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Science in the Primary Years Programme

Alignment between the International Baccalaureate and the national Australian Curriculum

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Acronyms

AC	Australian Curriculum
ACARA	Australian Curriculum Assessment and Reporting Authority
AQF	Australian Qualifications Framework
DP	Diploma Programme of the International Baccalaureate
IB	International Baccalaureate
IBCC	International Baccalaureate Careers-Related Certificate
MYP	Middle Years Programme
PYP	Primary Years Programme

Executive Summary

Introduction

The increasing number of national and international schools offering the International Baccalaureate Primary Years Programme (IB PYP) raises a number of questions relating to the structure of the curriculum. How can schools from across the world offer the same curriculum? Is there any common core content that must be included within the PYP framework to satisfy the International Baccalaureate (IB)? Moreover, to what extent does the PYP align with curriculum requirements of national and local state education systems?

Recent changes within the Australian education sector have seen an attempt to unify all states and territories within the same common curriculum framework. The Australian Curriculum, Assessment and Reporting Authority (ACARA) have been charged with the task of co-ordinating a timely and uniform curriculum throughout all Australian schools. Presently, all States and Territories offer different tertiary entrance qualifications and different systems of primary, middle and high school education. A transition to providing a common national curriculum, the 'Australian Curriculum' (AC), is presently underway and highlights how organisations such as the IB need to provide programmes that have the capacity work within national frameworks.

The issues raised within Australia can also be found in other countries globally that are attempting to provide an international dimension to their education system while maintaining their own unique and often complex set of curriculum requirements. This study is an attempt to show if, and if so how, schools in a number of different Australian states have incorporated the requirements of the ACARA national curriculum with that of the IB PYP framework, with a specific focus on science teaching and learning.

According to experts in the field (Bagnall, 2008, 2010, 2012, 2015; Cambridge & Thompson, 2004; Hayden & Thompson, 2000), the PYP can be regarded as a shelf curriculum. A shelf curriculum provides a curriculum framework but not the content. It is more concerned with the method of teaching than the content. Indeed, the IB Scope and Sequence document for PYP Science emphasises, "… the science contained within the PYP is characterized more by concepts and skills rather than by content" (IB, 2008, p. 1). The IB views science at the primary years as a transdisciplinary programme exploring the biological, chemical and physical aspects of the natural world and the relationships between them. The IB offers a sample programme of science inquiry but does not insist that it is mandatory for schools. In fact the IB acknowledges that "Some schools may need to reflect national, regional or local requirements within the units of inquiry that are developed and included in their programme of inquiry" (IB, 2008, p. 2).

In conclusion, this study is concerned with the way that Australian schools offering the IB PYP incorporate the requirements of the Australian Curriculum with the guidelines for science teaching and learning provided by IB for the PYP programme.

The research approach

The design of this study has two principle elements within it. There is a comparative curriculum analysis and an analysis of curriculum implementation. The comparative curriculum analysis, undertaken to address Research Questions 1 and 2, utilised both document analyses and interviews that helped clarify, analyse and report on the relationship between the IB PYP Science and the Australian Curriculum Science learning area. The curriculum implementation study, focusing on Research Questions 3 and 4, drew on interviews with PYP Co-ordinators, primary school principals and classroom teachers and observation of classroom practice. Readers should note that this report provides findings solely with regards to the comparative curriculum analysis called for by Research Questions 1 and 2, which are listed below.

RESEARCH QUESTIONS

Curriculum alignment:

1. In what ways does the science component of the PYP support the knowledge, concepts, skills and processes that you are expected to teach and students are expected to learn to meet the Australian Curriculum: Science content descriptions?

2. To what extent does science teaching and learning in the PYP support students to fulfill the general capabilities and cross curriculum priorities of the Australian Curriculum?

School implementation practices:

3. How do Australian IB World schools design and implement programs of inquiry, PYP planners and Science Scope and Sequence in ways that address the content and achievement standards of the Australian Curriculum: Science learning area?

4. What practices and factors contribute or impede the successful alignment of the science component of the PYP and the Australian Curriculum?

Curriculum analysis is required periodically in all education systems (Oates, 2011) so that improvements can be made. Such analysis helps identify the strengths and weaknesses of the curricular design. Levander and Mikkola (2009) pointed to the need to examine both the breadth and depth of content coverage as well as pedagogic aspects within curricula. The findings presented in this study therefore provide a valuable resource for those interested in the adoption of an international curriculum, like the IB PYP, that can retain a national focus within the curriculum.

The major results of this study are:

- there are no major obstacles for individual Australian primary schools to incorporate the science teaching and learning requirements of the International Baccalaureate Primary Years Program with that of the Foundation to Year 6 Science requirements of the Australian Curriculum.
- although there are substantial differences in terms of content, mostly in relation to the large size of the content covered in Australian Curriculum, the PYP Science and Australian Curriculum Science learning area are fairly neatly aligned in terms of the skills they develop with students.

Chapter 1: Introduction and background

About the International Baccalaureate Organization

The commodification of education that ensued partially as a result of the school choice movement in the later part of the 20th century has seen a proliferation of education systems and programmes available to national education providers. The International Baccalaureate (IB) provides one of the most successful curriculum models available for those schools interested in offering an international education choice for their student body. The IB is a not-for-profit educational foundation, motivated by its mission to develop inquiring, knowledgeable and caring young people who help create a better and more peaceful world through intercultural understanding and respect. The organization has built a reputation for quality, high standards and pedagogical leadership in the field of international education, encouraging students across the world to become engaged world citizens who are active, compassionate and lifelong learners (IB, 2015).

Founded in 1968 the IB has flourished in both the number of students and schools participating in the organisation's four programmes. The Diploma Programme, the first to be developed by the IB, was originally established to provide an entry-level qualification suitable for students studying in a wide range of international schools. The programme has increasingly appealed to national private and state schools wishing to provide an international focus to their students. The early years of the IB Diploma (1970-75) saw a significant interest in international schools in Europe and North America, completing the Diploma. A number of state schools, especially in the United States and Canada began taking the IB DP as an alternative to their own matriculation system. The IB currently works with 4000 schools in 147 countries to develop and offer four programs to over 1,235,000 students aged 3 to 19 years. The organization also provides professional development workshops for more than 60,000 teachers and administrators annually (IB, 2008). In 1994 the IB introduced the Middle Years Programme (MYP) and then in 1997 the Primary Years Programme (PYP). The most recent International Baccalaureate programme, the IB Career-related Programme (IBCP), was introduced in 2012.

As has been noted, globally, increasing numbers of international and national schools have chosen to adopt internationally accepted education programmes and qualifications alongside, or instead of, the local qualifications and curricula. According to Cambridge & Thompson, curriculum that empowers young people for "… international understanding and peace, responsible world citizenship and service […] makes sound educational sense" (2004, p. 172). IB programmes offer one such approach.

About the current study

Over the past decade IB programmes across the world have grown substantially. Current projections predict 10,000 authorized schools and 2 million IB students by the year 2020. To support the growth and development of the organization's programs, the IB Research Department commissions studies that seek to identify the impact and value of an IB education. As part of this agenda, this project examined the extent to which the IB Primary Years Programme enables students to learn curriculum content (knowledge, skills and understandings), and meet achievement standards for Years 3-6 of the Australian Curriculum: Science.

Australia has consistently been one of the most interested countries globally to adopt the IB alongside curriculum offered by Australian states and territories. The first school to adopt the IB Diploma in 1979 was a state school and while the majority of schools choosing the IB have since been private schools, the growth in popularity has continued throughout both the state and private sector.

Science in the Primary Years Programme

The IB PYP is designed for students aged approximately 3-12 years of age. It regards the student as an inquirer both within the classroom and beyond. The approach of the PYP is transdisciplinary and attempts to offer a challenging program to motivate both students and teachers alike. There are a total of six subject areas: Language; Mathematics; Science; Social Studies; Arts and; Personal, Social and Physical Education. The subject that is the focus of this study, Science, is intended to give students an appreciation and awareness of the world through a lens provided by a scientific stance. The scientific approach promoted by the PYP is characterised by a combination of concepts and skills with a breadth and balance of science content. These are contained within the units of inquiry that are made up of themes such as 'How the world works' and information relating to them may be found in the IB Primary Years Programme publication – 'Science Scope and Sequence' document.

The Science Scope and Sequence document views the exploration of the relationship between " the biological, chemical and physical aspects of the natural world …" (IB, 2008, p. 1) as one of the most significant elements of the programme. Viewing the world from a scientific perspective enables students to develop an understanding of the world. According to the IB, "Reflection on scientific knowledge also helps students to develop a sense of responsibility regarding the impact of their actions on themselves, others and their world" (IB, 2008, p. 1).

It is clearly stated in the introduction of the Science Scope and Sequence document that merely teaching and learning about Science as a subject is not the sole expectation of the PYP programme. Rather, it is the exploration of the connection between Science and other subjects that provides a transdisciplinary approach. Indeed, according to IB, "The transdisciplinary themes provide the framework for a highly defined, focused, in-depth programme of inquiry, and as science is relevant to all the transdisciplinary themes, all planned science learning should take place within this framework" (IBO, 2008, p. 1).

The importance of Science education

The importance of science education in developing educational and economic capital is emphasised in numerous government, industry and academic reviews. In Australia, the critical role of science education has been highlighted recently in the 2012 Chubb paper on the position of Mathematics, Engineering and Science in the national interest (Chubb, 2012). Chubb's findings are aligned with international perspectives outlined in a report by Rocard et al. (2007), produced for the European Commission, which firmly places the provision of Maths, Engineering and Science as important factors in the establishment of high technology fields within Europe. The Chubb paper notes that America's position of economic advantage is predominantly as a result of its scientific innovation that has produced roughly half of all economic growth in the last 50 years.

The Science, Technology, Engineering and Mathematics (STEM) fields and those who work in them are critical engines of innovation and growth. According to one recent estimate, while only about five percent of the U.S. workforce is employed in STEMS fields, the STEM workforce accounts for more than fifty percent of the nation's sustained economic growth. (U.S. Department of Labor, 2007).

It could be argued that the beginning of any emphasis on the development of interest in Science, Mathematics and Engineering should begin at the primary school level. However, there is little research that has been focused on curriculum design and implementation within this area in Australia, hence the significance of the study presented here.

Research on the IB PYP

The research literature relating to the IB PYP is contained in a number of sources. The most recent study in Australia of Science in the PYP (Campbell, Chittleborough, Jobling, Tytler, & Doig, 2014) looks at the science literacy of a number of Australian PYP schools and was undertaken by a team of academics at Deakin University. The study, entitled *Science literacy in the International Baccalaureate Primary Years Programme (PYP): NAP-SL outcomes*, drew on a sample of ten schools with a mix of urban, rural, government and non-government schools. The aim of the study was to evaluate the science literacy of students undertaking the IB PYP programme in a selection of Australian schools. These levels of attainment were then analysed and compared with the results of National benchmark tests within Australia, namely NAP-SL 2012 results. Comparisons were made with five science proficiency levels that have been adopted by the NAP-SL. Further comparisons were made between Australian NAP-SL results for female and male students with outcomes achieved by students taking the IB PYP from both government and non-government schools. Given the design of the study, it was difficult to say what caused the higher level of proficiency of the IB PYP cohort, 83.3% above the suggested proficiency level of 3.2 compared with 51.4% for national students. Caveats to the results of this study included that only two government PYP schools took part in the research, and the inclusion of a smaller number of female participants made reliable comparisons between PYP boys and girls problematic.

There are a number of studies that relate to various aspects of the IB PYP, without explicit focus on science that may be found at the IB Research Department website[1]. These include an Australian study (2014) in Victorian Government schools offering the PYP. Another study published in 2014 on early childhood education looked at two schools in Melbourne and two schools in Singapore. A major 2013 study in India looked at the impact of the PYP in various parts of India. An earlier 2010 study looked at the implementation of IB PYP and MYP programs in Texas State schools. It found that IB schools performed as well as their non-IB comparison schools in Mathematics and Reading. Classroom observations found favourable instructional practices took place more often in IB classrooms than non-IB Texas classrooms. They found there were several challenges facing both teachers and administrators of these schools. These included such things as finding suitably qualified IB staff, covering both Texas State and district requirements alongside those of the IB requirements. They also found that additional time was needed for collaborative lesson planning and paper work.

Research on the Australian Curriculum

In August 2014 a major Australian government sponsored report, Review of the Australian Curriculum, undertaken by Kevin Donnelly and Kenneth Wiltshire, was released to the public (Donnelly & Wiltshire, 2014)[2]. The review was initiated by an incumbent Liberal government, whereas a previous Labor government had implemented both ACARA and the development of the Australian Curriculum. Donnelly & Wiltshire's report was the result of a comprehensive study that collected feedback from major stakeholders throughout Australia. In total there were over 1600 submissions from individuals, the general public and a wide range of international research and commissioned reports that were drawn on for the review. The final report made 30 recommendations to the government to strengthen the Australian Curriculum. The significant findings for the purposes of this study were that there was too much curriculum content required by the AC, and this was noted to be particularly the case in the primary school years. Other findings were that: aspects of the AC made teaching too complicated and required reconsideration; and further; some stakeholders felt that parents were locked out of the schooling process whereas they wanted to be more closely involved in the learning process of their children. Donnelly & Wiltshire additionally recommended that the AC needed to be inclusive of all students, including those with disabilities. The report suggested that the AC should develop a vision statement to guide future developmental changes. There was a wide range

[1] The IB Research Department website can be accessed at the following address, http://www.ibo.org/en/about-the-ib/research/.
[2] The 294 page document may be found at the following address, http://www.studentsfirst.gov.au/review-australian.

of views also given regarding the role, function and power that was provided to the ACARA, the organisation responsible for creating and overseeing the Australian Curriculum.

