LEARNING FIRST

Fixing the hole in Australian education

The Australian Curriculum benchmarked against the best

Short report

A note from the author

As CEO of Learning First, and in my previous roles at the Grattan Institute and the OECD, I have written many reports advocating for reforms in Australian school education. But I have never produced a report that expressed so much alarm about a fundamental aspect of our education system. I have never conducted analysis that showed such severe problems as those presented here. I take no joy in presenting these findings, but I am certain that the only way we can improve Australian education is to be honest about them. Problems not faced are problems not fixed.

This report sets out the results of detailed analysis and benchmarking of the Australian science curriculum with curriculums in comparable and high-performing systems around the world. The results show the lack of breadth and depth of the Australian science curriculum, the flaws in its sequencing of content, and the lack of clarity about what to teach and assess.

The benchmarking took over a year to complete, but in truth the report is the culmination of years of work. Many years ago, Learning First focused on school improvement, teacher and leader development and professional learning. As we worked with numerous Australian systems and published reports, we saw time and again that good policies and programs, and tireless work from educators, were not having the impact they should have.

The more we investigated the causes of these problems, the more we realised that a defining problem was curriculum: both the Australian Curriculum itself, and how it could be interpreted and effectively enacted in schools and classrooms. Many teachers, school and system leaders also expressed to us their deep concerns about the Australian Curriculum, yet significant curriculum reform is not part of Australia's policy debate. We are on a mission to change that.

About seven years ago we started publishing reports on the importance of curriculum, and to propose reforms to strengthen the Australian Curriculum in order to improve student performance and make our schools fairer and more equal. We have published reports with Johns Hopkins Institute for Education Policy in the United States, and we have written numerous opinion pieces on the need for change (read our work at www.learningfirst.com).

Throughout this work, what hit home was how different the Australian Curriculum is from quality curriculums in other systems, especially those that perform highly (or are improving) in international assessments. Whenever we show Australian teachers high-quality curriculums from other systems, they invariably have the same response: this content is so much clearer and would be so much easier to teach than the Australian Curriculum.

But how could we prove this point to a larger audience? Last year we decided to start benchmarking the content of the Australian science curriculum. Through the example of science, we wanted to show how the Australian Curriculum differs from the curriculums of leading systems around the world and how much improvement is needed. The results of this benchmarking are stark. Before undertaking it I knew there were problems with the Australian Curriculum but my colleagues and I have been shocked by the size of the holes in the Australian science curriculum revealed in this report.

I hope the report provides a way forward for Australian school systems and schools. I am convinced that we cannot significantly improve their learning outcomes or reduce the increasing inequality within Australian education without a fundamental overhaul of the Australian Curriculum.

Dr Ben Jensen, CEO Learning First

Fixing the hole in Australian education

The Australian Curriculum benchmarked against the best

By Ben Jensen, Mailie Ross, Michael Collett,
Nicole Murnane and Emily Pearson

November 2023

Jacqueline Magee, James Button and Hai-Chau Le and the team of science leaders and teachers that undertook and verified the benchmarking all made significant contributions to this report.

Learning First is an education research and consulting group that works closely with schools and systems in various countries to improve educational equity and student learning. We draw lessons from leading research and the practical experience of high-performing systems around the world. Over the years, we have worked with federal, provincial and district leaders in numerous countries, and with every state and territory government in Australia. We have published numerous research reports and conducted research and advisory work for global organisations such as the OECD, the Bill and Melinda Gates Foundation and the National Centre on Education and the Economy in the United States.

Overview

Every year brings new evidence of decline in Australian school education: sliding performance and increasing inequality on international and national assessments.[1] More than a decade of school improvement and teacher development programs, literacy and numeracy strategies and other initiatives has failed to reverse the fall in results.

These deeply disturbing trends have many causes, but this report argues that a fundamental cause of Australia's education decline is the Australian Curriculum.

Learning First has conducted the first detailed benchmarking of the content of the Australian science curriculum against seven high-performing and comparable systems around the world. This benchmarking shows that compared with the curriculums of these systems, the Australian science curriculum sets a low standard for what students should learn. It lacks the content, depth and breadth to enable them to succeed.

Our benchmarking shows that the Australian science curriculum in the first nine years of schooling:

- Contains about half the science content of the average of other curriculums
- Lacks breadth of learning: it covers 44 science topics compared to an average of 74 topics in other systems
- Lacks depth of learning: just five science topics are covered in depth compared to an average of 22 topics covered in depth in other systems

The Australian science curriculum also contains poor sequencing and lack of specificity of content, which the research shows is vital for effective teaching and learning.

Curriculum experts often describe breadth and depth of content in a curriculum as trade-offs; should more time be spent going deeper into certain topics or should more topics be covered but in less depth?[2] Sadly, the Australian science curriculum lacks both breadth and depth. It covers fewer topics and goes into depth in these topics far less often than other benchmarked curriculums. A narrow and shallow curriculum has damaging consequences for both learning and equity.

Since the Australian Curriculum was released in 2010, the performance of students in international OECD PISA science assessments has fallen by almost a whole year of schooling.[3] Assigning blame directly to the curriculum is not possible, but the question must be asked: what would people expect to be the impact on student learning and equity if one school system was provided with a curriculum that contained half the content of others?

Instead of recognising these problems, whenever poor results are published, teachers are often explicitly or implicitly blamed. But in the light of our curriculum problem, Australian teachers have done an extraordinary job to not let the standards of students fall further than they have.

There is no reason Australia cannot have a world-class curriculum, as other systems do. The key is a new system of curriculum development, built on the latest research on quality curriculum. The curriculum's content, sequencing and breadth and depth of topics all need to be comprehensively benchmarked. We need to respond to data on how the curriculum is taught across schools and classrooms (what is working

[1] See for example: Australian Government, 2023; OECD, 2019
[2] See, for example: Black 1995; William H Schmidt et al. 1997
[3] Organisation for Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) 2018 Country Note: Australia.

and not working), and we need a new, explicit focus on inequality that ensures *every* Australian student has the right to learn a world-class curriculum.

