, are underpinned by the principles of ecologically sustainable development (ESD). These principles should be included in this unit, as should ESD policies and management procedures, for example, environmental impact assessments. The well-regarded Victorian approach where students undertake their own case study investigation enables ecological concepts and principles to be applied to relevant local issues. Biodiversity maintenance is an integral part of sustainable resource use and management, and should also be covered in this unit. The importance of other organisms is mentioned only in terms of yield for food and other products.

Stakeholders expressed the view that the basis for decision-making included in the draft content did not adequately reflect ESD principles:

- *Some suggested methods for making decisions are offered in unit 3 such as rate of production exceeds discovery, and maximum sustainable yield. In my view, this is a very narrow, economically focused selection of methods for assessing what decision should be made about impacting on the environment.*
- *Renewable energy is looked at from a 'cost-effectiveness' and 'constraint of efficiency of available technologies'. This appears to be looking at only a short term cost - not to factor in the long-term economic and environmental cost that will come from a reliance of fossil fuels.*

Unit 4

The 'Global climate change' sub-unit was generally well-regarded by stakeholders, although it was argued that the importance of biodiversity should be included. The 'Earth hazards' sub-unit was identified as needing significant strengthening in terms of consideration of all spheres, as well as distinction from the proposed senior geography course. Pollution (air, water, soil) and consideration of sustainable behaviours were identified as significant omissions in this unit.

The ‘Global climate change’ sub-unit could include a stronger focus on biodiversity by examining the effects of global change on flora and fauna distributions. Models of prospective species movements are available which will support a consideration of biodiversity, and can be included both from a knowledge (*Science Understanding* strand) and skills (*Science Inquiry Skills* strand) perspective. It would also be practical to include the concept of ‘Global Warming Potential’, expressed as carbon dioxide equivalent, in terms of enabling quantitative analysis in this unit and building capacity in evaluation.

Stakeholders report that the ‘Earth hazards’ sub-unit has too limited a perspective as written. While hazards like earthquakes impact on the environment and humans, there is no consideration of human influence on the occurrence and severity of natural hazards.

There is also considerable overlap between this unit and the current Geography draft. This can be resolved by recasting this unit to examine the how and why of hazards, and the interactions between the spheres, with topics such as pandemics not being covered in the Earth and environmental science course at all. A suggestion for such a recast was included in one submission:

> *Unit 4 could be called something more like ‘Dynamic Earth’ … with more focus on the areas in which the biosphere (all life, but certainly including us) intersects with the dynamic aspects of the planet that we term ‘natural hazards’. This shouldn’t just be a unit about volcanoes and earthquakes for the sake of them (exciting as they are), or some apologetic justification of the scientific stance on climate change. As with the other units, Dynamic Earth should be broader, and should also bring together aspects of the other units…e.g., our exploitation of nuclear energy at Fukushima (unlocking energy), intersecting with the tsunami (hydrosphere), caused by fracturing of the lithosphere…there are numerous examples of similarly linked hazards… created in one sphere, that impact on at least one of the others. I think most will already get the link between sea surface temperatures and El Niño/La Niña events, and volcanic eruptions with atmospheric dust plumes (impacting on aviation) etc but there are numerous possibilities to explore.*

3.4.4 PHYSICS

Whilst most traditional physics topics have been included in the draft curriculum, a number of topics that are beyond the scope of most secondary students are included and there is an absence of contemporary physics applications. As one respondent noted:

> *Over the past several years there has been substantial concern from the science community because not enough students are taking physics in the senior years. This course is likely to make that problem worse.*
> *It is a great pity the VCAA is considering giving up what is at present a good (if not the best) VCE Physics course to implement this rather old-fashioned one. This course represents a significant step backwards from the innovations of VCE Physics. The proposed ACARA course is contemporary only in that it includes some physics of the 20th century that has not previously been included in VCE Physics Study Designs. Curriculum comprises more than content. What is missing here is contemporary thinking about the scope and embeddedness of science.*

The most commonly expressed views were that the focus on models has been restrictive, content selection and sequencing are too often inappropriate, the lack of indication of content depth provides insufficient direction for teachers, there is too much content with little consideration of practical work, the *Science as a Human Endeavour* strand adds content load and is too limited in scope, and achievement standards as written are not useful.