The Australian government’s response to the review was based around a number of central themes. The first of these themes concerned overcrowding in the current curriculum. The government felt there was a general consensus that all areas of the curriculum, including primary, middle and secondary years, were too content heavy. The government singled out the primary school curriculum as most significantly affected by this issue, and indicated this should be addressed as a matter of priority.

Other areas that the government identified as needing to be addressed focused on parental involvement, access for all students, and rebalancing of the curriculum to ensure that meaningful learning takes place with no gaps in what areas are taught. A special mention was made on the need for an increased emphasis on phonics in early years reading. There was little specific focus on primary science in the overall recommendations.

The Review of the Australian Curriculum findings regarding the Science key learning area of the AC are included in Appendix 3 of our report. The Review recommended that the Foundation to 10 Science curriculum be reconsidered in relation to:

1. the need to focus on depth by reducing the content and coverage of the science curriculum for Foundation to Year 10
2. The cross-curriculum priorities should be removed from the science curriculum and not all the interrelated strands should be given equal prominence and weight across the various stages of schooling
3. “A better balance should be sought between a constructivist and an explicit teaching pedagogical approach to classroom practice” (Australian Government, 2014, p. 187).

These Science curriculum recommendations and the more general recommendation of the AC review were at the time of writing being considered by state and commonwealth governments and there was no clear indication as to whether they will be followed. However, the above findings provide some insight into the issues that arise in implementation of the AC Foundation (Year F) to Year 7 Science.

Study Methodology

Research Objectives

The goal of the current project was to explore the alignment of the Science component of the Primary Years Program with the aims, content and achievement standards of Years 3-6 of the Australian Curriculum: Science administered by the Australian Curriculum Assessment and Reporting Authority. Consisting of three phases, the study first used mapping techniques to explore areas of complementarity and difference between Science in the PYP and the Australian Curriculum Science learning area. Next, the study investigated the extent to which Australian IB World Schools perceive the PYP curriculum framework as supporting the i) three Science content strands, ii) general capabilities, and iii) cross-curriculum priorities of the Australian Curriculum. The final aspect of the research identified implementation approaches that schools found successfully fulfilling the principles and practices of the Primary Years Programme and the aims and requirements of the Australian Curriculum: Science. As was noted earlier, this document provides findings solely with regards to the comparative curriculum analysis called for by research questions 1 and 2 below.

Research Questions

The following four research questions have been addressed in this study. The first two address issues of curriculum alignment.

1. In what ways does the science component of the PYP support the knowledge, concepts, skills and processes that teachers are expected to teach and students are expected to learn to meet Australian Curriculum: Science content descriptions?
2. To what extent does science teaching and learning in the PYP support students to fulfill the general capabilities and cross-curriculum priorities of the Australian Curriculum?

The last two enquire about school implementation practices.

3. How do Australian IB World Schools design and implement their Programme of Inquiry, PYP planners and Science Scope and Sequence in ways that address the content and achievement standards of the Australian Curriculum Science learning area?
4. What do schools identify as factors and practices that impede or contribute to the successful alignment of the science component of the Primary Years Programme and Australian Curriculum: Science?

Table 1 (p. 15) shows how the research questions were addressed, including the proposed methodological design, relevant data and planned analyses. The study consisted of a comparative document analyses and interviews with a range of school staff and administrators to provide additional data to answer the research questions. The researchers would like to thank all those schools and teachers for their input and participation in this study.

Design and participants

This study is a comparative curriculum analysis utilising both document analysis and interviews that aim to synthesise, analyse and report on the relationship between the Australian Curriculum Science learning area and IB PYP Science. In total, four schools participated in the study. There were two in Queensland, one in Victoria and one in New South Wales. Interviews were conducted with 12 participants, which included schools administrators and PYP co-ordinators and a number of primary school teachers at each school. The funding for the project was limited and did not enable a bigger sample from across all states and territories of Australia. Two of the schools were private schools and two were state schools. One of the schools was in a rural location but was not in a remote area of Australia.

Table 1 over the page, shows the summary of the research questions and the study design.

Table 1

Research Questions and Study Design

Research Questions	Data	Analysis and reporting
Curriculum alignment 1. In what ways does the science component of the PYP support the knowledge, concepts, skills and processes that teachers are expected to teach and students are expected to learn to meet Australian Curriculum: Science content descriptions?	**Documents:** The IB PYP: PYP Science Scope and Sequence (2008); Science across the IB continuum (2011); Making the PYP happen: A curriculum framework for international primary education (2009); Making the PYP happen: Pedagogical leadership in a PYP school (2009); The Primary Years Programme: A basis for practice (2009) ACARA: The Shape of the Australian Curriculum Version 2.0 (2010); Australian Curriculum: Science (2011) **Interviews:** Interviews with IB and ACARA staff (science curriculum writers and teachers), will be used to clarify issues that are apparent in practice not transparent in documents.	Alignment will be examined and discussed in a summative way through comparative tables (summative in the report + detailed in appendices) produced from content analysis of the documents. The above is supplemented by an account of important points of clarification provided from interviews.
2. To what extent does science teaching and learning in the PYP support students to fulfil the general capabilities and cross-curriculum priorities of the Australian Curriculum?	**Documents:** The IB PYP: PYP Science Scope and Sequence (2008); Science across the IB continuum (2011); Making the PYP happen: A curriculum framework for international primary education (2009); Making the PYP happen: Pedagogical leadership in a PYP school (2009); The Primary Years Programme: A basis for practice (2009). ACARA: The Shape of the Australian Curriculum Version 2.0 (2010); Australian Curriculum: Science (2011) **Interviews:** with IB PYP Science teachers, will be used to clarify issues that are apparent in practice not transparent in documents.	This analysis summarises the cross-curriculum approaches in PYP and AC. Comparative tables (detailed + summative) which have been produced from the content analysis of the documents. Analysis of the IB teachers' interviews complements the above analysis.
School implementation practices 3. How do Australian IB World schools design and implement their programme of inquiry, PYP planners and science scope and sequence in ways that address the content and achievement standards of the Australian Curriculum Science learning area?	**Interviews:** Interviews with IB Science teachers will be used to explore issues in implementation and report on strategies employed in successful teaching and learning. **Observation:** will examine implementation practices. Field notes will record the design of lessons and the teaching and learning strategies employed in effective classes.	Interview transcripts have been analysed using thematic analysis to identify frequently reported effective teaching strategies and prominent implementation issues. These have been presented, supported by direct quotes from the teachers.
4. What do schools identify as factors and practices that impede or contribute to the successful alignment of the science component of the Primary Years Programme and Australian Curriculum: Science?	**Interviews:** with IB science teaching staff will be used to explore issues in implementation and report on strategies employed in successful teaching and learning.	Interview transcripts have been analysed using thematic analysis to identify frequently reported impeding or contributing factors. These have been presented in a table, supported by direct quotes from the teachers.

Data collection

Document analysis

Comparative analysis of curriculum was undertaken using content analysis and comparative summative tables. The comparison was conducted on several levels; firstly the alignment on content, secondly analysis of content that was not aligned, thirdly we compared the two curricula on their focus on skills.

Interviews and their analysis

While the major analysis relied on document analysis it was important to inform this with interviews with key stakeholders. Although the documents have high levels of transparency it is nevertheless inevitable that issues will arise that require clarification. Semi-structured face-to-face interviews were used to clarify and resolve issues that arose in the document analysis phase. Key staff members at the four schools were interviewed and we consulted with curriculum experts to clarify any outstanding issues.

Ethics

The project conformed to the ethical standards laid out in the Australian Government's National Statement on Ethical Conduct in Human Research (2007) and approval was gained from the University of Sydney Human Research Ethics Committee.

Chapter 2: Alignment between the IB PYP and AC Science curricula

This document reports on the alignment of the IB PYP Science and the Australian Curriculum Science curricula. This comparative analysis of curriculum used content analysis and comparative summative tables. The study examined both curricular content and curricular skills contained within the Australian Curriculum Science learning area and the IB PYP Science documents.

Curriculum alignment mapping – content

The first challenge in mapping the curriculum content was to develop a system that could reconcile the content structure of each curriculum. The IB PYP organises curriculum content under 'themes', 'lines of inquiry' and 'outcomes' for each age group, while the AC Science uses 'statements' which cover several curriculum 'areas' which are, in turn detailed in 'descriptors'. Because it was immediately apparent that the AC documents were larger and more complicated we decided to use the AC as the foundation and map the IB PYP on to it. Later, we discovered during the interviews that some teachers also took this approach in reconciling the two curricula, whilst others preferred to start with the IB PYP and map the AC on to that. It is important to note that the two curriculum designs are slightly different from each other. The AC curriculum is sometimes referred to as a developmental curriculum, while the IB PYP is often referred to as a spiral curriculum. As you will see in our results this second approach, of starting with the IB PYP curriculum and mapping onto that, is more problematic because the AC content is substantially larger than the IB PYP themes.

Another challenge for us, and for teachers, in analysing the two curricula related to different structures for progression. Progression in the IB PYP focuses on children's age, so that the curriculum can be applied appropriately across nations and schooling systems with different academic year and grade systems. In contrast, progression in the AC is focussed on Australian school years or grades. There has been an attempt, by state and territory governments, concurrent to the introduction of the AC, to produce a unified policy for age at school entry (the Foundation year) and consistent age grouping throughout the primary school grades.

The expected alignment between the IB PYP age groupings and the AC school years is presented in Table 2 below. However, as the analysis progressed it became clear that the content deemed appropriate for each school year or age grouping did not align as was expected. Table 3 shows how, once the content was mapped, it became evident that content for the younger IB PYP age groups aligned with AC Science content across the primary years. For any AC school year, except for Foundation (Year F), similar content could be found in IB PYP themes for a wide range of ages. This finding is consistent with the IB approach wherein key concepts are introduced early and then developed over the primary years. By contrast the AC introduces different concepts throughout the primary schooling years.

A final caveat that should be mentioned before the analysis begins below is that it is arguable that some areas that are reported as unmatched are correct. As schools are able to choose their own content based on the units they select, it may be the case that they are unmatched as a result of their choices rather than that there is a lack of or inability to match the two curriculum models. The ability of individual schools to maintain choice of content of curriculum may in fact be one of the major advantages of the blending the two curriculums. The AC has mandated approximately 60% of uniformity of curriculum across the States and Territories of Australia. In other words, there is room for some flexibility for schools wishing to maintain their own choice of content while meeting the demands of both curriculum models.

Table 2

Age Grouping and School Years - Expected Alignment

KEY	
Red	3-5 yr olds
Blue	5-7 yr olds
Green	7-9 yr olds
Brown	9-12 yr olds

AC "year groupings"	AC "typical age in years"	IB curriculum age groups	
F	5-7	3-5	5-7
1	6-8	5-7	
2	7-9	7-9	
3	8-10	7-9	9-12
4	9-11	9-12	
5	10-12	9-12	
6	11-13	9-12	

Table 3

Age Grouping and School Years - Actual Alignment of Content

AC "year groupings"	AC "typical age in years"	IB curriculum age groups			
F	5-7	3-5	5-7		
1	6-8	3-5	5-7		
2	7-9	3-5	5-7	7-9	
3	8-10	3-5	5-7	7-9	9-12
4	9-11	3-5	5-7	7-9	9-12
5	10-12	3-5	5-7	7-9	9-12
6	11-13	3-5	5-7	7-9	9-12

While there was substantial common content between the curricula, the expectations of how content related to age and how learning in different content areas should progress were substantially different. For example, in Year 3 the AC curriculum for eight to ten year olds is aligned with IB Science curriculum that is intended for students as young as three to five years old and some of the AC curriculum is not covered in the IB until students are a target age of nine to twelve years old.

As this finding is evident throughout the curriculum mapping we have colour coded the IB themes to reflect the different age groupings in all our summary tables. By doing this the target age disparity between the two curricula is evident in all our analyses.

On the following pages, we present the mapping of the IB PYP Science curriculum content on to the AC in a series of summary tables – one for each AC school year. These are necessarily brief and do not reflect all the detail seen in the AC and IB PYP curriculum documents. More detailed tables, which include the IB PYP Science 'lines of inquiry' and 'outcomes', for each school year, are presented in Appendix 1. We follow the summary tables with a discussion of findings across the school years and with a final summary table outlining curriculum content that was not found in both curricula.

Table 4

Curriculum Alignment in the Foundation Year

KEY	
Red	IB age grouping 3-5 yr olds

FOUNDATION Australian Curriculum			IB PYP Science
	Area	**Descriptors**	**Themes**
Science understanding	**Biological sciences**	Living things have basic needs, including food and water	T6 - Sharing the planet
	Chemical sciences	Objects are made of materials that have observable properties	T4 - How the world works
	Earth and space sciences	Daily and seasonal changes in our environment, including the weather, affect everyday life	T4 - How the world works
	Physical sciences	The way objects move depends on a variety of factors, including their size and shape	UNMATCHED
Science as human endevour	**Nature and development of science**	Science involves exploring and observing the world using the senses	Matched on skills

In the Foundation year, see Table 4 above, young students are introduced to the ‘Biological sciences’, ‘Chemical sciences’, ‘Earth and Space sciences’ and ‘Physical sciences’ and also to the concept of ‘Science as a human endeavour’. These themes are shared in both curricula, except that in the PYP the Physical sciences content is not covered. The ‘nature and development of science’ is covered in both curricula, but in different ways. In the AC this involves ‘exploring and observing the world’ which is listed in curriculum content; whereas in the IB PYP this is not explicitly listed. However, ‘observation’ is highlighted as an important aspects of the skills set that applies across the PYP Science curriculum. Skills implicit in the curriculum are examined in greater detail later in our analysis.