This report focuses on the Australian science curriculum. We have not yet benchmarked other subjects in the Australian Curriculum. If all other parts of the Australian Curriculum have been developed with comprehensive benchmarking, quality research, and analysis of what is taught and assessed in schools then we call on the Australian Curriculum, Assessment and Reporting Authority (ACARA) to release this information. If it does not exist, we recommend an overhaul of the entire Australian Curriculum.

A way forward: recommendations for change

With the right processes in place, a quality world-class curriculum can be achieved for Australian students. The following steps set out a tangible pathway. Curriculum leaders should:

1. Commit to an overhaul of the Australian Curriculum. A few minor amendments will not fix the problems with the lack of content and breadth and depth of topics covered, and with poor sequencing. A complete rewriting is essential.
2. Lead curriculum reform and public debate with a focus on the detail of what is taught and assessed in classrooms. The high-level slogans and sound bites of Australian Curriculum debate pull the curriculum further from the realities of what happens in classrooms, and make it harder to teach effectively
3. Adopt a new development *process* that ensures a world-class Australian Curriculum. All future versions should be built on:
   a. A comprehensive research program on quality curriculum and what is required to improve learning of ***all*** students
   b. Comprehensive benchmarking of detailed curriculum content, including breadth and depth of topics, to ensure the curriculum is world-class
   c. Detailed curriculum mapping to ensure effective sequencing of curriculum content
   d. Detailed comparative analysis of curriculum structure, presentation and writing of the curriculum to ensure it is clearer and easier to teach
   e. Data and analysis of how the curriculum is being implemented in schools and classrooms and how much work school leaders and teachers have to do to implement it.
4. Establish a clear and public curriculum entitlement that guarantees all Australian students the right to learn curriculum content that is as strong as the curriculum entitlement provided to students in other systems.

Curriculum reform always causes disruption and additional work in schools. This is a difficult time in Australian schools with teacher shortages and heavy workload pressures. Our call to overhaul the curriculum is therefore not taken lightly. Disruption to schools must be minimised. The roll-out of the latest version of the Australian Curriculum, already underway in some states and territories, may have to be halted until the work is done to create a truly world-class curriculum. On balance, it is better to bite the bullet and spend the next few years developing a truly world-class curriculum before imposing the cost and time of its implementation on schools.

The proposal set out in this report is neither far-fetched nor unachievable. But because the development of the Australian Curriculum has fallen so far behind best practice, significant reforms are required. Only with these changes can we establish what educators call the curriculum entitlement provided to all students, a commitment to young people that is a foundation of high performance and equity in leading education systems around the world.

Introduction: the holes in the Australian science curriculum

This report sets out the results of Learning First's detailed benchmarking of the content of the Australian science curriculum against seven comparable systems, including those that have consistently performed at high levels in the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA). These seven systems are the Canadian provinces of Alberta and Quebec, England, Hong Kong, Japan, Singapore, and the United States.[4]

Our benchmarking shows that the Australian science curriculum in the first nine years of schooling:

- Contains about half the science content of the average of other curriculums
- Lacks breadth of learning: it covers 44 science topics compared to an average of 74 topics in other systems
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The research is clear that the quality of the curriculum taught in classrooms has a significant impact on learning. Moreover, quality curriculum has a large impact on equity; improvements in the quality of the curriculum taught to disadvantaged students has been shown to be one of the best ways to close the achievement gap between advantaged and disadvantaged students.[5] The Australian Curriculum clearly has an impact on what is taught in classrooms. Some classes will cover more than what's documented in the curriculum, some will cover less. But a national curriculum sets the benchmark, the expectations for learning. The content in the curriculum is the curriculum guarantee provided to all students.[6]

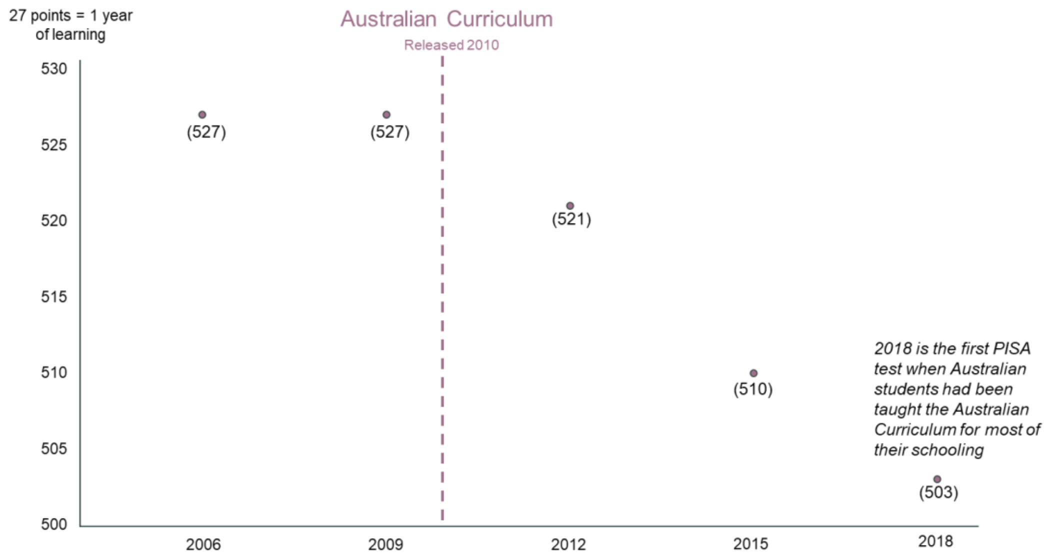
Figure 1 presents the science scores of Australian students in the OECD's PISA, taken by students around the world every three years. As the figure shows, the performance of Australian 15-year-olds were high and steady in 2006 and 2009. But since the release of the Australian Curriculum in 2010, the performance of students has steadily declined.

By 2018, Australian average science scores had fallen by 24 points, equivalent to nearly one full year of schooling. In other words, Australian students who were 15-years old in 2018 – who have spent most of their schooling studying the Australian Curriculum – perform at a level nearly a year below the level of their peers studying in 2009 before that curriculum was introduced. During this period, a growing number of countries around the world have leapfrogged Australian students in performance on PISA tests.