These concerns are detailed below:

(a) Scientific errors

A number of scientific errors are contained in the current draft. Examples include:

- A listed equation {*dose equivalent*} = {*quality factor*} x {*absorbed dose*} is now obsolete, with the correct equation being {*equivalent dose*} = {*radiation weighting factor*} x {*absorbed dose*}. The change was introduced in 1990 by the International Commission on Radiological Protection in ICRP Publication 60 – this has subsequently been superseded, but does not affect the revised equation specified above.
- The equation for elastic collisions is incorrect and, if interference phenomena are to be retained, the equations for resonance in strings and pipes should be reformulated.
- Wording should be accurate and scientifically correct, for example the statement that 'Graphic representations…can be used to explain and predict linear motion' is incorrect since graphic representations don't explain motion, and the *Science Understanding* statement regarding the measurement of motion with respect to a specified frame of reference should be reworded to incorporate the correct physics terminology of 'relative velocity'.
- The terms 'electric constant' (correctly, ε_0) and 'magnetic constant' (correctly, μ_0) are used in a non-standard way in the draft and should be avoided. The 'electric constant, K_e' (represented anywhere else as a lower case k, i.e. k_e) is

more widely referred to as the 'electrostatic constant' or 'Coulomb's constant', if given a name at all. In addition, the draft includes the 'magnetic constant' bundled into one term as *K.*

- *Science Understanding*, Unit 1: The statements that 'Thermal energy can be transferred between and within systems…' and 'Energy transfers and transformations in mechanical systems…always result in the production of thermal energy…'are incorrect since thermal energy is a state variable of a system. It is heat that is transferred.
- *Science Understanding,* Unit 1: Although 'Temperature is a measure of the average kinetic energy of particles in a system' is true for a monatomic ideal gas, since more general concepts of motion such as vibration (rotation should also be included) have been mentioned previously, this needs to be revised especially since these concepts relate to differences in heat capacities (due to degrees of freedom) which students have studied.
- Planck, Bohr and Einstein (*Science as a Human Endeavour*, Unit 4) are misleading choices for a list of people responsible for the photon model. Planck and Bohr, in separate ways, were actively against a particulate model for light. A more appropriate selection is Einstein and Compton.
- Confused and inconsistent definitions and applications of the terms 'accuracy', 'precision', 'validity' and 'reliability'. In the sciences, 'accuracy' has a very specific meaning but is frequently misused due to applications in the general literature, leading to a potential for confusion. Various points in the document illustrate this confusion, for example, the *Science Inquiry Skills* strand for each of the four units states 'Represent data in meaningful ways, including the use of appropriate SI units and symbols to indicate the accuracy of individual and multiple measurements'. The use of units and/or symbols (SI or otherwise) have nothing to do with indicating accuracy.

(b) Content selection

Most traditional physics topics have been included in the draft, but there is minimal content (apart from the standard model and relativity) that links to developments in physics that have occurred over the last 50 years. As one teacher stated:

> *Consider the Unit 1 SHE point: 'The development of electrical technologies for industrial and residential use in the late nineteenth century transformed society; electrical power is now a core element of modern societies.' This says it all! Where is the modern physics?*

Significant contemporary omissions include: semiconductor physics; photonics; medical physics; nuclear reactor design and the use of thorium as a nuclear fuel; astronomy and cosmology; sustainable energy; and new materials and light structures.

The *Science as a Human Endeavour* strand and the *Science Understanding* strands too often can be read as catalogues of knowledge items and too often do not link to or identify the concepts that underpin contemporary physics-related issues in society.

(c) Content sequencing

There is significant stakeholder concern regarding the sequencing of topics, particularly in cases where content is studied which requires pre-requisite knowledge specified in later units. A consultation submission included the following suggestion:

> *I would swap Units 1 & 2. I believe one should talk about motion and kinetic energy before one can talk about the kinetic model related to temperature, or the kinetic energy carried away by the constituents of radioactive decay etc., and an understanding of waves and light is useful before gamma rays are discussed.*

Further, a number of concepts have been included in Units 1 and 2 which are more appropriately placed in Units 3 or 4, and some content in Units 3 and 4 is more appropriately studied at a tertiary level. Other content which is deemed important by stakeholders has not been included in the draft. A survey respondent made the following observation:

> *I don't understand why the content of the Australian Curriculum in Physics is designed contrary to the order in which Physics is taught across the world and in Australian universities. Why is there no molecular physics that is important for the understanding of life and nature around us and for all energy concepts? Why are many concepts taught before the significant pre-requisite content which is taught later? Why not follow logical order: Motion, Molecular Physics and Thermodynamics (even if some parts of Thermodynamics are included in Chemistry), Electricity, Magnetic Fields, Wave Optics, Atomic Physics and Interactions of Light and Matter, and Nuclear Physics?*

The draft curriculum places electric circuits in the first unit, followed by mechanics in the second unit and Coulomb's Law and electric fields in the third unit. There is strong stakeholder support for inclusion of circuits following the development of the concepts of energy in mechanics, and of the fundamental electrical force and fields.

(d) Alignment of aims, rationale, content descriptions and achievement standards

Coherence across the elements of a curriculum document should be evident in an alignment between course rationale, aims, unit descriptions, content descriptions and achievement standards. Stakeholders reported general satisfaction with the rationale, but noted that there is not always a clear connection between the rationale and the rest of the document. Reference in the *Rationale*, for example, to '…the significant contribution physics has made to contemporary society' is not reflected in the content descriptions. As one teacher observed:

> *The curriculum document appears to be more a philosophical statement about the structure of physics, rather than a document aimed at exciting young people about the world of physics and its relevance to what interests them.*

An additional clear example of the lack of alignment across the document is that the 'models' focus of the content descriptions is not reflected at all in the achievement standards.

(e) Student engagement and relevance

There is widespread concern that because the proposed draft does not include the contemporary applications of Physics included in the current Victorian curriculum that many students would no longer choose to enrol in Physics, as illustrated by the following comments from teachers:

- *This course spells the death of physics. Every piece of international research shows that students will choose courses which they find relevant and/or useful. This course takes physics education in the state of Victoria back to pre-HSC times.*
- *I actually think that our current VCE course is better than the national draft. It has been kept current with advances in the use of Physics over the past 15 years or so. For example, Digital Electronics has evolved to Electronics, Photonics and the Synchrotron. I have seen numerous students pursue careers in aviation as a direct result from studying 'Investigations in Flight' as a detailed study. Not just those who wanted to be pilots, but those who chose aeronautical engineering after discovering that there <u>was</u> such a course.*

(f) A 'models' approach to curriculum design

The 'models' approach in the document is all-pervasive, resulting in a view that physics is not so much about investigating the real world as about making up models to 'explain' it, as reflected in the following consultation comments:

- *By starting with the model rather than the phenomena we are giving the wrong impression of Physics.*
- *Reading through this curriculum one gets the feeling that physics is a set of models you pull out to explain a separate set of phenomena. Rather than starting with a series of 'models', let's start with the real world.*
- *The big problem with this draft curriculum is that the subject of physics, the investigation of the real world, is being forced into a 'model' context. We have a set of 'models' which don't seem to relate to each other, rather than a wonderful story of how humans have come to understand their world. In reality, concepts of motion, force and energy were developed through an understanding of mechanics. These were found to extend into other areas – electricity, for example. So putting electricity before mechanics is expecting students to develop complex concepts, voltage for example, before they have developed the concrete ones.*
- *Ultimately the 'model' approach puts the cart before the horse. Science begins with the phenomena, explanations are sought, and then usually models follow. Curriculum and teaching should reflect this process.*
- *The 'models' approach is too heavy and ubiquitous. The course has been written with models as the focus and this has constrained its scope. Theories need to appear to show how ideas are developed from hypotheses. The extensive use of models is overkill, and will potentially discourage students (through boredom!). The group firmly believes that*

models are important, but so is the concept of 'testable predictions' when it comes to discussing models and theories.