Table 5

Curriculum Alignment in Year 1

KEY	
Red	IB age grouping 3-5 yr olds
Blue	IB age grouping 5-7 yr olds

YEAR 1 Australian Curriculum			IB PYP Science
	Area	**Descriptors**	**Themes**
Science understanding	**Biological sciences**	Living things have a variety of external features	T6 - Sharing the planet
		Living things live in different places where their needs are met	T6 - Sharing the planet
			T4 - How the world works
	Chemical sciences	Everyday materials can be physically changed in a variety of ways	T4 - How the world works
	Earth and space sciences	Observable changes occur in the sky and landscape	T6 - Sharing the planet
			T4 - How the world works
	Physical sciences	Light and sound are produced by a range of sources and can be sensed	UNMATCHED
Science as a Human Endeavour	**Nature and development of science**	Science involves asking questions about, and describing changes in, objects and events	Matched on skills
	Use and influence of science	People use science in their daily lives, including when caring for their environment and living things	T6 - Sharing the planet

As with the Foundation year, in Kindergarten there is also strong alignment between the curricula, with only one AC area descriptor unmatched by the PYP curriculum; and again, this content is associated with the Physical Sciences. Furthermore it can be noted that the Year 1 AC curriculum, refer to Table 5 above, typically for six to eight year olds, is matched by the PYP curriculum for three to seven year olds.

Table 6

Curriculum Alignment in Year 2

KEY	
Red	IB age grouping 3-5 yr olds
Blue	IB age grouping 5-7 yr olds
Green	IB age grouping 7-9 yr olds

YEAR 2 Australian Curriculum			IB PYP
	Area	**Descriptors**	**Themes**
Science Understanding	**Biological sciences**	Living things grow, change and have offspring similar to themselves	T4 - How the world works
	Chemical sciences	Different materials can be combined, including by mixing, for a particular purpose	T4 - How the world works
	Earth and space sciences	Earth's resources, including water, are used in a variety of ways	T6 - Sharing the planet
	Physical sciences	A push or a pull affects how an object moves or changes shape	UNMATCHED
Science as a Human Endeavour	**Nature and development of science**	Science involves asking questions about, and describing changes in, objects and events	Matched on skills
	Use and influence of science	People use science in their daily lives, including when caring for their environment and living things	T6 - Sharing the planet

Consistent with Foundation and Year 1 curricula, the Year 2 curriculum, see Table 6 above, is similarly closely matched with the exception of the 'Physical sciences'. Once again, the 'Nature and development of science' is not covered explicitly in the IB PYP content framework. It is, however, evident in the skills prescribed for by the PYP across the primary Science programme.

Table 7

Curriculum Alignment in Year 3

KEY	
Green	IB age grouping 7-9 yr olds
Brown	IB age grouping 9-12 yr olds

YEAR 3 Australian Curriculum			IB PYP
	Area	**Descriptors**	**Themes**
Science Understanding	**Biological sciences**	Living things can be grouped on the basis of observable features and can be distinguished from non-living things	T4 - How the world works
	Chemical sciences	A change of state between solid and liquid can be caused by adding or removing heat	T6 - Sharing the planet
	Earth and space sciences	Earth's rotation on its axis causes regular changes, including night and day	T4 - How the world works
	Physical sciences	Heat can be produced in many ways and can move from one object to another	T4 - How the world works
Science as a Human Endeavour	**Nature and development of science**	Science involves making predictions and describing patterns and relationships	Matched on skills
	Use and influence of science	Science knowledge helps people to understand the effect of their actions	T4 - How the world works

Table 7 above shows how in Year 3 the two curricula are completely matched, with no AC content area that is not covered in the IB PYP. However, it is also evident that for Year 3, a grade typically populated with eight to ten year olds, the aligning PYP curriculum is mostly designed for the nine to twelve year old age group. This is consistent with the IB approach of introducing core concepts in which understanding is developed over the primary years. However, it is also evident that in the IB PYP complex concepts, like the transfer of heat, are intended for older age groups (9-12 year olds) who have more advanced cognitive development. This stands in contrast to the AC in which such complex concepts are introduced, or may be introduced to students at a younger age (eight to ten years). Despite these apparent differences of just when the content was best covered, the four schools in our study found that the framework of the PYP was flexible enough to ensure that no AC content was omitted when teaching the PYP.

Table 8

Curriculum Alignment in Year 4

KEY	
Red	IB age grouping 3-5 yr olds
Blue	IB age grouping 5-7 yr olds
Green	IB age grouping 7-9 yr olds
Brown	IB age grouping 9-12 yr olds

YEAR 4 Australian Curriculum			IB PYP
	Area	**Descriptors**	**Themes**
Science Understanding	**Biological sciences**	Living things have life cycles	T4 - How the world works
		Living things, including plants and animals, depend on each other and the environment to survive	T6 - Sharing the planet
	Chemical sciences	Natural and processed materials have a range of physical properties; These properties can influence their use	T4 - How the world works
	Earth and space sciences	Earth's surface changes over time as a result of natural processes and human activity	T6 - Sharing the planet
	Physical sciences	Forces can be exerted by one object on another through direct contact or from a distance	UNMATCHED
Science as a Human Endeavou	**Nature and development of science**	Science involves making predictions and describing patterns and relationships	Matched on skills
	Use and influence of science	Science knowledge helps people to understand the effect of their actions	T4 - How the world works

In Year 4, see Table 8 above, our analysis revealed a return to the pattern seen in grades F, 1 and 2; with a close match on content, with the exception of 'Physical sciences'; and with AC content on the 'Nature and development of science' matched on skills in the PYP. More notably the AC Year 4 curriculum, for nine to twelve year olds, is now matched with PYP content designed for children ranging from three to twelve years old.

Table 9

Curriculum Alignment in Year 5

KEY	
Red	IB age grouping 3-5 yr olds
Blue	IB age grouping 5-7 yr olds
Green	IB age grouping 7-9 yr olds
Brown	IB age grouping 9-12 yr olds

Year 5 Australian Curriculum			IB PYP
	Area	**Descriptors**	**Themes**
Science Understanding	**Biological sciences**	Living things have structural features and adaptations that help them to survive in their environment	T6 - Sharing the planet
	Chemical sciences	Solids, liquids and gases have different observable properties and behave in different ways	T4 - How the world works
	Earth and space sciences	The Earth is part of a system of planets orbiting around a star (the sun)	T6 - Sharing the planet
	Physical sciences	Light from a source forms shadows and can be absorbed, reflected and refracted	UNMATCHED
Science as a Human Endeavour	**Nature and development of science**	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena	Matched on skills
		Important contributions to the advancement of science have been made by people from a range of cultures	UNMATCHED
	Use and influence of science	Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives	T4 - How the world works
		Scientific knowledge is used to inform personal and community decisions	T6 - Sharing the planet

As with Year 4, the Year 5 AC curriculum is aligned with PYP content designed for a wide range of ages – from three to twelve years of age - see Table 9 above. However, Year 5 is the only year with more than one curriculum descriptor unmatched. In this case two areas in the AC are not covered in the IB PYP; and these are from the 'Physical sciences' and from the 'Nature and development of science'.

Grade 6 is presented over the page in Table 10 and, again, reflects trends seen in grades F, 1, 2 and 4. Unmatched content is found in the area of 'Physical sciences'. This and other trends in curriculum alignment between AC and IB across the primary years are reviewed in the following list of summary points.

Table 10

Curriculum Alignment in Year 6

KEY	
Red	IB age grouping 3-5 yr olds
Blue	IB age grouping 5-7 yr olds
Green	IB age grouping 7-9 yr olds
Brown	IB age grouping 9-12 yr olds

Year 6 Australian Curriculum			IB PYP
	Area	**Descriptors**	**Themes**
Science Understanding	**Biological sciences**	The growth and survival of living things are affected by the physical conditions of their environment	T6 - Sharing the planet
	Chemical sciences	Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting	T4 - How the world works
	Earth and space sciences	Sudden geological changes or extreme weather conditions can affect Earth's surface	T4 - How the world works
	Physical sciences	Electrical circuits provide a means of transferring and transforming electricity	UNMATCHED
		Energy from a variety of sources can be used to generate electricity	T4- How the world works
Science as a Human Endeavour	**Nature and development of science**	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena	Matched on skills
		Important contributions to the advancement of science have been made by people from a range of cultures	T4 - How the world works
	Use and influence of science	Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives	T4 - How the world works
		Scientific knowledge is used to inform personal and community decisions	T4 - How the world works

Summary of the curriculum alignment mapping – content

Tables 3 to 10 show the mapping of IB PYP Science content to the content of the AC Science for Years F to 6. Together these tables clearly reveal that:

1. A great deal of content is common to both curricula. For example, there is no curriculum 'area' within the AC which is not also covered, to some extent, by content described in the IB PYP. Only approximately 16% of the content 'Descriptors' in AC are not matched with IB PYP content on a similar topic; these are analysed in more depth in the next section.
2. There are only seven of the smaller 'descriptor' sections of the AC that are not matched with similar content in the IB PYP and these are distributed evenly across school years; with nothing unmatched in Year 3, two 'Descriptors' unmatched in Year 5 and only one 'descriptor' unmatched in each of the other years.

3. Some seven ‘Descriptors’ under content ‘Areas’ in the AC were not matched by IB PYP content but can be seen to be matched with the IB PYP curriculum skills. These are also analysed in more detail in the following section.
4. Six of the seven unmatched AC descriptors relate to the Physical Sciences area. This may reflect either: omission in the IB disciplinary coverage; or, indeed, overly ambitious plans to introduce many complex Physical science concepts in the AC primary Science programme. Recent criticism of the AC suggests the curriculum is cramped and overambitious. The heavy requirements in Year 6, for example, include covering how ‘electrical circuits provide a means of transferring and transforming energy’. Further research on the cognitive abilities of students is needed to provide informed developmental perspectives on material that is appropriate for each age group.
5. While the AC content areas and descriptors are well matched with the IB PYP themes, the analysis is not conclusive on the *depth* of the curriculum delivered in each content area. Indeed the *depth* evident in each descriptor and theme varies and, although we can see alignment between the AC and IB PYP content on the basis of the language in the curriculum documents, it is not possible to estimate the depth of study delivered to address each curricula. Additional study of classrooms and assessment of learning is needed to examine the depth of content delivery.
6. Although content is well matched, it is clear that the ages and school years in which content is introduced are at times different in the two curricula. The colour coding of the IB PYP content reflects the age groupings it is considered appropriate for - and this does not align neatly with the AC school years.

To complete the curriculum content analysis we re-examined the aspects of the AC content that were not covered in the IB PYP and also re-examined the PYP to look for aspects of that curriculum that were not matched by the AC. The aspects of the AC that were unmatched were distributed evenly through the school years and tended to concentrate in the Physical Sciences. Indeed, as can be seen in Table 11, 6 out of 7 unmatched ‘Descriptors’ were from this ‘Area’. This suggests that the AC stipulates more ‘Physical sciences’ content than the IB PYP.

Table 11

AC Science Descriptors Unmatched by the IB PYP Science Curriculum

YEAR	AREA	Descriptor
Foundation	Physical sciences	The way objects move depends on a variety of factors, including their size and shape
Year 1	Physical sciences	Light and sound are produced by a range of sources and can be sensed
Year 2	Physical sciences	A push or a pull affects how an object moves or changes shape
Year 4	Physical sciences	Forces can be exerted by one object on another through direct contact or from a distance
Year 5	Physical sciences	Light from a source forms shadows and can be absorbed, reflected and refracted
Year 5	Nature and development of science	Important contributions to the advancement of science have been made by people from a range of cultures
Year 6	Physical sciences	Electrical circuits provide a means of transferring and transforming electricity

The aspects of the IB PYP Science that were unmatched by the AC are listed below in Table 12. There was, in general, strong alignment between the AC and the PYP themes, however some detail in ‘Lines of Inquiry’ and curriculum ‘Outcomes’ were not covered. After the review process, it can be seen that some aspects, marked in red, are also within the PYP Social Studies curriculum. Disregarding these we can see that the majority are from ‘Theme 4 - How the World Works’, and frequently relate to the physical and engineering sciences. This potentially counters the previous conclusion and suggests that, although the ‘Physical sciences’ are an apparent area where the two curricula differ, this is not because one focuses more than the other on the physical sciences, but because they tend to focus on different content within the ‘Physical sciences’.

Finally, it is important to note that overall, the curriculum analysis reveals that the AC Science documents are heavier with content. Full and detailed tables of curriculum mapping are available in Appendix 1 make this most apparent. Although at the AC ‘Area’ and PYP ‘Theme’ levels these curriculum are well matched; further detail regarding content is evident in the AC ‘Descriptors’ and this is not matched with content detail in the PYP ‘Lines of Inquiry’ and ‘Outcomes’.