While this decline cannot be blamed directly on the Australian Curriculum – the complexity of education systems makes it impossible to apply causality to a single initiative – it is vital to consider the impact of giving one school system a curriculum with half the content of other systems. A curriculum that did not include important topics, or included them at only a low level of content. What changes in learning outcomes and in equity would we expect over the subsequent decade?

[4] OECD, 2012, 2016, 2019.
[5] Grissmer, et al., 2023; Peng et al., 2023
[6] Curriculum research highlights the impact of high and low quality curriculum resources in schools (see for example, Borman et al., 2008; Boser et al., 2015; Grissmer, et al, 2023; Partelow & Shapiro, 2018; Peng, 2014; Whitehurst, 2009; Zucker et al., 2008) and the impact on learning and equity at the system-level following different curriculum reforms (Common Core, 2009; Crato, 2019, 2020; Hirsch, 2016; Steiner et al., 2018). Both are obviously related and should not be viewed in isolation when considering system improvement. But it is important to note the differences in the literature.

Figure 1: PISA science scores before and after the Australian Curriculum



Source: OECD: Programme for International Student Assessment (PISA) 2018 Country Note: Australia

A quality curriculum is rigorous, setting high expectations for student learning. It is clear and specific about what students are to learn: the domains, topics and specific content within each topic that needs to be taught at each year level.[7] It is cumulative, with content sequenced across year levels, so that student learning effectively builds on prior learning.[8] It must prepare students for ongoing education within and beyond school. Finally, a quality curriculum should be well rounded, providing breadth and depth of learning experiences across all areas of the curriculum.[9] Our benchmarking results show the Australian Curriculum fails in many of these areas.

What is the Australian Curriculum?

A curriculum is the foundation of an education system, providing the minimum guaranteed learning entitlement for all students. To quote the Australian Curriculum, Assessment and Reporting Authority (ACARA), the body responsible for developing the Australian Curriculum:

'The Australian Curriculum describes to teachers, parents, students and others in the wider community what is to be taught and the quality of learning expected of young people as they progress through school.'

Around the world, the essential components of standards and content in curriculums are presented in different ways. The Australian Curriculum includes:

1. Achievement standards for each learning area or subject, which describe the learning expected of students at each year level or band of years.
2. Content descriptions, which describe what is to be taught and what students are expected to learn.

[7] Berner, 2018; Common Core, 2009; Hirsch, 2016; Houchens, 2017; Magee & Jensen, 2018a, 2018b; Steiner et al., 2018, 2019
[8] Large significant impacts have been found when rigorous quality curriculum is used in multiple years in students' education creating a large cumulative impact: Hirschhorn, 1993; What Works Clearinghouse, 2016; Willingham, 2019
[9] Steiner et al., 2018

3. Optional content elaborations, which give teachers ideas about how they might teach the content.[10]

Why benchmark the science curriculum?

Science was chosen as a subject that lends itself to this form of benchmarking; chemistry is more consistently taught across the world than Australian history, for example. Moreover, science content can be identified and categorised in a manner that enables benchmarking that would be difficult in, for example, English.

In addition, it is widely considered that Australia has critical shortages in the science and technology workforce; areas that are critical for modern economies and societies. In 2022 the Australian Government announced a commitment to widen the pipeline of talent available to the science and technology sectors and address 'a decade long science and tech skills shortage.'[11] Last year, Engineers Australia called on the Australian government to invest in an engineering pipeline strategy to address 'plummeting rates of secondary students taking up STEM (science, technology, engineering, maths) subjects [that] is setting the nation up to fail as it transitions to a smart jobs economy.'[12]

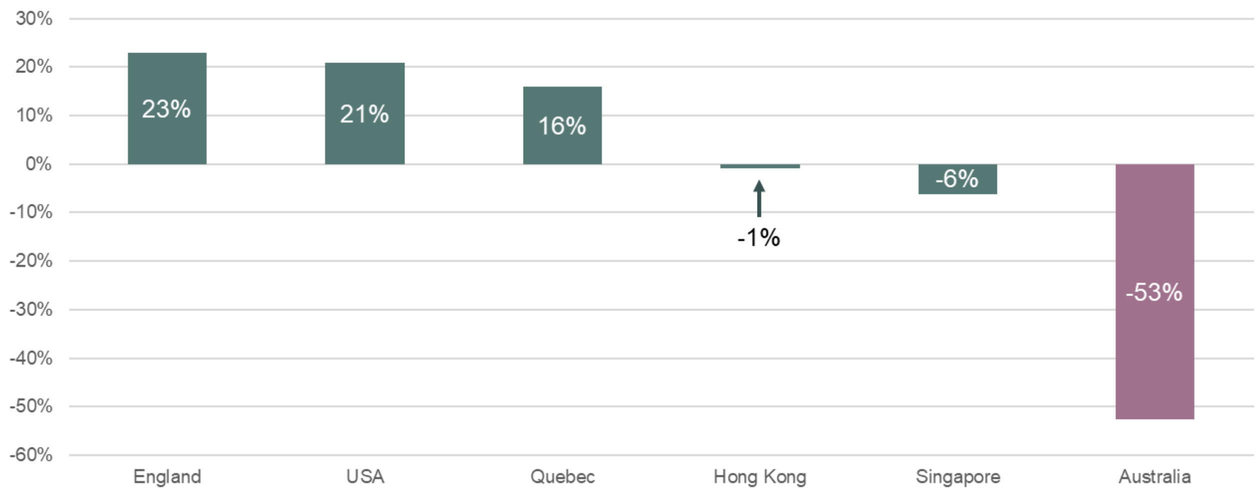
Results of benchmarking the Australian science curriculum

Findings from our benchmarking of the Australian science curriculum against seven comparable and high-performing overseas systems include:

1. *Over the first nine years of schooling, the Australian science curriculum has about half the content of the average of other systems benchmarked.*

By the time students in Australia finish Year 8, the Australian Curriculum determines that they will have covered around half as much content as the average of every other system benchmarked. Figure 2 shows that Australia is an outlier compared with other systems in terms of the amount of content in the curriculum.