(g) Content overload

The majority of respondents expressed the view that too much content was included in the current draft. This is exacerbated by the fact that the *Science as a Human Endeavour* strand frequently contains content that requires conceptual understandings not identified in the *Science Understanding* strand. The following comment illustrates the problem:

> *In reading the Unit 3 SHE point: 'Community support, and national and international funding and cooperation are necessary to build and operate large-scale scientific instruments (for example, the Large Hadron Collider, the Australian Synchrotron), my only response is 'So what?' I have no idea how the writers intend us to respond to this. Do we just state it as a fairly obvious factual statement and leave it at that, or do they want us to do something with it? The synchrotron (or the Large Hadron Collider) should be included in the SU strand if it is to be considered in SHE, but this will require a significant amount of additional material to be taught.*

Stakeholder feedback regularly called for a revision of the *Science as a Human Endeavour* strand so that it more closely links to the *Science Understanding* strand, as illustrated by this comment:

> *The inclusion of the Science as a Human Endeavour strand is a positive step … [h]owever, this strand is, at present, very shabbily treated when compared with the other two strands. There is some attempt at a history of science but there is scant acknowledgement of the substantial scholarship over the past five decades in the sociology or philosophy of physics. It is not impossible to teach these ideas in schools. I know this from my experience as a classroom teacher.*
>
> *The proposed course reads as a dry and boring catalogue of narrow ideas, presented with inadequate acknowledgement of the place of physics in everyday life. Unit 4 represents a particular problem here.*

(h) Content clarity

In Victoria, content specificity and clarity is particularly important at Units 3 and 4 where student assessment includes an external examination. To ensure assessment validity, it is important that teachers and students have a clear understanding of the extent to which concepts are examined. The lack of specificity of many of the content descriptions has been identified as making it more difficult to determine the extent of the content overload. One teacher optimistically observed:

> *Clarification of the draft content will presumably come with the production of a Victorian study design, especially if it is produced in its current form where it clearly articulates the level of detail required as well as which content is and isn't needed.*

The issue here for many stakeholders, however, is that if each state/territory is responsible for ensuring clarity, then very different curricula may be the result.

(i) Experimental and practical work

Stakeholders have reported disappointment at the lack of emphasis on experimental work, as illustrated by the following comments:

- *Experimental work is a fundamental part of Physics education. Computer simulations and data analysis are not experimental work … considering the heavy content loading of the curriculum, teachers may not find time to integrate meaningful experimental work. Given the nature of proposed topics in Unit 4, students will finish their senior secondary physics year completing little, if any, practical work. Thought must be given to the time needed to develop good experimental technique and analysis.*
- *Practical skills are required ... prac is not just to support learning, it is the way Physics is done. Honour it!*

The inclusion of an extended scientific investigation is a valued component of the *VCE Physics Study Design*, and stakeholders universally expressed disappointment at its removal as a mandated element in the draft. Although the draft states that 'The Senior Secondary Science subjects have been designed to accommodate, if appropriate, an extended scientific investigation with each pair of units', the reality is that the proposed content load would not enable an extended investigation to be included.

(j) Glossary

ACARA's *Curriculum Design Paper v3* (March 2012) states that the glossary of key terms should be developed such that '…subject specific terms that are considered essential for students to know and be able to use are defined and referenced to acknowledged sources'. Many of the definitions have not been appropriately resourced, do not provide clarity and hence have limited use. For example, the definition of '*Experimental (investigation)*' as 'An investigation that involves carrying out a practical investigation' attempts to define one term with another undefined term.

Comments on specific units

Unit 1:

Stakeholders welcomed the inclusion of thermodynamics in the 'Kinetic particle model – heating processes' sub-unit. Content related to the Laws of Thermodynamics, however, is beyond the scope of most Year 11 students. Caloric theory, referred to in the *Science as a Human Endeavour* strand, is also too demanding for Unit 1. The term 'thermal energy' is used incorrectly in this sub-unit. Further, as shown in the following teacher submission, exploring complex concepts is difficult without prior experience of more 'concrete' ideas:

> *Reading through the dot points under 'Kinetic particle model – heating processes' one sees terms such as the following: average kinetic energy, changes in internal energy, capacity to do mechanical work, work done by the internal energy of the system, change in internal energy of a system is equal to the energy added or removed by heating plus the work done on or by the system. These are all complex applications of the basic concepts of work and energy developed in mechanics. If they are introduced right at the beginning*

of the course before students have had a chance to develop their understanding of them in more concrete situations they will be confused – and quite likely put off physics for life!