Table 12

IBO PYP Science Content not Covered in the AC Science F-6

Age group	Themes	Lines of Inquiry	Outcomes	Pages
3-5 years	T6		Be aware of the role of plants in sustaining life (e.g. providing oxygen, food)	9
5-7 years	T1	Balanced choices		11
5-7 years	T1	Consequences of choices		11
5-7 years	T1		Identify the major food groups & be aware of the role they play in human development	11
5-7 years	T4	The evidence of the existence of air		15
5-7 years	T4	What air can do and how we use it		15
5-7 years	T4	The relationship between air, light & sound		15
5-7 years	T4		Investigate & identify the properties of air	15
5-7 years	T4		Examine how people use air in their everyday lives (e.g. transportation, recreation)	15
5-7 years	T4		Reflect on the impact of air on living things	15
5-7 years	T4		Apply his or her understanding about the properties of air (e.g. building a windmill)	15
5-7 years	T4		Explore links between air, light and sound (e.g. thunder & lightning)	15
7-9 years	T4	Considerations to take into account when building a structure		18
7-9 years	T4	How building impacts on the environment		18
7-9 years	T4	Indigenous architecture		18
7-9 years	T4		Investigate how buildings & other structures stand up (e.g. piles, buttresses, I-bean girders)	18
7-9 years	T4		Investigate the construction of a building or structure & identify the materials used	18
7-9 years	T4		critique the impact of a structure on the matural environment	18
9-12 years	T4		Demonstrate how energy can be stored and transformed from one form to another (e.g. storage of fat, batteries as a store of energy)	23
9-12 years	T4		Explain the impact of diet in providing the body with sources of potential energy	23
9-12 years	T6	Challenges and risks that children face		24
9-12 years	T6	How children respond to challenges & risks		24
9-12 years	T6	Ways in which individuals, organizations & nations work to protect children from risk		24
9-12 years	T6		Explore health and safety issues facing children (e.g. spread of disease, accidents, access to health care)	24
9-12 years	T6		Understanding the role of vaccinations	24
9-12 years	T6		Explain the need to act responsibly with regards to his or her health and the health of others (e.g. colds, head lice)	24
9-12 years	T2		Explore the principle of using gears to provide more work for less energy	25
9-12 years	T4	Ethical dilemmas associated with manufacturing processes & by-products		26
9-12 years	T4		Identify the difference between physical & chemical changes	26
9-12 years	T4		Recognize & report on the environmental impact of some manufacturing processes	26
9-12 years	T2	Feelings & attitudes associated with exploration		28
9-12 years	T2	Methods of navigation		28
9-12 years	T2		Investigate & explain how stars are used for navigation	28
9-12 years	T2		Demonstrate an understanding of other methods of navigation (e.g. compasses, satellites)	28
9-12 years	T4	Genetics & hereditary factors		29
9-12 years	T4		Identify the structures of plants and animals that are responsible for reproduction	29
9-12 years	T4		Analyse similarities and differences in the ways that different living things reproduce	29
9-12 years	T4		Be aware of the role of genetics in determining physical characteristics	29
9-12 years	T5	Circumstances that lead to the development of important inventions & their impact		30
9-12 years	T5		Examine the impact of particular technologies on sustainability	30
9-12 years	T5		Suggest areas for future technological advances	30

RED = this unit is also included in the social studies scope and sequence

Curriculum alignment mapping – skills

As a final step in the curriculum mapping we examined references to the development of skills within the two curricula. The IB Science skills are outlined in Table 13. These are skills to be implemented across Science curriculum content areas and are neatly aligned with the 'Outcomes' stipulated in the PYP documents. Further detail on the position of skills within the IB and AC curriculum is available in the curriculum documents, including Science Scope and Sequence (IB, 2008); Science across the IB continuum (IB, 2011); Making the PYP happen: A curriculum framework for international primary education (IBO, 2009); The Shape of the Australian Curriculum Version 2.0 (ACARA, 2010), and; Australian Curriculum: Science (Australian Curriculum, 2015).

Table 13

IB PYP Science Skills

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

In the AC, skills are outlined in relation to the development of the cross-curricular 'General Capabilities' and also in the 'Elaborations' of the content 'Areas' and 'Descriptors'. On the following pages we present the mapping of the IB PYP Science curriculum skills on to the AC 'Elaborations' in a series of summary tables – one for each AC school year. These tables use the numerical coding presented in Table 13 to illustrate the alignment between the two curricula. In some cases there are multiple numerical codes to show how more than one of the IB Skills aligns with AC Elaborations. We follow these tables with a discussion of findings relating to skills development in the PYP curriculum.

Table 14

Foundation Year Skills Alignment

FOUNDATION AC Science Inquiry skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questionning and predicting	Respond to questions about familiar objects and events	considering questions relating to the home and school and objects used in everyday life	4
Plranning and conducting	Explore and make observations by using the senses	using sight, hearing, touch, taste and smell so that students can gather information about the world around them	1
Processing and analysing data and information	Engage in discussions about observations and use methods such as drawing to represent ideas	taking part in informal and guided discussions relating to students' observations	3
		using drawings to represent observations and ideas and discussing their representations with others	8
Communicating	Share observations and ideas	working in groups to describe what students have done and what they have found out	3
		communicating ideas through role play and drawing	8

Using the key provided in Table 13, we can see that in Table 14 the AC Foundation Elaborations align with PYP Science Skills such as; 'observe carefully in order to gather data' (IB Science Skills 1), 'use scientific vocabulary to explain their observations and experiences' (IB Science Skills 3), 'identify or generate a question or problem to be explored' (IB Science Skills 4) and 'consider scientific models and applications of these models' (IB Science Skills 8).

In the following pages, Tables 15 through to 20 illustrate how the AC 'Elaborations' for Years 1-6 relate to a wide range of 'Skills' outlined in the PYP. Readers are reminded that the numerical coding for PYP Science Skills is provided in Table 13.

Table 15

Year 1 Skills Alignment

YEAR 1 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	Respond to and pose questions, and make predictions about familiar objects and events	thinking about "What will happen if……?" type questions about everyday objects and events	4
		using the senses to explore the local environment to pose interesting questions and making predictions about what will happen	4, 6
Planning and conducting	Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources	manipulating objects and making observations of what happens	1, 5
		researching ideas collaboratively using big books, web pages and ICT within the classroom	5
		exploring different ways of solving science questions through guided discussion	3, 5
		sorting information and classifying objects based on easily observable characteristics with teacher guidance	7
	Use informal measurements in the collection and recording of observations, with the assistance of digital technologies as appropriate	using units that are familiar to students from home and school, such as cups (cooking), hand spans (length) and walking paces (distance) to make and record observations with teacher guidance	2
Processing and analysing data and information	Use a range of methods to sort information, including drawings and provided tables	using matching activities, including identifying similar things, odd-one-out and opposites	7
		exploring ways of recording and sharing information through class discussion	3, 8
		jointly constructing simple column graphs and picture graphs to represent class investigations	8
	Through discussion, compare observations with predictions	discussing original predictions and, with guidance, comparing these to their observations	3, 7
Evaluating	Compare observations with those of others	discussing observations as a whole class to identify similarities and differences in their observations	3, 7
Communicating	Represent and communicate observations and ideas in a variety of ways such as oral and written language, drawing and role play	discussing or representing what was discovered in an investigation	3, 7
		engaging in whole class or guided small group discussions to share observations and ideas	3, 7

Table 16

Year 2 Skills Alignment

YEAR 2 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	Respond to and pose questions, and make predictions about familiar objects and events	using the senses to explore the local environment to pose interesting questions, make inferences and predictions	4, 6
		thinking about 'What will happen if...?' type questions about everyday objects and events	4
Planning and conducting	Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources	manipulating objects and materials and making observations of the results	1, 5
		researching with the use of simple information sources	5
		sorting objects and events based on easily identified characteristics	7
	Use informal measurements in the collection and recording of observations, with the assistance of digital technologies as appropriate	using units that are familiar to students from home and school, such as cups (cooking), hand spans (length) and walking paces (distance) to make and compare observations	2
Processing and analysing data and information	Use a range of methods to sort information, including drawings and provided tables	constructing column and picture graphs with teacher guidance to record gathered information	8
		sorting information in provided tables or graphic organisers	7, 8
	Through discussion, compare observations with predictions	comparing and discussing, with guidance, whether observations were expected	3, 7
Evaluating	Compare observations with those of others	discussing observations with other students to see similarities and differences in results	3, 7
Communicating	Represent and communicate observations and ideas in a variety of ways such as oral and written language, drawing and role play	presenting ideas to other students, both one-to-one and in small groups	3, 7
		discussing with others what was discovered from an investigation	3, 7

Table 17

Year 3 Skills Alignment

YEAR 3 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge	choosing questions to investigate from a list of possibilities	4
		jointly constructing questions that may form the basis for investigation	4
		listing shared experiences as a whole class and identifying possible investigations	3, 5
		working in groups to discuss things that might happen during an investigation	3, 6
Planning and conducting	Suggest ways to plan and conduct investigations to find answers to questions	working with teacher guidance to plan investigations to test simple cause-and-effect relationships	5
		discussing as a whole class ways to investigate questions and evaluating which ways might be most successful	3, 5
	Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate	recording measurements using familiar formal units and appropriate abbreviations, such as seconds (s), grams (g), centimetres (cm)	2
		using a variety of tools to make observations, such as digital cameras, thermometers, rulers and scales	1, 2
		discussing safety rules for equipment and procedures	2, 3
Processing and analysing data and information	Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends	using provided tables to organise materials and objects based on observable properties	7, 8
		discussing how to graph data presented in a table	3, 8
		identifying and discussing numerical and visual patterns in data collected from students' own investigations and from secondary sources	3, 7
	Compare results with predictions, suggesting possible reasons for findings	discussing how well predictions matched results from an investigation and sharing ideas about what was learnt	3, 7
Evaluating	Reflect on the investigation, including whether a test was fair or not	describing experiences of carrying out investigations to the teacher, small group or whole class	3
		discussing as a whole class the idea of fairness in testing	3, 5
Communicating	Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports	communicating with other students carrying out similar investigations to share experiences and improve investigation skill	3, 7
		exploring different ways to show processes and relationships through diagrams, models and role play	8
		using simple explanations and arguments, reports or graphical representations to communicate ideas to other students	7, 8

Table 18

Year 4 Skills Alignment

YEAR 4 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge	considering familiar situations in order to think about possible areas for investigation	4
		reflecting on familiar situations to make predictions with teacher guidance	6
		choosing questions to investigate from a list of possibilities	4
Planning and conducting	Suggest ways to plan and conduct investigations to find answers to questions	exploring different ways to conduct investigations and connecting these to the types of questions asked with teacher guidance	5
		working in groups, with teacher guidance, to plan ways to investigate questions	3, 5
	Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate	discussing and recording safety rules for equipment as a whole class	2, 3
		making and recording measurements using familiar formal units and appropriate abbreviations, such as seconds (s), grams (g), centimetres (cm) and millilitres (mL)	2
Processing and analysing data and information	Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends	identifying and discussing numerical and visual patterns in data collected from students' investigations and from other sources	3, 7
		using provided graphic organisers to sort and represent information	7, 8
		discussing with teacher guidance which graphic organisers will be most useful in sorting or organising data arising from investigations	7, 8
	Compare results with predictions, suggesting possible reasons for findings	discussing how well predictions matched results from an investigation and proposing reasons for findings	3, 7
		comparing, in small groups, proposed reasons for findings and explaining their reasoning	7, 8
Evaluating	Reflect on the investigation; including whether a test was fair or not	reflecting on investigations, identifying what went well, what was difficult or didn't work so well, and how well the investigation helped answer the question	3, 5
		discussing which aspects of the investigation helped improve fairness, and any aspects that weren't fair	3, 5
Communicating	Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports	communicating with other students carrying out similar investigations to share experiences and improve investigation skills	3, 7
		using simple explanations and arguments, reports or graphical representations to communicate ideas to other students	7, 8

Table 19

Year 5 Skills Alignment

YEAR 5 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be	exploring the range of questions that can be asked about a problem or phenomena and with guidance, identifying those questions that could be investigated	4
		applying experience from similar situations in the past to predict what might happen in a new situation	6
Planning and conducting	With guidance, plan appropriate investigation methods to answer questions or solve problems	experiencing a range of ways of investigating questions, including experimental testing, internet research, field observations and exploring simulations	5
		discussing the advantages of certain types of investigation for answering certain types of questions	3, 5
		considering different ways to approach problem solving, including researching, using trial and error, experimental testing and creating models	5
	Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate	discussing in groups how investigations can be made as fair as possible	3, 5
		using tools to accurately measure objects and events in investigation and exploring which tools provide the most accurate measurements	1, 2
		using familiar units such as grams, seconds and meters and developing the use of standard multipliers such as kilometres and millimetres	2
		recording data in tables and diagrams or electronically as digital images and spreadsheets	2
	Use equipment and materials safely, identifying potential risks	explaining rules for safe processes and use of equipment	2, 3
Processing and analysing data and information	Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate	constructing tables, graphs and other graphic organisers to show trends in data	8
		identifying patterns in data and developing explanations that fit these patterns	7
		identifying similarities and differences in qualitative data in order to group items or materials	7
	Compare data with predictions and use as evidence in developing explanations	sharing ideas as to whether observations match predictions, and discussing possible reasons for predictions being incorrect	3, 7
Evaluating	Suggest improvements to the methods used to investigate a question or solve a problem	working collaboratively to identify where methods could be improved, including where testing was not fair and practices could be improved	3, 5
Communicating	Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts	discussing how models represent scientific ideas and constructing physical models to demonstrate an aspect of scientific understanding	3, 8
		constructing multi-modal texts to communicate science ideas	8
		using labelled diagrams, including cross-sectional representations, to communicate ideas	8

