

A knowledge-rich approach to curriculum design

March 2024



The Australian Education Research Organisation (AERO) is Australia's national education evidence body, working to achieve excellence and equity in educational outcomes for all children and young people.

Acknowledgement

AERO acknowledges that this publication was commissioned by the New South Wales Education Standards Authority (NESA).

Acknowledgement of Country

AERO acknowledges the Traditional Custodians of the lands, waterways, skies, islands and sea Country across Australia. We pay our deepest respects to First Nations cultures and Elders past and present. We endeavour to continually value and learn from First Nations knowledges and educational practices.

Authors

Emma Lonsdale, Rosey Lind, Tess Marslen and Kate Griffiths

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How to cite

Australian Education Research Organisation. (2024). *A knowledge-rich approach to curriculum design*. <https://www.edresearch.edu.au/research/research-reports/knowledge-rich-approach-curriculum-design>

Publication details

ISBN 978-1-923066-25-0 (online)

Cover image: AERO

Contents

Executive summary	4
--------------------------	----------

Key concepts	6
---------------------	----------

1. Background	7
----------------------	----------

A knowledge-rich curriculum is an essential step towards meeting Australia's education goals	8
--	---

2. Evidence base underpinning a knowledge-rich curriculum	11
--	-----------

Cognitive science research demonstrates that knowledge is essential to how students learn	11
---	----

Skills should be taught within context, building on student knowledge	13
---	----

Knowledge is important for reading comprehension	13
--	----

3. Features for designing a knowledge-rich curriculum	15
--	-----------

Selective	15
-----------	----

Coherent	16
----------	----

Carefully sequenced	16
---------------------	----

Specific and clear	17
--------------------	----

4. Enablers to effectively enact a knowledge-rich curriculum	18
---	-----------

Professional learning to develop pedagogical content knowledge	19
--	----

Quality support materials	19
---------------------------	----

Whole-school approaches to curriculum delivery	19
--	----

Conclusion	21
-------------------	-----------

References	22
-------------------	-----------

Executive summary

A knowledge-rich curriculum is a common feature of educationally high-performing countries and an important step towards achieving Australia's education goals. It provides the foundation for excellence and equity in the education system by prioritising and explicitly outlining the essential knowledge and related skills that students should be taught and develop at each stage of their schooling. This differs from a skills-based curriculum, which focuses on developing skills or competencies in a generic manner, such as critical thinking, communication and problem-solving, and de-emphasises subject knowledge.

In this report, the Australian Education Research Organisation (AERO) provides an overview of the evidence underpinning a knowledge-rich curriculum and outlines the key design features and enablers to effectively enact a knowledge-rich curriculum in schools. It also addresses some of the prevailing myths and misconceptions about a knowledge-rich curriculum.

A knowledge-rich curriculum aligns with the science on how students learn

Cognitive science explains that students learn best when they are supported to acquire, retain and apply knowledge. In line with the science of learning, a knowledge-rich curriculum progressively builds students' subject knowledge, with plenty of opportunities for practise, review and retrieval to support long-term retention of learning. As students acquire more knowledge, it becomes easier for them to comprehend text, understand new concepts and acquire related skills.

Skills are developed as students acquire knowledge

Research shows that knowledge and skills cannot be taught separately. Knowledge provides the foundation for the development of skills, which are developed in context as students acquire factual knowledge (e.g., facts, theories) and procedural knowledge (e.g., processes, techniques). Skills like critical thinking or problem-solving require students to apply subject knowledge to analyse and address complex issues. A knowledge-rich curriculum provides the basis for students to build deep subject knowledge and understanding, which enables them to develop and apply skills in context.

A knowledge-rich curriculum is selective, coherent, carefully sequenced and clear

A knowledge-rich curriculum is designed in line with the cognitive science evidence for how students learn best. AERO's review identified the 4 key features of a knowledge-rich curriculum that enable students to progressively build and master essential subject-specific knowledge and skills:

1. **Selective** – Content is chosen purposefully for each subject, in alignment with a vision of education.
2. **Coherent** – The curriculum ensures content is interconnected across topics, subjects and stages.
3. **Carefully sequenced** – The curriculum is designed to develop deep and broad knowledge over time by building on prior content and gradually increasing complexity.
4. **Specific and clear** – The curriculum explicitly outlines what students are expected to know, understand and be able to do for subjects and topics across all stages.