Many of the points in the 'Nuclear model of the atom – ionizing radiation and nuclear reactions' sub-unit require greater specification, for example, what detail is required about the properties of alpha, beta and gamma radiations? Do students need to write and/or balance decay equations? The 'models' approach may not be strictly relevant to this sub-unit, as reflected in the following teacher comment:

This is not really about the nuclear model of the atom, that with the distribution of electrons around a central nucleus. This content is more about what is happening inside the nucleus, which doesn't have a single model to explain the phenomena, at least not at this level. Hence the model emphasis here is misplaced.

The 'dose equivalent' equation provided has no corresponding explicit link to the *Science Understanding* strand in terms of its use and/or application. The calculation of radiation exposure has interesting applications and, if the (updated) equation remains as a listed mathematical relationship, equivalent dose should be included in the *Science Understanding* and *Science as a Human Endeavour* strands in meaningful ways. Significant omissions include nuclear medicine/physics, effects of radiation on humans, nuclear reactor designs and decay chains. Stakeholders expressed concern at the possible extent to which the points in the *Science as a Human Endeavour* could be taken, adding to content load of the unit.

Again, there is an issue of content sequencing, as identified by the following submission:

We have taught the atomic model early in our VCE physics course for quite a while now. Does it work? On one level it does seem to. Kids are interested in radioactivity and nuclear energy. However, how much of what the students are learning is simply rote learning? Do they really understand HOW Rutherford discovered the nuclear atom? Can they really discuss the relative magnitudes of the electric and nuclear forces without any idea of Coulomb's law and inverse square rules? Do the relative masses of atomic particles make any sense unless we can give them some evidence of how we know they have the masses they do? What does nuclear energy mean when they have not yet developed the idea of the relationship between work and energy or between kinetic and potential energy? And of course the idea of the equivalence between mass and energy is pure hand-waving at this stage. So isn't the logical place for the nuclear model after mechanics and electromagnetism?

In the 'Electric charge model – electric circuits' sub-unit, series and parallel circuits need to be specified. Some teachers argue that an electric field model should be considered rather than a charge model since it better explains current in a wire without the need for Coulomb's Law, whilst many state that without inclusion of potential energy and Coulomb's Law, it is difficult to cover electricity well. The entire area of digital signals is not included. There is no specific mention of thermistors, diodes, LDRs, LEDs and other semiconductor components, and therefore no

electronic control systems and no household electronics. Other significant omissions include electrostatics, car/household electricity, low voltage DC examples, household wiring and electric shock.

Unit 2:
Content selection, limitations of a 'models' approach, content overload and implicit content in the *Science as a Human Endeavour* strand which adds to overall content were identified as significant issues in Unit 2.

It is not apparent from the content descriptions in the 'Models of force and linear motion' sub-unit which 'models' are being considered. Forces in springs and elastic potential energy are common, and appropriate, topics in physics courses that do not appear in this sub-unit or in that of Unit 3 'Field models – gravity and motion'. Further omissions include elastic and inelastic collisions, impulse, the effects of air resistance, specification of study of motion in one dimension and springs (either here or in Unit 3). As one teacher states:

> *Forces in springs and elastic potential energy are not mentioned in this topic or in the motion topic in Unit 3. It is as if they don't fit with the dominant 'model' approach and have been forgotten. However this is an important application for force and energy, indeed without it collisions cannot be effectively explained.*

It is not apparent from the content descriptions why the word 'models' in the 'Mechanical models of waves' sub-unit is plural. The formation of standing waves and interference phenomena with sound and other mechanical waves would present difficulties for students at this level, and could therefore be moved to Unit 4. Although 'sound pollution' is included in the *Science as a Human Endeavour* strand, decibel levels are not included as content. It is surprising that the contexts of hearing and musical instruments were not included in this sub-unit.