Table 20

Year 6 Skills Alignment

YEAR 6 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be	refining questions to enable scientific investigation	4
		asking questions to understand the scope or nature of a problem	4
		applying experience from previous investigations to predict the outcomes of investigations in new contexts	6
Planning and conducting	With guidance, plan appropriate investigation methods to answer questions or solve problems	following a procedure to design an experimental or field investigation	5
		discussing methods chosen with other students, and refining methods accordingly	3, 5
		considering which investigation methods are most suited to answer a particular question or solve a problem	5
	Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate	using familiar units such as grams, seconds and metres and developing the use of standard multipliers such as kilometres and millimetres	2
		using the idea of an independent variable (note: this terminology does not need to be used at this stage) as something that is being investigated by changing it and measuring the effect of this change	2
		using digital technologies to make accurate measurements and to record data	1, 2
	Use equipment and materials safely, identifying potential risks	discussing possible hazards involved in conducting investigations, and how these risks can be reduced	3, 5
Processing and analysing data and information	Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate	exploring how different representations can be used to show different aspects of relationships, processes or trends	8
		using digital technologies to construct representations, including dynamic representations	8
	Compare data with predictions and use as evidence in developing explanations	sharing ideas as to whether observations match predictions, and discussing possible reasons for predictions being incorrect	3, 7
		discussing the difference between data and evidence	3, 8
		referring to evidence when explaining the outcomes of an investigation	3, 8
Evaluating	Suggest improvements to the methods used to investigate a question or solve a problem	discussing improvements to the methods used, and how these methods would improve the quality of the data obtained	3, 5
Communicating	Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts	discussing the best way to communicate science ideas and what should be considered when planning a text	3, 8
		using a variety of communication modes, such as reports, explanations, arguments, debates and procedural accounts, to communicate science ideas	8
		using labelled diagrams, including cross-sectional representations, to communicate ideas and processes within multi-modal texts	8

Summary of the curriculum alignment mapping – skills

Table 20 above, and Tables 14-19 that preceded it, have presented our mapping of IB PYP Science Skills to the AC Science curriculum for Years F to 6. Together they show the following common features:

1. There is considerable overlap and alignment between the Science Skills promoted in the AC and PYP curriculum. There are no Skills listed in either curriculum which are not considered in the other curriculum, but the AC and PYP do differ in emphasis and in the arrangements for progression of Skills.
2. While the PYP focuses on eight Skills to be applied across the curriculum content and across different age categories, the AC focuses on different Skills in different year groups. For example, in the Foundation year, the AC skills outlined in 'Elaborations' align with the PYP 'Use of scientific vocabulary to explain their observations and experiences' and with the

‘Consideration and application of different scientific models’; whereas later in Year 5 AC, there is a greater emphasis on the use of instruments for measurement and the interpretation and evaluation of data.

3. Across the year groups of the AC, the numerical code 7 ‘Interpret and evaluate data gathered in order to draw conclusions’, numerical code 3 ‘Use scientific vocabulary to explain their observations and experiences’ and numerical code 2 ‘Use a variety of instruments and tools to measure data accurately’ are dominant in the AC. Less of the AC focuses on the development of observation skills and on the identification and generation of questions which are more apparent in the IB PYP.

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Appendices

Appendix 1: Curriculum alignment of knowledge and concepts

The following tables illustrate the alignment between the AC and IB PYP at each Australian school year. The IB PYP is not focused on Australian school year but rather age brackets that are more relevant to the international IB student cohort. He following tables summarise both curricula for each Australian schooling year, Foundation to Year 6. We have colour coded each of the corresponding IB themes in relation to their age grouping in the following way:

Red 3-5 years

Blue 5-7 years

Green 7-9 years

Orange 9-12 years

Alignment of the different content areas and theme is evident, although the age/developmental progression of the curricula vary substantially.

FOUNDATION Australian Curriculum				IB PYP			
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes	Pages
Science understanding	Biological sciences	Living things have basic needs, including food and water	identifying the needs of humans such as warmth, food and water, using students' own experiences	T6 - Sharing the planet	Characteristics of living things/Our needs and the needs of other living things	observe and describe the charactersitics of living and non-living things / observe the needs of living thing that enable them to stay healthy	7
				T1 - Who we are	Daily habits and routines (hygiene, sleep, play, eating)	recognize that living things, including humans, need certain resources for energy and growth	11
			recognising the needs of living things in a range of situations such as pets at home, plants in the garden or plants and animals in bushland	T6 - Sharing the planet	Characteristics of living things/Our needs and the needs of other living things	take responsibility for living things found in his or her environment.	7
			comparing the needs of plants and animals	T6 - Sharing the planet	Characteristics of living things/Our needs and the needs of other living things		7
	Chemical sciences	Objects are made of materials that have observable properties	sorting and grouping materials on the basis of observable properties such as colour, txture and flexibility	T4 - How the world works		use senses to describe observable properties of familiar materials (including solids, liquids, gases) / recognize that materials can be solid, liquid or gas	8
			thinking about how the materials used in buildings and shelters are suited to the local environment	T4 - How the world works	Manipulation of materials for specific purposes	apply understanding of basic properties of materials in order to match materials to purpose (for example, waterproofing, insulating)	8
			investigating different forms of clothing used for different activities	T4 - How the world works	Behaviour and uses of materials		8
			comparing the traditional materials used for clothing from around the world	T4 - How the world works	Changing properties of materials		8
	Earth and space sciences	Daily and seasonal changes in our environment, including the weather, affect everyday life	linking the changes in the daily weather to the way we modify our behaviour and dress for different conditions, including examples from different cultures	T4 - How the world works	Health and safety as related to climate and seasonal changes	talk about activities that occur during the day and night / compare activities that occur during the seasons / make connections between the weather and how to protect himself or herself	6
			investigating how changes in the weather might affect animals such as pets, animals that hibernate, or migratory animals	T4 - How the world works	Night and day cycles (dark and light) / Seasonal changes	identify simple patterns in daily and seasonal cycles / observe the features of the local environment that are affected by daily and seaasonal cycles	6
			learning how Aboriginal and Torres Strait Islander concepts of time and weather patterns explain how things happen in the world around them				
	Physical sciences	The way objects move depends on a variety of factors, including their size and shape	observing the way different shaped objects such as balls, blocks and tubes move				
			comparing the way different sized, but similar shaped, objects such as tennis balls, golf balls, marbles and basketballs roll and bounce				
			observing how the movement of different living things depends on their size and shape				
Science as human endevour	Nature and development of science	Science involves exploring and observing the world using the senses	recognising that observation is an important part of exploring and investigating the things and places around us	T4 - How the world works		use senses to describe observable properties of familiar materials (including solids, liquids, gases)	8
			sharing observations with others and communicating their experiences				
			exploring and observing using hearing, smell, touch, seeing and taste	T4 - How the world works		use senses to describe observable properties of familiar materials (including solids, liquids, gases)	8

YEAR 1 Australian Curriculum				IB PYP			
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes	Pages
Science understanding	Biological sciences	Living things have a variety of external features	recognising common features of animals such as head, legs and wings	T6 - Sharing the planet	Characteristics of living things		7
			describing the use of animal body parts for particular purposes such as moving and feeding	T6 - Sharing the planet	Characteristics of living things		7
			identifying common features of plants such as leaves and roots	T6 - Sharing the planet	The structure of a plant	identify the parts of plants that are used by other living things (for example, for food, shelter, tools)	9
			describing the use of plant parts for particular purposes such as making food and obtaining water	T6 - Sharing the planet	Characteristics of living things		7
		Living things live in different places where their needs are met	exploring different habitats in the local environment such as the beach, bush and backyard	T6 - Sharing the planet			
			recognising that different living things live in different places such as land and water				
			exploring what happens when habitats change and some living things can no longer have their needs met	T4 - How the world works		investigate the responses of plants or animals to changes in their habitats	12
	Chemical sciences	Everyday materials can be physically changed in a variety of ways	predicting and comparing how the shapes of objects made from different materials can be physically changed through actions such as bending, stretching and twisting	T4 - How the world works	Manipulation of materials for specific purposes		8
			exploring how materials such as water, chocolate or play dough change when warmed or cooled	T4 - How the world works		describe observable changes (including changes of state) that occur in materials / be aware of how to change water into a solid, liquid and gas	8
	Earth and space sciences	Observable changes occur in the sky and landscape	exploring the local environment to identify and describe natural, managed and constructed features	T6 - Sharing the planet		describe the natural features of local and other environments (for example, underlying geology)	13
			recording short and longer term patterns of events that occur on Earth and in the sky, such as the appearance of the moon and stars at night, the weather and the seasons	T4 - How the world works	Seasonal changes	identify simple patterns in daily and seasonal cycles	6
	Physical sciences	Light and sound are produced by a range of sources and can be sensed	recognising senses are used to learn about the world around us: our eyes to detect light, our ears to detect sound, and touch to feel vibrations				
			identifying the sun as a source of light				
			recognising that objects can be seen when light from sources is available to illuminate them				
			exploring different ways to produce sound using familiar objects and actions such as striking, blowing, scraping and shaking				
			comparing sounds made by musical instruments using characteristics such as loudness, pitch and actions used to make the sound				
Science as a Human Endeavour	Nature and developm	Science involves asking questions about, and describing changes in, objects	jointly constructing questions about the events and features of the local environment with teacher guidance				
			recognising that descriptions of what we observe are used by people to help identify change				
	Use and influence of science	People use science in their daily lives, including when caring for their environment and living things	considering how science is used in activities such as cooking, fishing, transport, sport, medicine and caring for plants and animals	T6 - Sharing the planet	Caring for plant life	show responsibility when caring for plants	9
			considering that technologies used by Aboriginal and Torres Strait Islander people require an understanding of how materials can be used to make tools and weapons, musical instruments, clothing, cosmetics and artworks				
			exploring how musical instruments can be used to produce different sounds				
			comparing how different light sources are used in daily life				
			identifying ways that science knowledge is used in the care of the local environment such as animal habitats, and suggesting changes to parks and gardens to better meet the needs of native animals	T6 - Sharing the planet		Observe the needs of living things that enable them to stay healthy	7

YEAR 2 Australian Curriculum				IB PYP			
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes	Pages
Science Understanding	Biological sciences	Living things grow, change and have offspring similar to themselves	representing personal growth and changes from birth	T4 - How the world works	Life cycles / How living things change over their life time	identify the common components of life cycles (for example, birth, growth, maturity, reproduction, death)	12
			recognising that living things have predictable characteristics at different stages of development	T4 - How the world works	Life cycles / How living things change over their life time		12
			exploring different characteristics of life stages in animals such as egg, caterpillar and butterfly	T4 - How the world works	Developmental stages of various living things	describe the life cycles of a variety of living things (for example, a range of animals and plants) / compare the life cycles of different living things	12
			observing that all animals have offspring, usually with two parents	T4 - How the world works	Life cycles		12
	Chemical sciences	Different materials can be combined, including by mixing, for a particular purpose	exploring the local environment to observe a variety of materials, and describing ways in which materials are used	T4 - How the world works	Manipulation of materials for specific purposes		8
			investigating the effects of mixing materials together	T4 - How the world works	Manipulation of materials for specific purposes		8
			suggesting why different parts of everyday objects such as toys and clothes are made from different materials	T4 - How the world works	Manipulation of materials for specific purposes		8
			identifying materials such as paper that can be changed and remade or recycled into new products	T6 - Sharing the planet	Reusing and recycling different materials	investigate ways that familiar materials can ne reused / describe how a particular material is recycled	16
	Earth and space sciences	Earth’s resources, including water, are used in a variety of ways	identifying the Earth’s resources including water, soil and minerals, and describing how they are used in the school	T6 - Sharing the planet	Sources of water and how water is used	describe how water sustains life	21
				T6 - Sharing the planet		reflect on and self-assess his or her personal use of natural resources	16
			describing how a resource such as water is transferred from its source to its point of use	T6 - Sharing the planet	What happens to water after we have used it / Distribution and availability of usable water		21
			considering what might happen to humans if there were a change in a familiar available resource, such as water	T4 - How the world works	Human response to the Earth's changes		20
			identifying actions at school such as turning off dripping taps, that can conserve resources	T4 - How the world works		explain people's responsibility regarding the use of materials from the environment	18
				T6 - Sharing the planet	Responsibilities regarding water		21
	Physical sciences	A push or a pull affects how an object moves or changes shape	exploring ways that objects move on land, through water and in the air				
			exploring how different strengths of pushes and pulls affect the movement of objects				
			identifying toys from different cultures that use the forces of push or pull				
			considering the effects of objects being pulled towards the Earth				
Science as a Human Endeavour	Nature and development of science	Science involves asking questions about, and describing changes in, objects and events	describing everyday events and experiences and changes in our environment using knowledge of science				
			suggesting how everyday items work, using knowledge of forces or materials				
			identifying and describing sources of water	T6 - Sharing the planet		explain why fresh water is a limited resource / identify water issues and propose solutions for responsible, equitable water use (for example, desalination)	21
	Use and influence of science	People use science in their daily lives, including when caring for their environment and living things	monitoring information about the environment and Earth’s resources, such as rainfall, water levels and temperature	T6 - Sharing the planet		explore the impact of the sun on the availiability of water	21
			finding out about how Aboriginal and Torres Strait Islander people use science to meet their needs, including food supply				
			exploring how different cultures have made inks, pigments and paints by mixing materials				
			identifying the ways humans manage and protect resources, such as reducing waste and caring for water supplies	T6 - Sharing the planet	Human use of the local natural environment / Actions that benefit or harm the local environment	analyse ways in which humans use the natural environment	13
				T6 - Sharing the planet	Personal choice that can help sustain the environment / Reducing waste	explore the role of living things in recycling energy and matter	16
				T6 - Sharing the planet		analyse systems of water storage and usage, both natural and human-made	21
			recognising that many living things rely on resources that may be threatened, and that science understanding can contribute to the preservation of such resources	T6 - Sharing the planet	Limited nature of the Earth's resources		16