Figure 2: Percentage of content included in systems' curriculum compared with the average, from Foundation to Year 8



Note: Amount of content is defined as number of mandatory items of content. Content that is optional is not included in this data. This figure compares cumulative coverage but does not compare the same number of years of instruction. Australia and the United States commence science in the Foundation year. In England, Quebec and Hong Kong, science starts in Year 1. In Singapore, science starts in Year 3. England presents Years 7-9 content as a single stage, so this figure includes England's content up to Year 9; however, English students in

[10] Australian Curriculum also includes general capabilities and cross-curriculum priorities. For more information, see https://www.australiancurriculum.edu.au/f-10-curriculum/structure/

[11] See the Minister for Industry and Science 'Paving a pathway for a diverse science and tech workforce', 6 September 2022. Accessed at: https://www.minister.industry.gov.au/ministers/husic/media-releases/paving-pathway-diverse-science-and-tech-workforce.

[12] Engineers Australia, 2022. Accessed at: https://www.engineersaustralia.org.au/news-and-media/2022/07/media-release-new-report-shows-alarming-stem-skill-shortage-threatens-new.

Year 9 are the age-equivalent of Australian students in Year 8. See methodology for more detail. Alberta and Japan are not included as the benchmarking could only include their primary school curriculums.

There are some differences among the benchmarked systems by science teaching domain. In biological sciences, for example, there is nearly 70 per cent less content in the Australian Curriculum over the first nine years of schooling (F-8) than in the average content of all systems. Australia performs relatively better in chemical sciences, but there is still just under a third less content than there is in the average of other systems. In Earth and space sciences there is 43 per cent less content, and in physical sciences 56 per cent less content, than there is in the average of other systems.

If we analyse different years of schooling, the benchmarking shows that the Australian science curriculum contains:

- 45 per cent less content that the average of the primary school science curriculums of Alberta, Quebec, the United States, Japan, Singapore, England and Hong Kong
- 59 per cent less content between Years 7-10 than the average of the secondary school science curriculums of Hong Kong and England (Years 7-9) and of Quebec (Years 7-10)
- 20 per cent less science content in four years of secondary school than the Singapore science curriculum has in just Years 7-8
- 70 per cent less content than the Quebec science curriculum in Years 7-10.

Along with a lack of content, the Australian Curriculum also introduces some topics later than in other curriculums. For example:

- Evolution is taught in Year 10 compared with Years 5-6 in Quebec and Year 6 in England
- Acids and bases is taught as optional content in Year 10 compared with Year 6 in Japan, Year 8 in Hong Kong and Years 7-8 in Quebec and Singapore.

The examples above highlight areas where the Australian science curriculum lowers standards in schools. Some might assume that the Australian Curriculum presents these topics later because it goes deeper into the content. But that is not correct. For example, the Australian Curriculum introduces evolution only in Year 10, when it states: '*use the Theory of Evolution by natural selection to explain past and present diversity and analyse the scientific evidence supporting the theory*'.

By contrast, England's science curriculum introduces the topic of evolution at Year 6 and states that students should be able to:

- Recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago.
- Recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents.
- Identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution.

England's curriculum then builds on the content for evolution in Years 7-9.

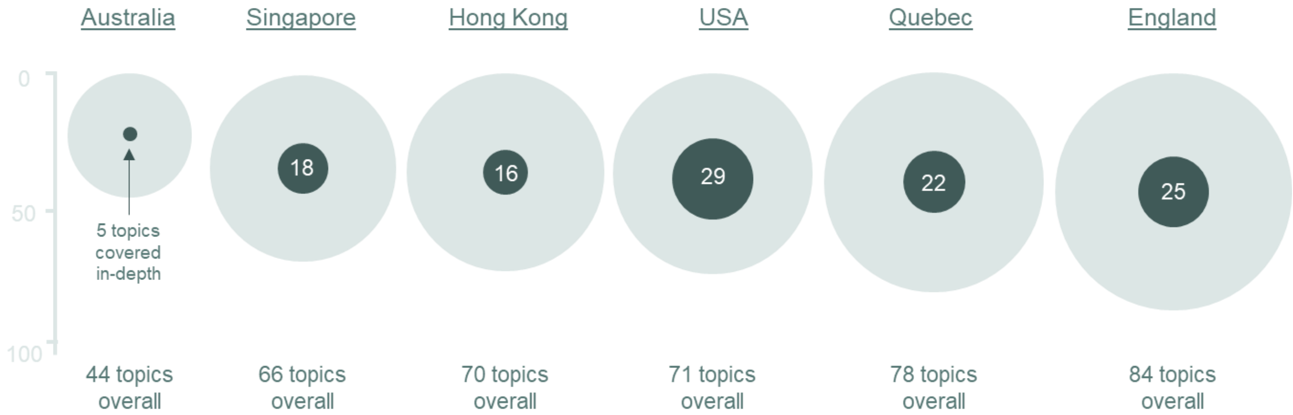
2. *The Australian science curriculum lacks breadth and depth*

The breadth and depth of a curriculum is vital for student learning. Students need a breadth of learning to understand a range of important topics and make connections between them. They also need to learn important topics in depth to extend their understanding.

Curriculum experts often discuss breadth and depth of content in a curriculum as trade-offs; should more time be spent going deeper into certain topics or should more topics be covered but in less depth?[13] Unfortunately the Australian science curriculum lacks both breadth and depth. It covers fewer topics and goes into depth in these topics far less often than do other benchmarked curriculums. The Australian science curriculum is narrow and shallow, with damaging consequences for both learning and equity.

Figure 3 presents the number of topics covered in the first nine years of each benchmarked science curriculum, and the number of these topics covered in depth. In the first nine years of schooling, the Australian Curriculum covers only 44 science topics compared with an average of 74 in the other benchmarked systems.