The 'Wave model of light' sub-unit should also include the particle model. Although models are appropriate in looking at light, the way in which models has been incorporated in the document has raised significant stakeholder concern, as expressed in the following two teacher comments below:

- *By starting with the model rather than the phenomena we are giving the wrong impression of how Physics works. We should look at the properties of light and be drawn to a wave model (and particle model).*
- *To refer in the SHE strand to the rejection of other models without explaining what they were and why they were accepted seems arbitrary, putting the 'model' fetish ahead of common sense pedagogy.*

Sequentially, the ray model should be placed before the wave and particle models. The draft confuses the ray model with the particle model; an alternative phrasing is 'The ray model is a precursor to the wave model and can be used in its simplified version when describing the laws of reflection and refraction'. Exclusion of the particle model of light in this sub-unit omits content that contributes to student understanding of light. Stakeholders report that this unit is notable by its inclusion of inappropriate content (for example, interference should be treated mathematically in Unit 4 and linked to wave particle duality, whilst diffraction and resonance are too

difficult at this stage) and exclusion of essential and engaging topics for students at this level (for example, photonics, image formation by curved mirrors and lenses, and sight).

Unit 3:
The draft document defines/redefines terms, potentially leading to confusion for both students and teachers and missing an opportunity to link to other parts of the curriculum.

With the predominant focus of the 'Field models – gravity and motion' sub-unit being on universal gravitation, there are limited opportunities for undertaking practical experimental activities. Greater specification of content is required, for example, is uniform circular motion to be considered in the vertical plane as well as the horizontal plane? Are banked curves to be considered? Adopting a 'field model' approach has resulted in omission of important topics for secondary physics including springs, Hooke's Law and elastic potential energy. Apparent weightlessness is an important concept in understanding how forces act on bodies, and geosynchronous satellites are an important application of gravity and motion; these could be incorporated into this sub-unit through the deletion of the more demanding concept of escape velocity and the related equation for gravitational potential energy in an inverse square field. Other significant omissions include torque, stability of structures, Kepler's third law, friction and air resistance.

In the 'Electromagnetism' sub-unit, a number of the listed formulae require revision. For example, the equation for the magnetic force on a current carrying wire should use conventional language; the use of the phrase 'current element' to represent the product of the current and the wire length is abstruse; for equations involving changing angles, clarity should be provided about whether students will be required to perform trigonometric calculations or whether it would be sufficient to consider the qualitative aspects of changing the angle; and the formula for torque includes the cosine function, whilst others use a perpendicular subscript. Accuracy of scientific language is sometimes an issue, for example, since 'electromotive force' is not an actual force, it would be better referred to as 'the induced emf' rather than 'this force…'. Content scope is sometimes not clear, for example, does reference to the force used in DC motors to produce torque include commutators? If so, does that mean split ring and slip ring? Are alternators included?

Unit 4:
Although there has been some support for the inclusion of special relativity, stakeholders have overwhelmingly identified the highly theoretical and mathematically challenging nature of the selected content, as well as the lack of opportunity for students to undertake experimental work, as being significant problems in Unit 4. Few opportunities for experimental practical activities exist in Unit 4, and those that exist require expensive equipment which would result in the activity being undertaken as a class exercise or as a computer simulation. Either way, many of the *Science Inquiry Skills* cannot be adequately addressed, either in terms of the content descriptions or the achievement standards. In particular, the sub-units

'The Theory of Relativity' and 'The Standard Model' have no school-based experiments. 'The Quantum Model' allows for practical activities which either require expensive equipment (for example, the photoelectric effect and hydrogen spectrum) or for which new equipment must be purchased due to new curriculum content inclusion (for example, blackbody radiation).

'The Theory of Relativity' is inappropriate as a sub-unit, as written. Simultaneity is a challenging and complex topic, and therefore requires elaboration beyond a single word in order that students, teachers, curriculum developers, curriculum writers and assessors are given guidance as to what is expected. The accuracy and purpose of some of the statements in the *Science Understanding* strand are questionable (for example, the unclear articulation of $E=mc^2$), as are both statements in the *Science as a Human Endeavour* strand regarding Einstein's theory of special relativity and GPS tracking systems (for example, rather than GPS tracking systems being stated as an application of special relativity, it would be more accurate to say that the effects of special relativity must be taken into account in order that GPS tracking systems operate as precisely as they do).

Stakeholder feedback indicates emphatically that 'The Quantum Model' sub-unit is pitched beyond the level of most senior secondary students. Statements related to the Heisenberg Uncertainty Principle are too complex and subtle for most physics students at this level. Predictions and measurements of sub-atomic phenomena in consideration of wave-particle duality add further complexity to the sub-unit, with the associated mathematics being beyond the capacity of the majority of secondary students. The explanation of phenomena at the subatomic level can also be conceptually difficult for students.