YEAR 3 Australian Curriculum				IB PYP			
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes	Pages
Science Understanding	Biological sciences	Living things can be grouped on the basis of observable features and can be distinguished from non-living things	recognising characteristics of living things such as growing, moving, sensitivity and reproducing	T4 - How the world works	Reproduction as part of a life cycle		29
			recognising the range of different living things	T6 - Sharing the planet		take responsibility for living things found in his or her environment	7
			sorting living and non-living things based on characteristics	T6 - Sharing the planet		Observe and describe the characteristics of living and non-living things	7
			exploring differences between living, once living and products of living things				
	Chemical sciences	A change of state between solid and liquid can be caused by adding or removing heat	investigating how liquids and solids respond to changes in temperature, for example water changing to ice, or melting chocolate	T6 - Sharing the planet		recognize that water exists in the air in different forms	21
			exploring how changes from solid to liquid and liquid to solid can help us recycle materials	T6 - Sharing the planet		group materials on the basis of properties for the purpose of recycling	16
				T4 - How the world works		recognize that materials can be solid, liquid or gas	8
			predicting the effect of heat on different materials	T4 - How the world works	Forms of energy		23
	Earth and space sciences	Earth's rotation on its axis causes regular changes, including night and day	recognising the sun as a source of light	T4 - How the world works	Forms of energy		23
			constructing sundials and investigating how they work				
			describing timescales for the rotation of the Earth	T4 - How the world works	Seasonal changes		6
			modelling the relative sizes and movement of the sun, Earth and moon				
	Physical sciences	Heat can be produced in many ways and can move from one object to another	describing how heat can be produced such as through friction or motion, electricity or chemically (burning)	T4 - How the world works	Forms of energy		23
			identifying changes that occur in everyday situations due to heating and cooling				
			exploring how heat can be transferred through conduction	T4 - How the world works	Forms of energy		23
			recognising that we can feel heat and measure its effects using a thermometer				
Science as a Human Endeavour	Nature and development of science	Science involves making predictions and describing patterns and relationships	making predictions about change and events in our environment				
			researching how knowledge of astronomy has been used by some Aboriginal and Torres Strait Islander people				
			considering how posing questions helps us plan for the future				
	Use and influence of science	Science knowledge helps people to understand the effect of their actions	considering how heating affects materials used in everyday life	T4 - How the world works		identify and describe different forms of energy	23
			investigating how science helps people such as nurses, doctors, dentists, mechanics and gardeners				
			considering how materials including solids and liquids affect the environment in different ways				
			deciding what characteristics make a material a pollutant				
			researching Aboriginal and Torres Strait Islander people's knowledge of the local natural environment, such as the characteristics of plants and animals				

YEAR 4 Australian Curriculum				IB PYP			
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes	Pages
Science Understanding	Biological sciences	Living things have life cycles	making and recording observations of living things as they develop through their life cycles	T4 - How the world works	Reproduction as part of a life cycle / Reproducitve processes		29
			describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants	T4 - How the world works	Developmental stages of various living things	describe the life cycles of a variety of living things (for example, a range of animals and plants)	12
			comparing life cycles of animals and plants	T4 - How the world works		recognize that plants and animals go through predictable life cycles	29
			recognising that environmental factors can affect life cycles such as fire and seed germination	T4 - How the world works		investigate the responses of plants or animals to changes on their habitats	12
		Living things, including plants and animals, depend on each other and the environment to survive	investigating how plants provide shelter for animals	T6 - Sharing the planet	Interdependence within ecosystems, biomes and environments		27
			investigating the roles of living things in a habitat, for instance producers, consumers or decomposers	T6 - Sharing the planet	Ways in which organisms are interconnected in nature	describe the interactions of living things within and between ecosystems	27
			observing and describing predator-prey relationships	T6 - Sharing the planet	Interdependence within ecosystems, biomes and environments	describe the interactions of living things within and between ecosystems	27
			predicting the effects when living things in feeding relationships are removed or die out in an area	T6 - Sharing the planet		analyse the effects of chaning a link in a food web	27
			recognising that interactions between living things may be competitive or mutually beneficial	T6 - Sharing the planet	How human interaction with the environment can affect the balance of systems	examine interactions between living things and non-living parts of the environment / explain how human activities can have positive or adverse effects on local and othe environments (for example, waste disposal, agriculture, industry)	27
	Chemical sciences	Natural and processed materials have a range of physical properties; These properties can influence their use	describing a range of common materials, such as metals or plastics, and their uses	T4 - How the world works	Behaviour and uses of materials		8
			investigating a particular property across a range of materials	T4 - How the world works		uses senses to describe observable properties of familiar materials (including solids, liquids, gases)	8
			selecting materials for uses based on their properties	T4 - How the world works		apply understanding of basic properties of materials in order to match materials to purpose (for example, waterproofing, insulating)	8
			considering how the properties of materials affect the management of waste or can lead to pollution				
	Earth and space sciences	Earth's surface changes over time as a result of natural processes and human activity	collecting evidence of change from local landforms, rocks or fossils	T6 - Sharing the planet		recognize the importance of the fossil record to inform the concept of evolution	19
				T4 - How the world works		identify the evidence that the Earth has changed (for example, land formations in local environment) / reflect on the explanations from a range of sources as to why the Earth changes	20
			exploring a local area that has changed as a result of natural processes, such as an eroded gully, sand dunes or river banks	T4 - How the world works	How the different components of the Earth are interrelated / How the Earth has changed and in continuing to change / Why the Earth changes	identify the long-term and short-term changes on Earth (for example, plate tectonics, erosion, floods, deforestation) / describe how natural phenomena shape the planet	20
			investigating the characteristics of soils				
			considering how different human activities cause erosion of the Earth's surface	T6 - Sharing the planet		identify or generate a question or problem to be explored in relation to human impact on the local environment	13
			considering the effect of events such as floods and extreme weather on the landscape, both in Australia and in the Asia region				
	Physical sciences	Forces can be exerted by one object on another through direct contact or from a distance	observing qualitatively how speed is affected by the size of a force				
			exploring how non-contact forces are similar to contact forces in terms of objects pushing and pulling another object				
			comparing and contrasting the effect of friction on different surfaces, such as tyres and shoes on a range of surfaces				
			investigating the effect of forces on the behaviour of an object through actions such as throwing, dropping, bouncing and rolling				
			exploring the forces of attraction and repulsion between magnets				
Science as a Human Endeavour	Nature and development of science	Science involves making predictions and describing patterns and relationships	exploring ways in which scientists gather evidence for their ideas and develop explanations				
			considering how scientific practices such as sorting, classification and estimation are used by Aboriginal and Torres Strait Islander people in everyday life				
	Use and influence of science	Science knowledge helps people to understand the effect of their actions	investigating how a range of people, such as clothing designers, builders or engineers use science to select appropriate materials for their work				
			considering methods of waste management and how they can affect the environment				
			exploring how science has contributed to a discussion about an issue such as loss of habitat for living things or how human activity has changed the local environment	T4 - How the world works		explore scientific and technological developments that help people understand and respond to the changing Earth	20
			considering how to minimise the effects of erosion caused by human activity	T6 - Sharing the planet	Actions that benefit or harm the local environment		13

			YEAR 5 Australian Curriculum	IB PYP		
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes
Science Understanding	Biological sciences	Living things have structural features and adaptations that help them to survive in their environment	explaining how particular adaptations help survival such as nocturnal behaviour, silvery coloured leaves of dune plants	T6 - Sharing the planet	Concept of adaptation / Circumstances that lead to adaptation	recognize the ways in which plants and animals have adapted over ti
			describing and listing adaptations of living things suited for particular Australian environments	T6 - Sharing the planet	How plants and animals adapt or respond to environmental conditions	recognize the ways in which plants and animals have adapted over ti
			exploring general adaptations for particular environments such as adaptations that aid water conservation in deserts	T6 - Sharing the planet	How plants and animals adapt or respond to environmental conditions	make links between different features of the environment and the specific needs of living things / assess the impact that changes in environmental conditions can have on living things
				T6 - Sharing the planet		investigate the conservation of energy in ecosystems
	Chemical sciences	Solids, liquids and gases have different observable properties and behave in different ways	recognising that substances exist in different states depending on the temperature			
			observing that gases have mass and take up space, demonstrated by using balloons or bubbles	T4 - How the world works	The evidence of the existence of air	investigate and identify the properties of air
			exploring the way solids, liquids and gases change under different situations such as heating and cooling	T4 - How the world works	Changing properties of materials	describe observable changes (including changes of state) that occur i materials
			recognising that not all substances can be easily classified on the basis of their observable properties	T4 - How the world works		recognize that materials can be solid, liquid or gas
	Earth and space	The Earth is part of a system of planets orbiting around a star (the sun)	identifying the planets of the solar system and comparing how long they take to orbit the sun			
			modelling the relative size of and distance between Earth, other planets in the solar system and the sun			
			recognising the role of the sun as a provider of energy for the Earth	T6 - Sharing the planet		recognize that solar energy sustains ecosystems through a transformation of energy
	Physical sciences	Light from a source forms shadows and can be absorbed, reflected and refracted	drawing simple labelled ray diagrams to show the paths of light from a source to our eyes			
			comparing shadows from point and extended light sources such as torches and fluorescent tubes			
			classifying materials as transparent, opaque or translucent based on whether light passes through them or is absorbed			
			recognising that the colour of an object depends on the properties of the object and the colour of the light source			
			exploring the use of mirrors to demonstrate the reflection of light			
			recognising the refraction of light at the surfaces of different transparent materials, such as when light travels from air to water or air to glass			
Science as a Human Endeavour	Nature and development of science	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena	developing an understanding of the behaviour of light by making observations of its effects			
			testing predictions relating to the behaviour of solids, liquids and gases by conducting observational experiments			
			researching how scientists were able to develop ideas about the solar system through the gathering of evidence through space exploration	T2 - Where we are in place and time	Reasons for exploration (historical and personal) / What we learn through exploration	identify regular and irregular events in time and space that occur in t solar system / examine the impact of events that occur in the solar systems on the Earth
		Important contributions to the advancement of science have been made by people from a range of cultures	describing how scientists from a range of cultures have improved our understanding of the solar system, such as Copernicus, Khayyám and Galileo			
			researching the different types of scientists who work in teams in space exploration, and Australia's involvement in space exploration			
			learning how Aboriginal and Torres Strait Islander Peoples used observation of the night sky to assist with navigation			
	Use and influence of science	Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives	investigating how the development of materials such as plastics and synthetic fabrics have led to the production of useful products	T4 - How the world works		assess the benefits and challenges of changing materials to suit people's needs and wants (for example, plastic)
			describing how technologies developed to aid space exploration have changed the way people live, work and communicate	T5 - How we organize ourselves	Technology and inventions of the home, workplace and leisure activities	analyse the way in which technology supports the functioning of workplaces (for example, schools) / investigate technology developments
			exploring objects and devices that include parts that involve the reflection, absorption or refraction of light such as mirrors, sunglasses and prisms			
		Scientific knowledge is used to inform personal and community decisions	considering how best to ensure growth of plants	T6 - Sharing the planet	Caring for plant life	
			considering how decisions are made to grow particular plants and crops depending on environmental conditions			
			comparing the benefits of using solid, liquid or gaseous fuels to heat a home	T4 - How the	Forms of energy	