Effective teaching practices are essential to enact a knowledge-rich curriculum in schools

Teachers should be supported to use effective teaching practices to enable a knowledge-rich curriculum to have its intended impact on student learning. AERO's review identified 3 key enablers for a knowledge-rich curriculum in schools:

- professional learning to develop pedagogical content knowledge (the 'what and how' of teaching)
- quality support materials
- whole-school approaches to curriculum delivery.



Key concepts

Curriculum

Curriculum is the teaching and learning standards that outline what students are expected to know, understand and be able to do at each stage of their schooling. In Australia, the curriculum operates at national, jurisdictional and school levels. National and jurisdictional curricula (and syllabuses) outline essential content, which supports schools to enact the curriculum.

Different approaches to curriculum include:

- **Knowledge-rich curriculum** – A knowledge-rich curriculum prioritises and explicitly outlines the subject knowledge and related skills that students should be taught and develop at each stage of their schooling.
- **Skills-based curriculum** – A skills-based curriculum focuses on developing skills or competencies in a generic manner, such as critical thinking, communication and problem-solving, and de-emphasises subject knowledge.

Knowledge

Knowledge is the subject-specific information, concepts and principles that students are expected to know and understand at each stage of their schooling. Knowledge provides the foundation for the development of skills, as students learn and combine subject knowledge, which they can then apply in context.

- **Disciplinary knowledge** is knowledge of the approaches, general principles and ways of working specific to a subject area (Ashbee, 2021). For example, history, mathematics and physics each have distinctive principles, theories, methodologies and practices that are recognised and accepted within that discipline. Disciplinary knowledge includes procedural knowledge, which is knowledge of the processes and techniques required to perform a task (i.e., ‘knowing how’) (Rata, 2019). Examples include knowing how to play a musical instrument or solve a mathematical equation.
- **Factual knowledge** (or declarative or substantive knowledge) is knowledge of facts, theories and information that can be explicitly stated (i.e., ‘knowing that’) (Rata, 2019). Examples include historical dates, scientific laws, mathematical formulas and vocabulary words.

Skills

Skills are the methods, tools, strategies and processes that students develop as they learn. Examples of skills include critical thinking, communication and problem-solving. Skills are developed in context as students acquire factual and procedural subject knowledge.

1. Background

The Australian Education Research Organisation (AERO) was commissioned by the NSW Education Standards Authority (NESA) to report on the evidence and rationale for a knowledge-rich approach to curriculum design. AERO conducted a desktop review of the evidence on effective curriculum design and the cognitive science evidence for how students learn best.¹ This report is based on the most rigorous and relevant research from national and international reviews, reports and seminal research.

The term ‘curriculum’ can have various meanings, depending on context, and can encompass the standards outlining what students should know and do at different stages of schooling and/or the specific materials used to achieve these standards (Magee et al., 2018). The international research on curriculum design and implementation reflects this variation in meaning, as well as different approaches to curriculum in education systems around the world. In this report, curriculum refers to what students are expected to know, understand and be able to do (NESA, n.d.), in line with the Australian view of curriculum as teaching and learning standards.

Australia has a shared national curriculum – the Australian Curriculum – which outlines what students should be taught and the quality of learning expected as students progress through school (Australian Curriculum, Assessment and Reporting Authority, n.d.). The Australian Curriculum is endorsed by all education ministers and identifies the essential content that students should learn. States and territories are responsible for implementing the curriculum and can ‘adopt and adapt’ the Australian Curriculum to develop jurisdictional curricula and syllabuses, which outline the content and learning outcomes in more detail. Schools enact the curriculum in line with jurisdictional curricula and syllabuses and the Australian Curriculum.

This report examines the evidence regarding a knowledge-rich curriculum, meaning a curriculum that prioritises and explicitly outlines the subject knowledge and related skills that students should be taught and develop at each stage of their schooling. The specificity of a knowledge-rich curriculum and its focus on subject knowledge and skills stands in contrast to curriculum approaches that prioritise skills and include generic outcome statements, with limited guidance for schools and teachers.

This report is organised into 4 parts:

- [Part 1](#) provides background and describes why a knowledge-rich curriculum is an essential step towards meeting Australia’s education goals of excellence, equity and lifelong learning.
- [Part 2](#) outlines the cognitive science evidence for how students learn and how this underpins the design of a knowledge-rich curriculum.
- [Part 3](#) describes the key design features of a knowledge-rich curriculum, namely that it is selective, coherent, carefully sequenced and clear.
- [Part 4](#) identifies the enabling factors required for schools and teachers to effectively enact a knowledge-rich curriculum.