Figure 3: Total number of topics and the number of topics covered in depth from Foundation to Year 8



Note: Topics are those in mandatory content from Foundation to Year 8. Content that is optional is not included in this data. Topic depth is based on a quartile analysis of the number of individual items of content in each topic. A topic was classified as being 'in depth' for a system if the number of content items within that topic was in the upper quartile. This figure compares cumulative coverage but does not compare the same number of years of instruction. Australia and the United States commence science in the Foundation Year. In England, Quebec and Hong Kong, science starts in Year 1. In Singapore, science starts in Year 3. England presents Years 7-9 content as a single stage, so this figure includes England's content up to Year 9. Alberta and Japan are not included in the above graph as only their primary school curriculum was included in the benchmarking.

Moreover, the Australian Curriculum provides students with the opportunity to learn only five topics in depth compared to, on average, 22 topics covered in depth in other systems.

Science topics covered in depth in at least three of the benchmarked systems that are not covered in depth in the mandatory content of the F-8 Australian Curriculum are:

- Cells and organelles
- Contact and non-contact forces
- Electrical circuits
- Energy and food webs in ecosystems
- Energy conservation and transformation
- Gravity
- Heat energy
- Magnets and magnetism
- Mass, volume and density
- Materials
- Material properties

[13] Black, 1995; Schmidt & Mcknight, Curtis & Raizen, Senta & Jakwerth, Pamela & Valverde, Gilbert & Wolfe, Richard & Britton, Edward & Bianchi, Leonard & Houang, Richard, 2002; William, n.d.

- Plant reproduction
- Reproductive system (animals)
- Spheres of the Earth
- Stars and the universe
- States of matter

To give an example, the topic of magnets and magnetism is covered in depth in the curriculums of Alberta, England, and Singapore but not in the Australian Curriculum. Table 1 provides an illustration of what these differences look like. The long version of this report provides numerous other examples of where important topics are lacking in the Australian science curriculum.

Table 1: Content in the topic magnets and magnetism

Australia	**Year 4** • Identify how forces can be exerted by one object on another and investigate the effect of frictional, gravitational and magnetic forces on the motion of objects.
Alberta	**Year 4** • Magnetic force is a non-contact force that attracts or repels magnetic materials. • Magnetic materials contain iron, cobalt, or nickel. • Magnetic force is strongest at the magnetic poles. • Magnets have two magnetic poles, known as north and south. • Opposite magnetic poles attract each other and like magnetic poles repel each other. • Both magnetic poles attract magnetic material. • Some materials can become magnetised by interacting with a magnet.
England	**Year 3** • Notice that some forces need contact between two objects, but magnetic forces can act at a distance. • Observe how magnets attract or repel each other and attract some materials and not others. • Compare and group together a variety of everyday materials on the basis of whether they are attracted to a magnet, and identify some magnetic materials. • Describe magnets as having two poles. • Predict whether two magnets will attract or repel each other, depending on which poles are facing. **Years 7-9** Magnetism • Magnetic poles, attraction and repulsion. • Magnetic fields by plotting with compass, representation by field lines. • Earth's magnetism, compass and navigation. • The magnetic effect of a current, electromagnets, D.C. motors (principles only). Forces • Non-contact forces: gravity forces acting at a distance on Earth and in space, forces between magnets and forces due to static electricity.
Singapore	**Years 3-4** • Recognise that a magnet can exert a push or a pull. • Identify the characteristics of magnets: - magnets can be made of iron or steel

	- magnets have two poles. A freely suspended bar magnet comes to rest pointing in a North-South direction - unlike poles attract and like poles repel - magnets attract magnetic materials - *Note: Recall of other magnetic materials such as nickel and cobalt is not required.* • List some uses of magnets in everyday objects. **Years 7-8** • Show an understanding that a force can be a contact force (e.g., friction) or non-contact force, (e.g., magnetic force, gravitational force)

3. *Poor sequencing and lack of specificity in the Australian science curriculum*

High-quality curriculum enables students to learn and master content in a clear sequence that reflects the research on how students remember new information, building on what they have previously learnt.[14] All educators know sequencing is vital: students need to learn and understand simple concepts, such as the force of gravity, before they try and learn complex concepts such as how gravity causes planets to orbit the sun. Research on effective sequencing of content focus on how it enables students to make better connections between related pieces of information, to more effectively build their understanding of topics over time.[15]

The Australian science curriculum includes cases of poor and even non-existent sequencing, compared with clear sequencing in the curriculums of other systems. Figure 4 compares the sequencing of content about animal body systems (an important and complex part of biological sciences taught in all curriculums) in the science curriculums of England and Australia.

The figure shows how the science curriculum in England carefully details the sequencing of content required for effective teaching and learning. The content starts with the fundamentals in the early years of primary school, where students are taught how to identify which parts of the body are associated with each sense, and the basic function of muscles and the skeleton. The curriculum then introduces the digestive and circulatory system in Years 4-6. All this material provides a foundation for content taught in Years 7-9 that goes into more depth about body systems with detailed information on the digestive, respiratory, reproductive, skeletal and muscular systems.

The Australian Curriculum, by contrast, sequences none of this content. In fact, there is no content on body systems in science until Year 8.

[14] Black, 1995
[15] While outside the scope of this paper, this draws on a number of areas of research including cognitive load research that highlights the importance of effectively sequencing new content. See for example: Australian Education Research Organisation, 2023; Cowan, 2008; Willingham, 2007

Figure 4: Sequence of animal body systems content in the science curriculums of England and Australia