			YEAR 6 Australian Curriculum	IB PYP			
	Area		Elaborations	Themes	Lines of Inquiry	Outcomes	Pages
Science Understanding	Biological sciences	The growth and survival of living things are affected by the physical conditions of their environment	investigating how changing the physical conditions for plants impacts on their growth and survival such as salt water, use of fertilizers and soil types	T6 - Sharing the planet		assess the impact that changes in environmental conditions can have on living things	19
			observing the growth of fungi such as yeast and bread mould in different conditions				
			researching organisms that live in extreme environments such as Antarctica or a desert	T6 - Sharing the planet	How plants and animals adapt or respond to environmental conditions	make links between different features of the environment and the specific needs of living things	19
			considering the effects of physical conditions causing migration and hibernation	T6 - Sharing the planet	How plants and animals adapt or respond to environmental conditions		19
	Chemical sciences	Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting	describing what happens when materials are mixed	T4 - How the world works	Manipulation of materials for specific purposes		8
			investigating the solubility of common materials in water				
			investigating the change in state caused by heating and cooling of a familiar substance	T4 - How the world works	Practical applications and implications of change in materials	investigate the ways materials can be changed (for example, metal, sand)	26
			investigating irreversible changes such as rusting, burning and cooking				
			exploring how reversible changes can be used to recycle materials	T6 - Sharing the planet		investigate ways that familiar materials can be reused	16
	Earth and space sciences	Sudden geological changes or extreme weather conditions can affect Earth's surface	investigating major geological events such as earthquakes, volcanic eruptions and tsunamis in Australia, the Asia region and throughout the world				
			recognising that earthquakes can cause tsunamis	T4 - How the world works	How the different components of the Earth are interrelated		20
			describing how people measure significant geological events				
			exploring ways that scientific understanding can assist in natural disaster management to minimise both long- and short-term effects	T4 - How the world works		identify the long-term and short-term changes on Earth (for example, plate tectonics, erosion, floods, deforestation)	20
			considering the effect of drought on living and non-living aspects of the environment	T4 - How the world works		describe how natural phenomena shape the planet	20
	Physical sciences	Electrical circuits provide a means of transferring and transforming	recognising the need for a complete circuit to allow the flow of electricity				
			investigating different electrical conductors and insulators				
			exploring the features of electrical devices such as switches and light globes				
		Energy from a variety of sources can be used to generate electricity	investigating how moving air and water can turn turbines to generate electricity	T4- How the world works		identify and describe different forms of energy	23
			investigating the use of solar panels	T4- How the world works		assess renewable and sustainalbe energy sources (for example, wind, solar, water)	23
			considering whether an energy source is sustainable	T4- How the world works	Renewable and sustainalbe energy		
Science as a Human Endeavour	Nature and development of science	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena	investigating how knowledge about the effects of using the Earth's resources has changed over time				
			describing how understanding of the causes and effects of major natural events has changed as new evidence has become available				
			investigating the use of electricity, including predicting the effects of changes to electric circuits				
			considering how gathering evidence helps scientists to predict the effect of major geological or climatic events				
		Important contributions to the advancement of science have been made by people from a range of cultures	investigating how people from different cultures have used sustainable sources of energy, for example water and solar power	T4 - How the world works	Forms of energy		23
			exploring institutions and locations where contemporary Australian scientists conduct research on catastrophic natural events				
			learning how Aboriginal and Torres Strait Islander knowledge, such as the medicinal and nutritional properties of Australian plants, is being used as part of the evidence base for scientific advances				
			investigating the development of earthquake measurements from the Chinese invention of the seismograph in the second century	T2 - Where we are in palce and time		investigate which simple machines were developed by past civilizations (for example, lever, ramp, pulley, screw, wheel)	25
	Use and influence of science	Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives	researching the scientific work involved in global disaster alerts and communication, such as cyclone, earthquake and tsunami alerts	T4 - How the world works		explore scientific and technological developments that help people understand and respond to the changing Earth	20
			investigating how electrical energy is generated in Australia and around the world				
			researching the use of methane generators in Indonesia				
			considering how electricity and electrical appliances have changed the way some people live				
		Scientific knowledge is used to inform personal and community decisions	considering how personal and community choices influence our use of sustainable sources of energy	T4 - How the world works		examine ways in which the local community could be improved in relation to the conservation of energy	23
			investigating how understanding of catastrophic natural events helps in planning for their early detection and minimising their impact	T4 - How the world works		explore scientific and technological developments that help people understand and respond to the changing Earth	20
			recognising that science can inform choices about where people live and how they manage natural disasters	T4 - How the world works		explore scientific and technological developments that help people understand and respond to the changing Earth	20
			considering how guidelines help to ensure the safe use of electrical devices				
			discussing the use of electricity and the conservation of sources of energy	T4- How the world works	Conservation of energy	examine ways in which the local community could be improved in relation to the conservation of energy	23

Appendix 2: Curriculum alignment of skills

These tables present the alignment of skills between the IB PYP and the AC. The IB skills are applied consistently across curriculum areas; however the AC outlines different skills for each year and for each content area.

FOUNDATION AC Science Inquiry skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questionning and predicting	Respond to questions about familiar objects and events	considering questions relating to the home and school and objects used in everyday life	4
Plranning and conducting	Explore and make observations by using the senses	using sight, hearing, touch, taste and smell so that students can gather information about the world around them	1
Processing and analysing data and information	Engage in discussions about observations and use methods such as drawing to represent ideas	taking part in informal and guided discussions relating to students' observations	3
		using drawings to represent observations and ideas and discussing their representations with others	8
Communicating	Share observations and ideas	working in groups to describe what students have done and what they have found out	3
		communicating ideas through role play and drawing	8

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

YEAR 1 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	Respond to and pose questions, and make predictions about familiar objects and events	thinking about "What will happen if……?" type questions about everyday objects and events	4
		using the senses to explore the local environment to pose interesting questions and making predictions about what will happen	4, 6
Planning and conducting	Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources	manipulating objects and making observations of what happens	1, 5
		researching ideas collaboratively using big books, web pages and ICT within the classroom	5
		exploring different ways of solving science questions through guided discussion	3, 5
		sorting information and classifying objects based on easily observable characteristics with teacher guidance	7
	Use informal measurements in the collection and recording of observations, with the assistance of digital technologies as appropriate	using units that are familiar to students from home and school, such as cups (cooking), hand spans (length) and walking paces (distance) to make and record observations with teacher guidance	2
Processing and analysing data and information	Use a range of methods to sort information, including drawings and provided tables	using matching activities, including identifying similar things, odd-one-out and opposites	7
		exploring ways of recording and sharing information through class discussion	3, 8
		jointly constructing simple column graphs and picture graphs to represent class investigations	8
	Through discussion, compare observations with predictions	discussing original predictions and, with guidance, comparing these to their observations	3, 7
Evaluating	Compare observations with those of others	discussing observations as a whole class to identify similarities and differences in their observations	3, 7
Communicating	Represent and communicate observations and ideas in a variety of ways such as oral and written language, drawing and role play	discussing or representing what was discovered in an investigation	3, 7
		engaging in whole class or guided small group discussions to share observations and ideas	3, 7

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

YEAR 2 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	Respond to and pose questions, and make predictions about familiar objects and events	using the senses to explore the local environment to pose interesting questions, make inferences and predictions	4, 6
		thinking about 'What will happen if...?' type questions about everyday objects and events	4
Planning and conducting	Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources	manipulating objects and materials and making observations of the results	1, 5
		researching with the use of simple information sources	5
		sorting objects and events based on easily identified characteristics	7
	Use informal measurements in the collection and recording of observations, with the assistance of digital technologies as appropriate	using units that are familiar to students from home and school, such as cups (cooking), hand spans (length) and walking paces (distance) to make and compare observations	2
Processing and analysing data and information	Use a range of methods to sort information, including drawings and provided tables	constructing column and picture graphs with teacher guidance to record gathered information	8
		sorting information in provided tables or graphic organisers	7, 8
	Through discussion, compare observations with predictions	comparing and discussing, with guidance, whether observations were expected	3, 7
Evaluating	Compare observations with those of others	discussing observations with other students to see similarities and differences in results	3, 7
Communicating	Represent and communicate observations and ideas in a variety of ways such as oral and written language, drawing and role play	presenting ideas to other students, both one-to-one and in small groups	3, 7
		discussing with others what was discovered from an investigation	3, 7

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

YEAR 3 AC Science Inquiry Skills			IB Science Skills
Area	Description	Elaborations	
Questioning and predicting	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge	choosing questions to investigate from a list of possibilities	4
		jointly constructing questions that may form the basis for investigation	4
		listing shared experiences as a whole class and identifying possible investigations	3, 5
		working in groups to discuss things that might happen during an investigation	3, 6
Planning and conducting	Suggest ways to plan and conduct investigations to find answers to questions	working with teacher guidance to plan investigations to test simple cause-and-effect relationships	5
		discussing as a whole class ways to investigate questions and evaluating which ways might be most successful	3, 5
	Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate	recording measurements using familiar formal units and appropriate abbreviations, such as seconds (s), grams (g), centimetres (cm)	2
		using a variety of tools to make observations, such as digital cameras, thermometers, rulers and scales	1, 2
		discussing safety rules for equipment and procedures	2, 3
Processing and analysing data and information	Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends	using provided tables to organise materials and objects based on observable properties	7, 8
		discussing how to graph data presented in a table	3, 8
		identifying and discussing numerical and visual patterns in data collected from students' own investigations and from secondary sources	3, 7
	Compare results with predictions, suggesting possible reasons for findings	discussing how well predictions matched results from an investigation and sharing ideas about what was learnt	3, 7
Evaluating	Reflect on the investigation, including whether a test was fair or not	describing experiences of carrying out investigations to the teacher, small group or whole class	3
		discussing as a whole class the idea of fairness in testing	3, 5
Communicating	Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports	communicating with other students carrying out similar investigations to share experiences and improve investigation skill	3, 7
		exploring different ways to show processes and relationships through diagrams, models and role play	8
		using simple explanations and arguments, reports or graphical representations to communicate ideas to other students	7, 8

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

YEAR 4 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge	considering familiar situations in order to think about possible areas for investigation	4
		reflecting on familiar situations to make predictions with teacher guidance	6
		choosing questions to investigate from a list of possibilities	4
Planning and conducting	Suggest ways to plan and conduct investigations to find answers to questions	exploring different ways to conduct investigations and connecting these to the types of questions asked with teacher guidance	5
		working in groups, with teacher guidance, to plan ways to investigate questions	3, 5
	Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate	discussing and recording safety rules for equipment as a whole class	2, 3
		making and recording measurements using familiar formal units and appropriate abbreviations, such as seconds (s), grams (g), centimetres (cm) and millilitres (mL)	2
Processing and analysing data and information	Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends	identifying and discussing numerical and visual patterns in data collected from students' investigations and from other sources	3, 7
		using provided graphic organisers to sort and represent information	7, 8
		discussing with teacher guidance which graphic organisers will be most useful in sorting or organising data arising from investigations	7, 8
	Compare results with predictions, suggesting possible reasons for findings	discussing how well predictions matched results from an investigation and proposing reasons for findings	3, 7
		comparing, in small groups, proposed reasons for findings and explaining their reasoning	7, 8
Evaluating	Reflect on the investigation; including whether a test was fair or not	reflecting on investigations, identifying what went well, what was difficult or didn't work so well, and how well the investigation helped answer the question	3, 5
		discussing which aspects of the investigation helped improve fairness, and any aspects that weren't fair	3, 5
Communicating	Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports	communicating with other students carrying out similar investigations to share experiences and improve investigation skills	3, 7
		using simple explanations and arguments, reports or graphical representations to communicate ideas to other students	7, 8

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

YEAR 5 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be	exploring the range of questions that can be asked about a problem or phenomena and with guidance, identifying those questions that could be investigated	4
		applying experience from similar situations in the past to predict what might happen in a new situation	6
Planning and conducting	With guidance, plan appropriate investigation methods to answer questions or solve problems	experiencing a range of ways of investigating questions, including experimental testing, internet research, field observations and exploring simulations	5
		discussing the advantages of certain types of investigation for answering certain types of questions	3, 5
		considering different ways to approach problem solving, including researching, using trial and error, experimental testing and creating models	5
	Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate	discussing in groups how investigations can be made as fair as possible	3, 5
		using tools to accurately measure objects and events in investigation and exploring which tools provide the most accurate measurements	1, 2
		using familiar units such as grams, seconds and meters and developing the use of standard multipliers such as kilometres and millimetres	2
		recording data in tables and diagrams or electronically as digital images and spreadsheets	2
	Use equipment and materials safely, identifying potential risks	explaining rules for safe processes and use of equipment	2, 3
Processing and analysing data and information	Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate	constructing tables, graphs and other graphic organisers to show trends in data	8
		identifying patterns in data and developing explanations that fit these patterns	7
		identifying similarities and differences in qualitative data in order to group items or materials	7
	Compare data with predictions and use as evidence in developing explanations	sharing ideas as to whether observations match predictions, and discussing possible reasons for predictions being incorrect	3, 7
Evaluating	Suggest improvements to the methods used to investigate a question or solve a problem	working collaboratively to identify where methods could be improved, including where testing was not fair and practices could be improved	3, 5
Communicating	Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts	discussing how models represent scientific ideas and constructing physical models to demonstrate an aspect of scientific understanding	3, 8
		constructing multi-modal texts to communicate science ideas	8
		using labelled diagrams, including cross-sectional representations, to communicate ideas	8

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
7	Interpret and evaluate data gathered in order to draw conclusions
8	Consider scientific models and applications of these models (including their limitations)

YEAR 6 AC Science Inquiry Skills			IB Science Skills
Area	**Description**	**Elaborations**	
Questioning and predicting	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be	refining questions to enable scientific investigation	4
		asking questions to understand the scope or nature of a problem	4
		applying experience from previous investigations to predict the outcomes of investigations in new contexts	6
Planning and conducting	With guidance, plan appropriate investigation methods to answer questions or solve problems	following a procedure to design an experimental or field investigation	5
		discussing methods chosen with other students, and refining methods accordingly	3, 5
		considering which investigation methods are most suited to answer a particular question or solve a problem	5
	Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate	using familiar units such as grams, seconds and metres and developing the use of standard multipliers such as kilometres and millimetres	2
		using the idea of an independent variable (note: this terminology does not need to be used at this stage) as something that is being investigated by changing it and measuring the effect of this change	2
		using digital technologies to make accurate measurements and to record data	1, 2
	Use equipment and materials safely, identifying potential risks	discussing possible hazards involved in conducting investigations, and how these risks can be reduced	3, 5
Processing and analysing data and information	Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate	exploring how different representations can be used to show different aspects of relationships, processes or trends	8
		using digital technologies to construct representations, including dynamic representations	8
	Compare data with predictions and use as evidence in developing explanations	sharing ideas as to whether observations match predictions, and discussing possible reasons for predictions being incorrect	3, 7
		discussing the difference between data and evidence	3, 8
		referring to evidence when explaining the outcomes of an investigation	3, 8
Evaluating	Suggest improvements to the methods used to investigate a question or solve a problem	discussing improvements to the methods used, and how these methods would improve the quality of the data obtained	3, 5
Communicating	Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts	discussing the best way to communicate science ideas and what should be considered when planning a text	3, 8
		using a variety of communication modes, such as reports, explanations, arguments, debates and procedural accounts, to communicate science ideas	8
		using labelled diagrams, including cross-sectional representations, to communicate ideas and processes within multi-modal texts	8

IB Science Skills	
1	Observe carefully in order to gather data
2	Use a variety of instruments and tools to measure data accurately
3	Use scientific vocabulary to explain their observations and experiences
4	Identify or generate a question or problem to be explored
5	Plan and carry out systematic investigations, manipulating variables as necessary
6	Make and test predictions
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Appendix 3: Science excerpts from the Review of the Australian Curriculum – final report.