¹ All relevant evidence was assessed according to AERO’s [Standards of Evidence](#), which establish AERO’s view on what constitutes rigorous and relevant evidence. When evidence is rigorous and relevant, it provides confidence that a particular approach is effective in a particular context.

A knowledge-rich curriculum is an essential step towards meeting Australia's education goals

A knowledge-rich curriculum is a powerful lever to support excellence and equity in schooling by setting high expectations and making explicit the shared knowledge all students should be supported to access (Counsell, 2023; Hirsch, 2016; Wiliam, 2013). It is a common feature of high-performing and equitable education systems around the world, based on their performance in Programme for International Student Assessment (PISA) tests (Chiefs for Change, 2017; Common Core, 2009; Organisation for Economic Co-operation and Development [OECD], 2023).

In Australia, the Alice Springs (Mparntwe) Education Declaration sets out shared education goals to promote excellence and equity and enable all young Australians to become confident and creative individuals, successful lifelong learners, and active and informed members of the community (Council of Australian Governments Education Council, 2019). A knowledge-rich curriculum is an essential step towards meeting these goals. Students come to school with different knowledge, language and skills. Australian Early Development Census (AEDC) data show that there are established language and skills gaps between students from socio-economically disadvantaged areas compared to students from socio-economically advantaged areas² when they start school (Harman-Smith et al., 2022) and, without suitable interventions, these gaps widen as students progress through school (Williams et al., 2023).

A knowledge-rich curriculum can help address these gaps. For example, research indicates that a knowledge-rich curriculum can have a large, positive school effect on reducing reading gaps over time (Hirsch, 2016; Wexler, 2019). One way it does this is by providing all students with equitable access to shared knowledge from the start of their schooling. In other words, a knowledge-rich curriculum does not rely on students' assumed knowledge – rather it promotes equity by providing all students with access to a common body of knowledge, regardless of background.

Seminal curriculum research refers to 'powerful knowledge' or the right of all students to progressively and systematically build specialised content knowledge and disciplinary learning that enables them to link concepts, gain new insights and make inferences (Muller & Young, 2019). All students are entitled to this knowledge but unless it is explicitly taught in schools, students do not necessarily acquire this knowledge. This is because there is unequal access to this knowledge outside the classroom and it is not necessarily acquired in everyday life (Counsell, 2023). Importantly, powerful knowledge should not be confused with 'knowledge of the powerful,' which refers to tightly held or restricted knowledge and reflects historical and societal power imbalances (Muller & Young, 2019). Rather, powerful knowledge in the curriculum extends students' thinking and stimulates learning, enabling them to become more independent learners, who can think in more abstract ways over time (Chi et al., 1981; Kirschner, 2009; Kirschner & Hendrick, 2020; Willingham, 2021).

2 The AEDC defines socio-economic disadvantage using the Index for Relative Socio-Economic Disadvantage, which ranks the disadvantage of one area against other areas in Australia. These ranks are based on the Socio-Economic Indexes for Areas, developed by the Australian Bureau of Statistics.



Myth: ‘A knowledge-rich curriculum is rigid and does not cater to individual learners’ needs or interests.’

A knowledge-rich curriculum engages students in their learning. It supports all students to reach their potential by progressively building the knowledge and skills they need for future success. Without this grounding, students are at risk of falling behind or missing out on essential knowledge and skills. A knowledge-rich curriculum enables students to appreciate the value of knowledge and sets them up for lifelong learning, so they can pursue their interests and access a range of study, work and life opportunities.

A knowledge-rich curriculum supports student achievement and excellence, as it sets high expectations for learning and teaching and enables students to progressively access more and more challenging content. Careful sequencing in a knowledge-rich curriculum enables students to master subject knowledge and related skills that are essential for their studies and achievement in the classroom. A knowledge-rich curriculum is designed to engage students in their learning and support them to appreciate the educational, civic and cultural value of knowledge, particularly when supported by strong teacher knowledge (Muller & Young, 2019). The broad and deep knowledge and skills that students attain through a knowledge-rich curriculum create a starting point for lifelong learning and enable students to access future opportunities in training, work, community and life more broadly (Counsell, 2023; Muller & Young, 2019).

Box 1 demonstrates how departing from a knowledge-rich curriculum can negatively impact student excellence and equity outcomes with reference to curricula in France, Finland and Scotland.

Box 1: The effects of departing from a knowledge-rich curriculum

Several formerly high-achieving jurisdictions have declined in academic results since departing from a knowledge-rich curriculum.