England		Australia
• Identify, name, draw and label the basic parts of the human body and say which part of the body is associated with each sense	**Year 1**	
	Year 2	
• Identify that humans and some other animals have skeletons and muscles for support, protection, and movement	**Year 3**	
• Describe the simple functions of the basic parts of the digestive system in humans • Identify the different types of teeth in humans and their simple functions	**Year 4**	
	Year 5	
• Identify and name the main parts of the human circulatory system, and describe the functions of the heart, blood vessels and blood • Describe the ways in which nutrients and water are transported within animals, including humans	**Year 6**	
• The hierarchical organisation of multicellular organisms: from cells to tissues to organs to systems to organisms • The structure and functions of the human skeleton, to include support, protection, movement and making blood cells • Biomechanics – the interaction between skeleton and muscles, including the measurement of force exerted by different muscles • The function of muscles and examples of antagonistic muscles • The tissues and organs of the human digestive system, including adaptations to function and how the digestive system digests food (enzymes simply as biological catalysts) • The importance of bacteria in the human digestive system • The structure and functions of the gas exchange system in humans, including adaptations to function • The mechanism of breathing to move air in and out of the lungs, using a pressure model to explain the movement of gases, including simple measurements of lung volume • Reproduction in humans (as an example of a mammal), including the structure and function of the male and female reproductive systems, menstrual cycle (without details of hormones), gametes, fertilisation, gestation, and birth, to include the effect of maternal lifestyle on the foetus through the placenta	**Year 7**	
	Year 8	• Analyse the relationship between structure and function of cells, tissues and organs in a plant and an animal organ system and explain how these systems enable survival of the individual
	Year 9	• Compare the role of body systems in regulating and coordinating the body's response to a stimulus, and describe the operation of a negative feedback mechanism • Describe the form and function of reproductive cells and organs in animals and plants, and analyse how the processes of sexual and asexual reproduction enable survival of the species

Note: While Foundation has not been included in the above figure, this year level does not include science content directly related to animal body systems. In health and physical education, there is a Foundation content description that refers to naming the body parts but it is in the context of making healthy and safe choices.

The above example highlights the difficulties of teaching the Australian Curriculum. Teachers in England can rely on a curriculum with clear and explicit sequencing of animal body systems content across their years of schooling. Students encounter new and increasingly complex content in a sequence that builds on prior learning. The Australian science curriculum, on the other hand, leaves teachers trying to teach complex content about animal body systems to students who have not had the benefit of sequenced content in previous years.

As well as poor sequencing, the lack of specificity of the science content in the Australian Curriculum makes it even harder for teachers to know what to teach and at what breadth and depth. As a result, Australian teachers are regularly required to make judgement calls on content, such as which body systems to cover when teaching Year 8 biological sciences. Without clear direction on what to teach, there is no way to guarantee that all students build shared knowledge and skills that prepares them equally for their senior years of schooling and beyond.

This highlights what is seemingly counter-intuitive: that adding more content to the Australian Curriculum would make it easier to teach. Simply adding more content on top of poorly sequenced material would create huge problems for Australian teachers. Instead, a larger amount of carefully sequenced content, along with precision about what and what not to teach, can make teaching easier. It is impossible, for example, to look at the above example and not wonder how Australian teachers in Year 8 can possibly teach body systems content that the curriculum in England has spread across many years of primary and lower secondary school.

It is true that many Australian teachers add content, and provide learning tasks and activities, that enrich their students' learning experiences. But when a curriculum has as many holes in it as does the Australian Curriculum, a ceiling is inevitably placed on student learning. Individual teachers cannot decide to teach the digestive system in Year 4 (when it is taught in England) a full four years before the Australian Curriculum determines that students should be learning about animal body systems.

A broken curriculum development process

The process through which the Australian Curriculum is developed is broken. The Australian science curriculum is not based on:

- Leading research highlighting the importance to equity and student learning of a content-rich curriculum, research that has clearly been a focus of the high-performing and comparable systems benchmarked in this report.[16]
- Comprehensive quality benchmarking of curriculum content against high-performing and comparable systems overseas. The Australian science curriculum would never have been permitted to have just half the content, on average, of comparable systems over the first nine years of schooling if such benchmarking had been undertaken during development of the curriculum.
- Curriculum mapping that analyses sequencing of content; there would not be the sequencing problems in the Australian science curriculum if quality curriculum mapping had been completed.

The process of curriculum development in Australia is too focused on collating and analysing stakeholder feedback. Stakeholders need to speak and be heard but their feedback should be one component of curriculum development and review.

The Australian Curriculum review and development process is also too influenced by a general education debate that is full of high-level discussion and broad objectives but very light on the detail of the curriculum. Yet it is the detail that is taught and assessed in schools and classrooms; the detail that students learn. The detail of the curriculum is what matters.

[16] For example, the creators of the Next Generation Science Standards (NGSS), the United States science curriculum benchmarked in this report, was benchmarked 'against countries whose students perform well in science and engineering fields, including Finland, South Korea, China, Canada, England, Hungary, Ireland, Japan, and Singapore'. See Next Generation Science Standards n.d.

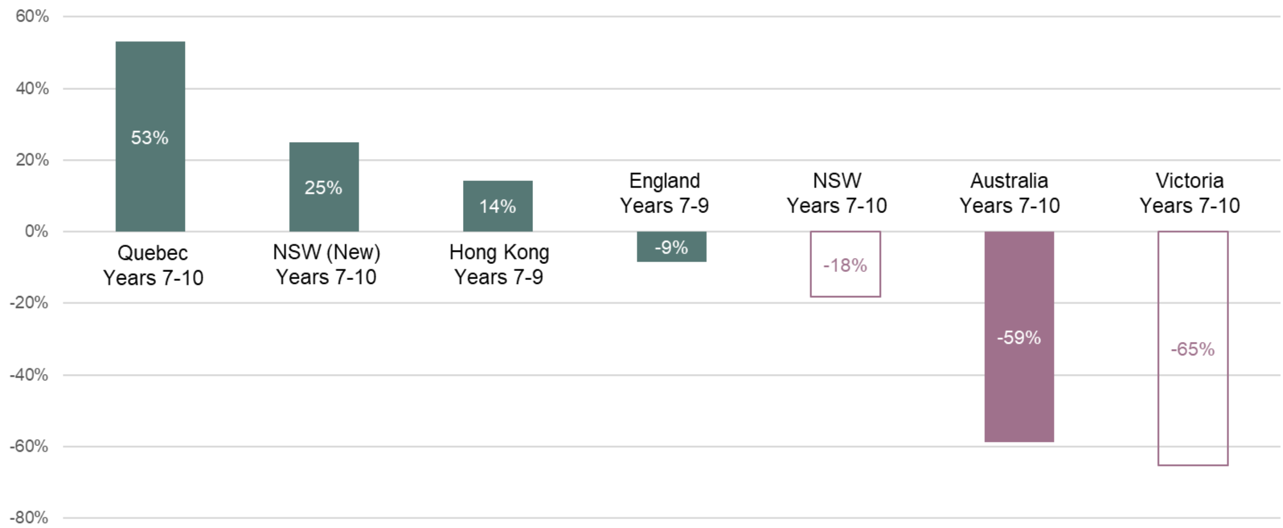
Hope for the future: recent curriculum reform in New South Wales