As currently written, 'The Standard Model' sub-unit is little more than a catalogue of particles and a list of recall statements. Too much rote learning is required and students would find it difficult to demonstrate 'understanding'.

Many of the suggested mathematical relationships would be challenging and beyond the capacity of most secondary students. Some of the listed relationships would be both new for Victorian teachers, for example, Bohr model equations, spectra equations and uncertainty relationships, whilst others would be difficult to show derivation to secondary students, for example black body formulae.

4 EXPERT REFERENCE GROUPS

English

Name	Position	School/Organisation
Kellie Heintz	Lecturer	The University of Melbourne
Janny McCurry	Teacher, Head of English	Our Lady of Mercy College
Jan May	Teacher	St Leonard's College
Marion Meiers	Senior Research Fellow	ACER
Kirsten Wheeler	Teacher	Hillcrest Christian College
Grant Findlay	Teacher, Director of English	Westbourne Grammar School
Dave Pargetter	Teacher, Head of English	Penleigh and Essendon Grammar School
Dr Deane Blackler	Teacher, Director of Curriculum and Professional Learning	Trinity Grammar School
Dr Larissa McLean-Davies	Lecturer	The University of Melbourne

Essential English

Name	Position	School/Organisation
Kellie Heintz	Lecturer	The University of Melbourne
Chris Wheat	Teacher	Sunshine Secondary College
Jan May	Teacher	St Leonard's College
Malcolm Dow	Teacher	Methodist Ladies' College

Literature

Name	Position	School/Organisation
Kellie Heintz	Lecturer	The University of Melbourne
Margaret Smith	Chief Assessor, Literature	VCAA
Meredith Maher	Assistant Chief Assessor	VCAA
Monika Wagner	Teacher	St Michaels Grammar School
Margaret Saltau	Teacher	Isik College
Mary Purcell		The Mac.Robertson Girls' High School
Heather Maunder	Teacher, Head of English	Swinburne Senior Secondary College
Malcolm Martin	Teacher, Head of Learning - English	Wesley College
Professor Brenton Doecke	Chair in Education	Deakin University
Karen Lynch	Teacher	Kew High School

English as an Additional Language or Dialect

Name	Position	School/Organisation
Daina Coles	Manager – ESL Unit	DEECD
John Ingamells	ESL Adviser	DEECD, Southern Region
Dr Alan Williams	Lecturer	University of Melbourne
Anita Calore	Senior Project Offer – ESL Unit	DEECD
Elizabeth Buckley	Teacher	Taylors College

Mathematics

Name	Position/organisation
Allason McNamara	President Mathematical Association of Victoria, Head of Mathematics, Mt Scopus Memorial College
Andrew Hay	General Manager Teaching and Learning, Independent Schools Victoria
Antje Leigh-Lancaster	Senior Project Officer Teaching and Learning Division DEECD/ Senior Publisher Pearson Publishing
Brian Hodgson	Mathematics Education Consultant
Frank Moya	Mathematics Education Consultant
George Toth	Mathematics/Numeracy Manager Catholic Education Office, Victoria
Helen Mulvogue	Head of Mathematics, Our Lady of Sion College
Mary Papp	Mathematics Coordinator, Nossal High School
Dr Deborah King	Director Mathematics and Statistics Learning Centre, University of Melbourne
Dr Michael Evans	ICE-EM Mathematics Manager, Australian Mathematical Sciences Institute
Dr Peter Hoffman	Associate Director, Engineers Australia
Trevor Raine	Mathematics teacher, Maffra Secondary College

Modern History

Name	Position/organisation
John Whitehouse	University of Melbourne
Gerry Martin	St Michael's Grammar School
Di Wolff	Mentone Girls Secondary College
Pam Shire	Ivanhoe Grammar School
Judy Anderson	Melbourne Girls' Grammar
Vince Toohey	St Kevin's College
Shane Bourke	MacKillop College
Rosalie Triolo	Monash University
James Fiford,	Social Education Victoria (SEV)
Ingrid Purnell	History Teachers Association of Victoria (HTAV)
Paul Beekman	University High School
Andrew Sloan	Melbourne High School
Ian Coffey	St Francis Xavier's
Pauline Rule	VCAA