From 1989, France moved away from a highly explicit curriculum based on a common core of knowledge to a skills-based curriculum which emphasised school autonomy and a shift from traditional subject disciplines. The impact of this change was a steady decline in both student achievement and equity. Literacy scores, in particular, declined significantly from previously high global rankings, and there were more pronounced effects on disadvantaged students (Hirsch, 2016).

Finland shifted from a knowledge-rich curriculum towards a skills-based curriculum in the early 2000s. While Finland achieved strong PISA results for several years following this change, analysis suggests this is the result of earlier education policies, including a knowledge-rich curriculum, rather than the skills-based curriculum (Joseph & Buckingham, 2018; Sahlgren, 2015). Between 2012 and 2022, Finland experienced an overall decline in PISA results, dropping 33 points in mathematics, 6 points in reading and 14 points in science. This downward trend has remained constant since 2012, and is likely explained by the change in curriculum rather than other factors such as COVID-19 (OECD, 2023).

Scotland's introduction of the new 'Curriculum for Excellence' in 2010 saw a shift from knowledge-based learning to a competence-based approach. The new approach, which emphasised transferable skills and interdisciplinary learning, corresponded with a steep decline in student performance, including a drop of 18 points in PISA mathematics, 11 points in reading and 7 points in science from 2018 to 2022. Critics argue that the 'Curriculum for Excellence' competence-based approach creates a false dichotomy between knowledge and skills and undermines the importance of factual learning, which is crucial for conceptual understanding in subjects like maths, science and reading (Christodoulou, 2023b; Paterson, 2023).

2. Evidence base underpinning a knowledge-rich curriculum

This section outlines the scientific evidence for how students learn, which underpins how and why a knowledge-rich curriculum works best. It includes an explanation of how memory works to support effective learning and teaching, the strong link between knowledge and skills and the importance of vocabulary and background knowledge for reading comprehension across all subjects.

Cognitive science research demonstrates that knowledge is essential to how students learn

Cognitive science research outlines how the brain learns and stores information, and how memory works to process information and develop knowledge. Studies in cognitive science suggest that a well-structured and organised body of knowledge can enhance cognitive processes such as memory, comprehension and problem-solving (Centre for Education Statistics and Evaluation [CESE], 2017; Deans for Impact, 2015; Kirschner & Hendrick, 2020; OECD, 2002; Perry et al., 2021). Building a foundation of factual information helps students make connections between concepts and promotes meaningful learning (Sweller, 2016).

A knowledge-rich curriculum enables students to progressively learn broad and deep knowledge and skills as it is structured in line with how memory works (Ashbee, 2021; Deng, 2022).

Myth: ‘A knowledge-rich curriculum works well for some students and settings but does not support all students in their learning.’

A knowledge-rich curriculum is carefully structured to build knowledge and skills for all students in line with how learning happens. It is underpinned by cognitive science research, which has identified the most effective practices for learning (AERO, 2023a). All students benefit from a curriculum that aligns with the processes of acquiring, retaining, retrieving and consolidating learning. Some students will require more frequent, intense and sustained scaffolding and support – for example, through a multi-tiered system of supports. Multi-tiered system of supports complements a knowledge-rich curriculum by providing high-quality instruction for all students and evidence-based interventions for students who need additional support.

Learning is a function of memory

Students learn by using working memory to focus on and process new information, allowing them to connect information to what they already know. With effective teaching and when learning is carefully sequenced, this information is then transferred to long-term memory, where it is stored as knowledge grouped into increasingly complex schemas.

Students are novice learners, so it takes time for them to process new information and develop these schemas in their long-term memory (Chi et al., 1981). As students develop more complex schemas, they are increasingly able to recognise links between pieces of information and understand how concepts are related (Chi et al., 1981; Kirschner & Hendrick, 2020).

Knowledge is like ‘mental Velcro’ (Hirsch, 2016) – the more knowledge students have in long-term memory, the easier it is to attain new knowledge that builds on their existing knowledge base (Sweller, 1994). With practise, students can automatically recall information from long-term memory, which frees up working memory and enables them to progress to deeper, more complex learning (CESE, 2019). With effective instruction, students gradually move towards becoming expert learners who can draw on existing schemas to apply knowledge to increasingly complex concepts (Kirschner & Hendrick, 2020; Sweller, 2016, 2022; Willingham, 2021).

Once students have mastered a set of knowledge and built schemas that connect relevant information, they can recall knowledge from long-term memory to working memory, where it can be combined and recombined with other information to generate new ideas, solve unfamiliar problems and think critically and creatively (Fiorella & Mayer, 2016; Kirschner et al., 2006).