While a complete overhaul of the Australian Curriculum seems like an impossible task, hope lies in the example set by the development of the new NSW curriculum. Australian states and territories are required to implement the Australian Curriculum. New South Wales and Victoria each have their own curriculum (called syllabus in New South Wales) that is adapted from the Australian Curriculum. New South Wales has released a draft of its new science curriculum for Years 7-10. Victoria, whose existing curriculum is based on Version 8.4 of the Australian Curriculum, plans to release its new science curriculum in 2024.[17]

Learning First also benchmarked the existing and new versions of the NSW science curriculum (Years 7-10) and the existing version of the Victorian curriculum (Years 7-10) against some other systems examined in this report. Figure 5 presents the percentage of content included in these systems' Years 7-10 science curriculums. Victoria has slightly less content than the Australian Curriculum. But the big story is the increase in the amount of science content in the NSW curriculum.

The new NSW science curriculum has just over 50 per cent more content than the old one. It has less science content than Quebec but more than Hong Kong and England. However, England and Hong Kong have only been benchmarked for Years 7-9. A simple calculation of amount of content per year means that the NSW secondary school science curriculum has about the same amount of content per year as the secondary school science curriculum in England, and a bit less content per year as that in Hong Kong. All the research indicates that these changes will have a significant positive impact on student learning and equity in New South Wales school education.

Figure 5: Percentage of content included in systems' curriculums compared to the average, from Year 7-10



The process undertaken in New South Wales was not perfect; more work is always needed. But it was led by curriculum leaders who worked from the research on what makes a quality curriculum, and who analysed and benchmarked the content of curriculums from around the world.[18] Their work shows that an effective overhaul of the Australian Curriculum is possible.

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[17] Victorian Curriculum and Assessment Authority Bulletin: Accessed at https://www.vcaa.vic.edu.au/news-and-events/bulletins-and-updates/bulletin/2023/93November/Pages/93NovemberF-10.aspx.

[18] Disclosure: Learning First was an advisor to NESA on the development of its new curriculum.

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Annex: how we benchmarked the science curriculums

A curriculum is the foundation of an education system, providing the guaranteed learning entitlement for all students. To quote ACARA, the body responsible for developing the Australian Curriculum:

'*The Australian Curriculum describes to teachers, parents, students and others in the wider community what is to be taught and the quality of learning expected of young people as they progress through school*.'

Learning First benchmarked the Australian science curriculum by comparing the content of what the curriculum says is to be taught at each year level with content from the science curriculums of seven other systems: Alberta (Canada), Quebec (Canada), Singapore, England, the United States, Hong Kong and Japan.

Different curriculums present content – what is to be taught – in different ways. For example, the Australian science curriculum consists of three strands (Science understanding, Science as a human endeavour and Science inquiry) and includes:

- **Achievement standards** for each learning area or subject that describe the learning expected of students at each year level or band of years.
- **Content descriptions** that describe what is to be taught and what students are expected to learn.
- **Optional content elaborations** that give teachers ideas about how they might teach the content.

In contrast, the Hong Kong science curriculum for Years 7-9 is divided into thematic units, and the content is presented in three categories:

- Students should learn
- Students should be able to
- Suggested learning and teaching activities.

Benchmarking does not make a judgement about which structure is best, but instead compares the level of content in different curriculums. It is possible to have lots of words on a page but not much content and vice versa.

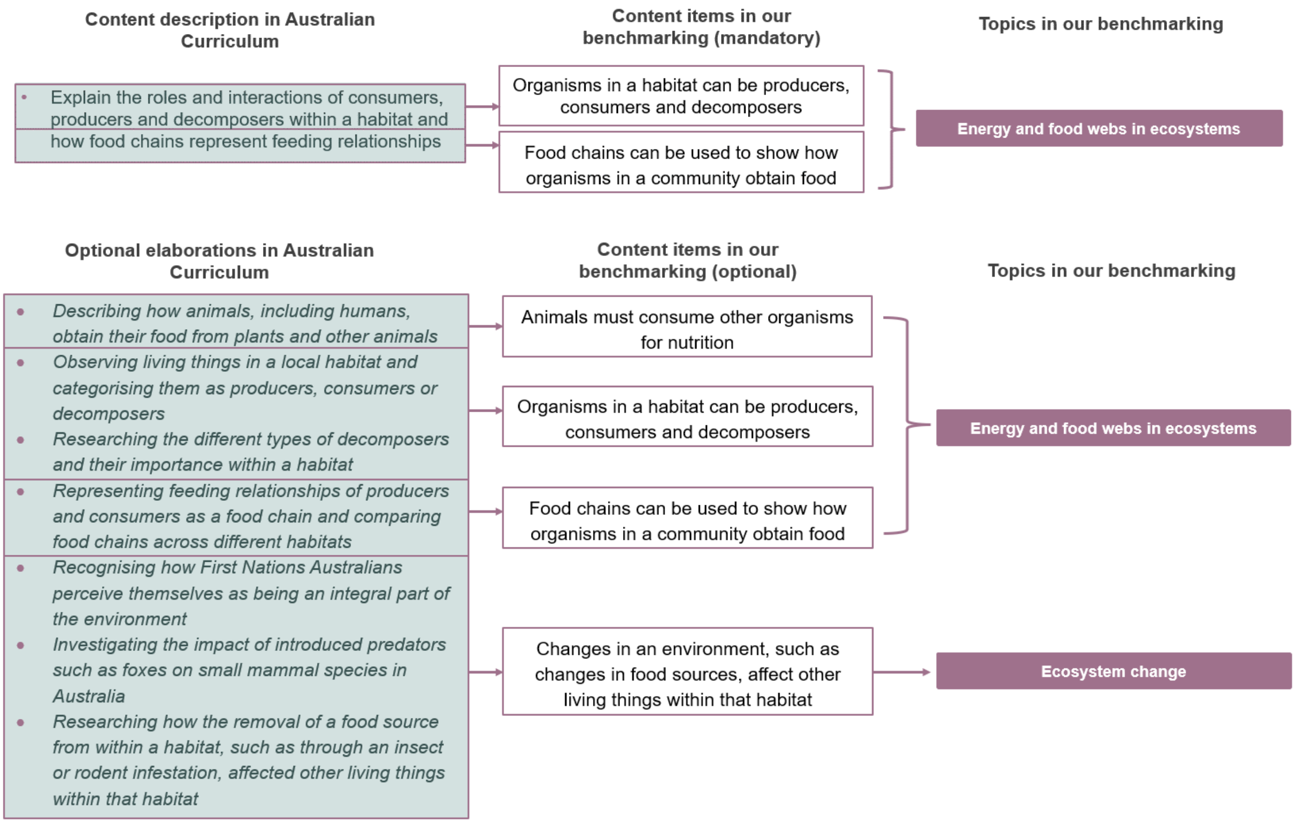
Learning First analysed the content in each curriculum in order to identify the individual pieces of scientific knowledge within each curriculum document. Each piece of scientific knowledge was coded as an individual content 'item'. One item of content represents one piece of scientific knowledge – for example, 'the cell is the basic unit of life' – that students are expected to learn. Every content item was identified as either mandatory or optional to teach.