Ancient History

John Whitehouse	University of Melbourne
Christopher Dart	University of Melbourne
Ned Johnson	CAE
Ingrid Purnell	HTAV

Stephen Kennedy	Dandenong High School
Nick.Vlahogiannis	Melbourne Girls Grammar School
Pauline Rule	VCAA

Biology

Name	**Position**	**School/Organisation**
Ian Bentley	Lecturer in Science Education, Practicum Coordinator	Faculty of Education, La Trobe University
Suzanne Clark	Director	Ecolink
Jacinta Duncan	Director	Gene Technology Access Centre
Merrin Evergreen	Head of Science	St Leonards College
Elizabeth George	Head of Science	Penola Catholic College
Sarah Green	Teacher	Northcote High School
Prof Nick Hoogenraad	Executive Director	La Trobe Institute for Molecular Biology
	Head of School	School of Molecular Sciences, La Trobe University
Chris Krishna-Pillay	Education Manager	CSIRO
Cheryl Power	Senior Lecturer	Dept Microbiology and Immunology, University of Melbourne
Brian Stevenson	Education Consultant	private
Annette Williams	Head of Science	Shelford Girls Grammar

Chemistry

Name	**Position**	**School/Organisation**
Soula Bennett	Director	Quantum
Francesca Calati	Manager, Outreach Programs	La Trobe University
Suzanne Clarke	Director	Ecolink
Lanna Derry	Teacher	Tintern Girls Grammar
Mark Learmonth	Lecturer, Science and Mathematics Education	Melbourne Graduate School of Education, The University of Melbourne
Caitlin Lewis	Education Manager	CSIRO
Vanessa Jackson-McRae	Head of Science	St Catherine's School
Angela Stubbs	Teacher	Star of the Sea
Dr Chris Thompson	First-year Chemistry Lecturer	Monash University
Dr Jacolyn Weller	Lecturer	Faculty of Education, La Trobe University
Michelle Wills	Teacher	Elisabeth Murdoch College
Jenny Wilson	Teacher	Methodist Ladies College

Earth and Environmental Science

Name	Position	School/Organisation
Marion Anderson	First Year Coordinator Lecturer	Monash University
Dr Helena Bender	Senior Tutor for Reshaping Environments	The University of Melbourne
Suzanne Clarke	Director	Ecolink
Paul Donaldson	Teacher	Fairhills High School
Jillian Dumsday	Teacher	Camberwell Anglican Girls Grammar School
Prof Annette Gough	Head of School, Education	RMIT
Britt Gow	Teacher	Hawkesdale College
Bob Hartmann	Director	Earth Science Centre Mt Clear College
Prof Janet Hergt	Head, School of Earth Sciences Deputy Dean	Faculty of Science The University of Melbourne
Sarah Houseman	CEO	Victorian Association for Environmental Education
Stephen Latham	Education Officer	Geography Teachers Association of Victoria
David Ponsford	Education Officer	Parks Victoria
Suzy Puszka	Teacher	MacRobertson Girls High
Haydn Swan	Lecturer, Geology Geology Co-ordinator	School of Science, Information Technology and Engineering (SITE) University of Ballarat

Physics

Name	Position	School/Organisation
Craig Anderson	Teacher	Leongatha Secondary College
Syd Boydell	Teacher	Scotch College
Ian Christie	Teacher	Victorian Space Sciences Education Centre
Saverio Ciccone	Teacher	Overnewton College
Jill Crawford	Teacher	Methodist Ladies College
Sue Grant	Teacher	Box Hill TAFE
	President	Australian Institute of Physics (Victorian branch) Education Committee
Colin Hopkins	Head of Physics	Bialik College
Theo Hughes	Senior Administrator - Teaching	Chemistry Department Monash University
Paul Keyte	Teacher	Melbourne High School
Greg Lancaster	Lecturer	Education Faculty Monash University
Simon Matheson	Education Manager	CSIRO
Kim Northmore	Teacher	Simonds Catholic College, St Brigid's VCE Campus
Dan O'Keeffe	Secretary	Australian Institute of Physics (Victorian branch) Education Committee
Dr Dorothy Smith	Lecturer	Faculty of Education La Trobe University