Excerpt from the Donnelly, K. and Wiltshire, K. (2014). *Review of the Australian Curriculum – Final Report*. Accessed on 29 January 2014 at http://www.studentsfirst.gov.au/review-australian-curriculum.

Science

A number of submissions express support for the manner in which the science curriculum was developed by ACARA and argue that the curriculum is challenging and robust. The Australian Science Teachers Association (ASTA), for example, states that the process was 'exhaustive' and 'inclusive and significant'. The Association also describes the curriculum as 'academically rigorous' and warns against changes at a time when 'teachers of science across Australia need more time to become familiar with the current national curriculum ...'.[375]

The Australian Academy of Science also expresses support in its submission:

> *The Academy strongly supports the Australian Science Curriculum. The process for its development was thorough and collaborative, allowing for critical input from all parts of the community including the science community.*[376][377]

The Academy's submission goes on to say that the 'basic structure of the science curriculum is sound', that the curriculum is 'intellectually rigorous' and that the 'presence of the general capabilities and cross-curriculum priorities in the science curriculum have not distracted from the scientific discipline orientation'.

When talking about the Foundation to Year 10 curriculum in general, including science, the submission from the Department of Education, Tasmania is also supportive when it states that Tasmanian teachers view the curriculum in a positive way, considering it 'challenging' and 'aspirational'.

Not surprisingly, given the often conflicting views about education and the fact that the Australian Curriculum seeks to accommodate a diverse range of beliefs about the intended curriculum, a number of submissions also express concerns.

ASTA, while expressing support for the general capabilities and cross-curriculum priorities notes, 'they should not distort the focus of the science concepts being taught'.[378] One of the subject matter specialists, Professor Igor Bray, is also concerned about the place of the cross-curriculum priorities when he writes, 'Science knows nothing about the nationality or ethnicity of its participants, and this is its great unifying strength'.[379] [380] Professor Bray goes on to argue:

> *Science can change society, but society cannot change Science. In this context it may be prudent to state explicitly that scientific statements are those that are able to be falsified by empirical evidence, and that scientific facts are not logical truths but those statements that have not yet been falsified despite repeated experiments. There is no room for cultural sensitivity.*

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[375] Australian Science Teachers Association, 2014, Submission to the Review of the Australian Curriculum
[376] Australian Academy of Science 2014, Submission to the Review of the Australian Curriculum, p. 2.
[377] In opposition to this, one submission criticises ACARA's consultation process for privileging the views of professional associations over practising teachers and for enforcing pre-determined objectives.
[378] Australian Science Teachers Association 2014, Submission to the Review of the Australian Curriculum.
[379] Bray, I 2014, 'Subject matter specialist report on the Australian Curriculum: Science (Foundation to Year 6 and Senior Secondary Physics)', prepared for the Review of the Australian Curriculum.
[380] Bray, while questioning the impact of the cross-curriculum priorities, does suggest that there is a place in science education for learning about the contributions to science of individuals from a range of cultures and including men and women.

The submission by APPA, while supporting the inclusion of the cross-curriculum priorities, notes that:

> *there are other examples in Science and Technologies where the writers have responded to the expectation that the priorities should be reflected across all learning areas, but without a sufficient basis for their inclusion in every case.*[381]

The analysis by teachers at the JMSS is somewhat more critical of the cross-curriculum priorities – with the exception of sustainability – when they conclude:

> *However the other two priorities, Aboriginal and Torres Strait Islander histories and culture and Asia and Australia's engagement with Asia, do not embed well into the science curriculum. The elaborations where these two cross-curriculum priorities are intended seem gratuitous and have tenuous link to the content.*

The report goes on to suggest that the two priorities 'would be better placed in human geography, studies of society and environment, history – in other words the humanities field'.

While not referred to in the report by either Professor Bray or the teachers at the science school, an example of a cross-curriculum priority that might be regarded suspiciously is one related to physics where the statement is made:

> *Through an investigation of contexts that draw on Aboriginal and Torres Strait Islander histories and cultures students can appreciate Aboriginal and Torres Strait Islander Peoples' understanding of physical phenomena, including of the motion of objects, and of astronomical phenomena.*

The science curriculum divides the subject into three interrelated strands: science understanding, science as a human endeavour and science inquiry skills. While this division is accepted by a number of submissions, not all are equally supportive. The JMSS report, while fully supporting the three strands, suggests that it is 'not necessary to devote equal time to each strand...'.[382]

Professor Bray also expresses concerns when he argues that the division into three strands 'has little value' and that he could not find evidence that other intended curriculum documents from overseas adopted the same approach.

Another concern relates to the amount of content in the curriculum. The Australian Academy of Science, under the heading 'Challenges', warns against attempts to cover too much territory when it suggests:

> *The natural response to this increased information [related to the exponential growth in scientific knowledge] is to add more content to the science curriculum. Research and experience globally show that this results in superficial learning by students.*[383]

In relation to the primary school curriculum, the APPA is even more strident when it argues:

[381] Australian Primary Principals Association 2014, Submission to the Review of the Australian Curriculum, p. 12.
[382] John Monash Science School (JMSS) 2014, 'Subject matter specialists report on the Australian Curriculum: Science (Years 7 to 10 and Senior Secondary Biology, Chemistry and Earth and Environmental Science)', prepared for the Review of the Australian Curriculum.
[383] Australian Academy of Science 2014, Submission to the Review of the Australian Curriculum, p. 2.

It is unrealistic to provide a mandatory outline of content that would demonstrably be impossible to deliver in many schools (especially those with a student population many of whom experience multiple factors of disadvantage) and probably impossible in any school.[384]

According to APPA the dangers of an overcrowded curriculum relate to teachers being forced to choose breadth instead of depth and the much needed focus on literacy and numeracy being undermined – especially during the early years. As a result, and under the heading of 'Pedagogy', the submission concludes that the Australian Curriculum fails to 'foster and facilitate good teaching'.

APPA argues that one solution to the problem of overcrowding, especially during the early years of primary school, is to narrow the focus of the curriculum. The APPA submission argues that 'Science should be very limited in scope in the first three years' and that even in the upper primary years, subjects like science should have a 'lower priority than English and Mathematics'.

Professor Bray, in his analysis of the science curriculum, argues in a similar fashion when he suggests that science should not be introduced until Year 3 on the basis that:

The F-6 curriculum is considerably overcrowded due to the inappropriate imposition of high-level disciplines to the lower (F-2) years. Instead, the formative years should be dominated by the core literacy, numeracy, social and physical development. The latter years are the appropriate time for engaging in greater breadth of learning, and also increasing the depth of learning undertaken in previous years.

Professor Bray also notes that Singapore and Finland, two of the top performing education systems as measured by the PISA tests, do not introduce science into the curriculum until Year 3 and Year 5 respectively.

While ACARA argues that intended curriculum documents are neutral in relation to pedagogy and it is up to classroom teachers to decide how to teach, as noted in Chapter One, the reality is that any curriculum document, intentionally or unintentionally, privileges a particular approach to teaching and learning.

One submission, mirroring the Queensland experience, argues that the Australian science curriculum can be characterised as adopting 'post-modern education philosophies of constructivism, inquiry learning, spiralled curricula and the embedding of themes and skills from social sciences'.[385]

The result, according to the author, will be future generations of Australians with an 'impoverished understanding of science and the tragedy of unrealised intellectual potential'.

A submission by Professor Peter Ridd mounts a similar critique when it argues:

The science curriculum's focus on inquiry-based learning, and the de-emphasis of knowledge would indicate that the curriculum shaping process has been heavily influenced by modern educational fads which are pushed on the community largely by university education faculties.[386]

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[384] Australian Primary Principals Association 2014, Submission to the Review of the Australian Curriculum, p. 5.
[385] Submission number RAC1400942 2014, Submission to the Review of the Australian Curriculum,
[386] Ridd, P 2014, Submission to the Review of the Australian Curriculum.

As part of this Review, subject matter specialists were asked to compare the Australian Curriculum against overseas intended curriculum documents. In relation to science the JMSS evaluation concludes, on analysing the curriculum documents from Finland and Singapore, 'Generally, it is considered that the courses on offer in both countries go to greater depth in the core sciences of physics, chemistry and biology'.

In relation to a number of science topics the evaluation also notes that they are introduced earlier in the Singapore and Finnish curriculums when compared to the Australian Curriculum. While the report argues that the Years 7 to 10 curriculum is 'generally robust, balanced and flexible' it does identify a number of areas that need strengthening.

In relation to Years 11 and 12 the review suggests that the senior chemistry units are a 'somewhat indecisive set of units that does not have the rigour or depth of either the traditional or modern type of chemistry courses'. The review is more positive when it describes the earth and environmental science course as 'a holistic, exciting course showcasing science as a modern, interdisciplinary study'.

The senior biology course, on the whole, is described as a 'comprehensive and rigorous course' with the exception of concerns about the impact of the general capabilities and the cross-curriculum priorities. The review notes that a number of the capabilities and priorities are poorly detailed and 'do not directly relate to the Senior Biology course and should not be included in the course description' unless clear links are provided.

The Singapore senior biology course, while very similar to the Australian course, is considered stronger as the content descriptors are more detailed. The review notes, 'The benefits are that teachers, students and parents are fully aware of what is expected for any particular topic'.

In addition to what is referred to here it should be noted that the teachers from the JMSS in their evaluation provide a series of comprehensive and detailed suggestions to strengthen and improve the Australian Curriculum: Science.

Professor Bray, when comparing the Australian senior physics course against those from Singapore and Finland makes a number of observations. Compared to the Australian Curriculum, Professor Bray argues that the curriculum in Singapore, notwithstanding that it is more prescriptive, is superior on the basis that:

> *It does not hide that Senior Physics is a high stakes course, and so the Syllabus begins with a clear presentation of assessment issues. The content is given with great clarity and clear development in fifteen pages. The sectional subdivisions are readily recognizable to any teacher or student of Physics. There are no artificial overarching themes. The mathematics listed is appropriate and consistent. A number of internationally renowned textbooks are listed as supporting material.*

Professor Bray describes the Singapore curriculum as robust and rigorous and suggests that any student successfully completing the course would be well prepared for any university in the world.

While many submissions to the Review support the achievement standards, as previously noted when discussing mathematics, some submissions argue that a more robust and rigorous from of assessment is required. Professor Bray, when discussing the achievement standards related to senior school physics argues that they 'remain unhelpful and should be discarded'. Professor Bray goes on to argue:

> *Achievement standards may be listed in the form of what is the goal for every student to attain, but they cannot be practically subdivided into any discrete levels of partial achievement. The reality is that students achieve these goals to varying and unpredictable degrees. So a mark of 100% means all has been achieved, and any lower percentage a partial degree of achievement. This is good enough for all practical purposes.*

Another of Professor Bray's concerns relates to notation, where he argues that those responsible for writing the senior school physics course and certain textbooks are guilty of a significant mistake.

> *I find it disappointing that some present-day school physics textbooks, and the proposed Australian National Curriculum, write v=u+at as one of the equations of motion (for constant acceleration a). Any textbook using such notation should be excluded from any consideration. The correct form for this equation is v(t)=v(t0)+a(t-t0), which is readily derived from a=dv/dt once elementary integration has been learned in mathematics. By the end of Year 12 every physics student should understand such a derivation as it underpins the critically important relationship between mathematics and physics. There is no room in physics for sloppy mathematical notation. The example given is just one of several such failings.*

Conclusion

Many of the submissions describe the Australian Curriculum: Science as well-structured, challenging and robust. The observation is also made that ACARA consulted widely and adopted a collaborative approach to curriculum development.

A number of other submissions and evaluations undertaken by the subject matter specialists, on the other hand, note a number of shortcomings and concerns. The relevance and educational value of the cross-curriculum priorities are questioned, as is the weight given to the subdivision 'Science as a human endeavour'.

As with the Australian Curriculum overall, specific mention is also made of the danger of mandating too much content and, as a result, sacrificing depth for breadth. In relation to the way the science curriculum is structured, Professor Bray notes that in Singapore and Finland – two of the most successful education systems as measured by international mathematics and science tests – science is not taught until Years 3 and 5 respectively. When science is introduced, though, these overseas systems have a more focused and detailed treatment of essential knowledge, understanding and skills.

On comparing the Australian Curriculum against the senior school science curriculums developed in Singapore and Finland, the evaluations carried out by the subject matter specialists lead to mixed results. While Professor Bray and the science teachers from JMSS conclude that the Singapore physics and biology courses are stronger than the Australian, the Australian earth and environmental science course is commended as adopting a holistic, modern and interdisciplinary approach.

In relation to the achievements standards, Professor Bray argues that they represent a coarse method of assessment and he recommends a more finely-graded marking system. In relation to the science curriculum's underlying approach to teaching and learning, another submission also makes the point that the curriculum privileges a constructivist approach by failing to acknowledge the importance of explicit teaching.

Recommendations

- That ACARA, in the process of reviewing the Australian Curriculum: Science, takes note of the concerns outlined above – especially the need to focus on depth by reducing the content and coverage of the science curriculum for Foundation to Year 10.
- The cross-curriculum priorities should be removed from the science curriculum and not all the interrelated strands should be given equal prominence and weight across the various stages of schooling.
- A better balance should be sought between a constructivist and an explicit teaching pedagogical approach to classroom practice.