Learning First did not start with a universal list of content items and then check which curriculums did or did not include them. Rather, we identified discrete pieces of scientific knowledge in all the curriculums analysed for this report, coded them as content items, and cross-referenced them against every other curriculum to determine whether they existed in other systems' science content.

After a database of content items was developed for all systems included in the analysis, content items were then sorted into topics. A topic is a disciplinary area of knowledge made up of closely related content items.

To illustrate the coding process, let's consider the Australian Curriculum's Year 4 biological sciences content description: '*explain the roles and interactions of consumers, producers and decomposers within a habitat and how food chains represent feeding relationships*'. Our benchmarking shows that this content description forms two unique content items, contributing to one topic (Energy and food webs in ecosystems) within our benchmarking database. In addition, the optional elaborations have been coded as four optional content items (two of which were not present in the content description), contributing to an additional topic (Ecosystem change). **Error! Reference source not found.** shows this coding.

Figure 6: Illustration of our benchmarking process



Each topic was then sorted into a domain, using the sub-strands within the 'Science understanding' strand of the Australian Curriculum. These four sub-strands, and hence the four domains used for this benchmarking, are biological sciences, Earth and space sciences, physical sciences and chemical sciences[19].

In order to confirm the content items, topics and domains for all systems benchmarked, we undertook multiple rounds of validation of the database by curriculum experts, data analysts and current and former science teachers who collectively have studied each domain at a tertiary level. Once we had established and validated the database to represent the benchmarked curriculums as individual items of content sorted into topics and domains, we could then make comparisons between systems.

The total number of topics and items of content under each domain across all curriculums were:

[19] These domains are referred to differently across systems. For example, biological sciences is sometimes referred to as life sciences.

	Biological sciences	Chemical sciences	Physical sciences	Earth and space sciences
Topics	35	28	29	27
Items of content	362	243	349	253

To illustrate, the chemical sciences domain comprised 28 topics:

- Acids and bases
- Atomic theory
- Chemical bonding
- Chemical change
- Chemical formulas and equations
- Chemical reactions
- Combustion
- Concentration and solutions
- Displacement reactions
- Electrochemistry
- Electronic structure and valency
- Elements and compounds
- Hydrocarbons
- Mass, volume and density
- Materials
- Material properties
- Metals
- Neutralisation reactions
- Particle model
- Periodic table of elements
- Physical change
- Pure and impure substances
- Radioactive decay and fusion
- Rate of reaction
- Solubility
- States of matter
- Synthesis and decomposition reactions
- Thermal expansion

Among these topics, the 'particle model' topic contained 12 items of content:

- All matter is made of tiny particles.
- Attractive forces are strongest in solids.
- Attractive forces are weakest in gases.
- Gas particles move randomly (Brownian motion).
- Particles in gases are separated by large spaces.
- Particles in liquids are able to slide over each-other.
- Particles in solids are close together and vibrate.
- Particles of matter are in constant motion.
- The speed and distance between particles increases with temperature.
- The speed of particles changes with heat and explains changes of state.
- There are attractive forces between particles.
- There is empty space between particles.

How were systems included in the benchmarking compared?

Benchmarking for this report compared the Australian science curriculum for Foundation to Year 10 (F-10) with the science curriculums of Alberta (Canada), Quebec (Canada), Singapore, England, the United States, Hong Kong and Japan. The Victorian science curriculum F-10 and draft NSW science curriculum 7-10[20] were also benchmarked.

In this report, curriculum levels of instruction for all systems are referred to as 'years' to align with how the Australian Curriculum represents the different stages of learning. However, not all curriculums formally

[20] We benchmarked the new Year 7-10 draft science curriculum for New South Wales as the primary school science curriculum was not yet available.

use this language to represent each level. For example, what the Australian Curriculum calls Year 1, the United States calls First Grade.

It was not possible to compare the exact same number of years of instruction across each system. Students in Australia, Alberta and the United States begin studying science in their Foundation year. In England, Hong Kong and Quebec, science starts in Year 1; in Japan and Singapore, in Year 3.

Where possible, curriculums were benchmarked up to Year 10. For some systems, this was not possible because the curriculum was not available past a certain year level, or because the science curriculum becomes specialised beyond Years 8-9 (for example, it contains a specialist chemistry subject). This is why the majority of comparisons in this report focus on curriculums from Foundation to Year 8. However, because England presents Years 7-9 content as a single stage, content was coded up to Year 9, rather than Year 8. The full methodology can be found in the full report.