Reducing the burden on working memory supports effective learning

Cognitive load theory outlines that the brain can only process small amounts of new information in working memory at one time, but that large amounts of information can be stored in schemas in long-term memory for recall at a later stage (CESE, 2017; Chen et al., 2018; Kirschner et al., 2006; Sweller, 1994, 2016).

While long-term memory has no known limits (Cowan, 2008; Sweller, 1994), working memory has very limited capacity. Cognitive overload can occur when students try to process too much information in working memory at the same time, which limits their ability to understand and retain what they are learning (Chen et al., 2018). Having a broad and deep set of schemas in long-term memory can reduce the risk of cognitive overload, as students can recall information from schemas to link concepts and process new information in working memory (Willingham, 2021).

Myth: ‘Students don’t need to be explicitly taught facts – they can look them up on Google.’

There are 2 problems with this myth. The first is that students need some knowledge in order to look something up on Google and assess whether that is accurate information. Looking up something on the Internet can also interrupt the learning process in a way that frustrates and disengages students. Secondly, the myth implies that a knowledge-rich curriculum is concerned with teaching ‘facts’. A knowledge-rich curriculum builds deep factual and procedural knowledge, which students group into schemas in long-term memory. With consistent practise, students can automatically recall information from long-term memory, which reduces cognitive load and frees up working memory, so that students can progress to deeper, more complex learning. For example, when students master vocabulary or times tables, they can automatically and seamlessly apply this knowledge to understand more complex texts or solve mathematical problems, without experiencing cognitive overload and without interrupting the learning process to stop and google facts.

Skills should be taught within context, building on student knowledge

Skills are the methods, tools, strategies, and processes that students develop as they learn. Although skills are sometimes thought of as an area of learning that is distinct from knowledge, cognitive science research shows that skills and knowledge are tightly linked and cannot be taught separately (Willingham, 2019). Knowledge provides a ‘pathway’ or progression to the skill: as students accumulate and combine subject knowledge, they are increasingly able to apply their learning to perform related tasks (Christodoulou, 2023b; Willingham, 2021). As one of the architects of the skills-based Scottish Curriculum, Keir Bloomer, has said in response to criticisms: ‘we did not make sufficiently clear that skills are the accumulation of knowledge. Without knowledge there can be no skills’ (Christodoulou, 2023b).

Skills – such as problem-solving, reasoning and critical and creative thinking – are best developed in context as students attain deep subject knowledge (CESE, 2019; Willingham, 2019). Students should be explicitly taught factual knowledge (i.e., facts, theories or ‘knowing that’) and procedural knowledge (i.e., processes, techniques or ‘knowing how’) (Rata, 2019) in the context in which they will apply the skills (CESE, 2019; Willingham, 2019). Over time, as students acquire deep and broad subject knowledge, they will increasingly be able to develop judgement (i.e., ‘knowing why’) and skills in a particular context (Rata, 2019). For example, in history, students should be taught factual knowledge (such as historical events and dates) and procedural knowledge (such as assessing the reliability of historical sources), so that they can apply their learning to solve problems and think critically in the context of history (Christodoulou, 2023a; Wiliam, 2013).

Myth: ‘A knowledge-rich curriculum promotes rote learning at the expense of skills development, like critical and creative thinking.’

Skills cannot be learnt without knowledge. A knowledge-rich curriculum provides the knowledge students need to build mental schemas and apply knowledge to complex tasks. Subject knowledge enables students to think creatively and critically to solve problems. As Daisy Christodoulou says: ‘the ingredients make the cake, just as the knowledge makes the skill’ (Christodoulou, 2023b).

Knowledge is important for reading comprehension

Knowledge is important for students to comprehend text, which is necessary for all subjects at all year levels. A knowledge-rich curriculum supports strong reading comprehension by building vocabulary and rich background knowledge that students can draw on as they encounter increasingly complex concepts and language in their schooling.

The Simple View of Reading outlines that reading comprehension is largely the function of 2 broad skill sets: word recognition and language comprehension (AERO, 2023b). Word recognition includes decoding – that is, the ability to identify letter–sound relationships and letter patterns to correctly pronounce what is being read, and the capacity to recognise printed words. Language comprehension is the ability to derive meaning from spoken and written words. It consists of vocabulary, background knowledge and an understanding of how words are combined to form sentences.

Research consistently shows the importance of vocabulary and solid background knowledge for language comprehension (Elleman & Compton, 2017; Smith et al., 2021; Willingham, 2021), as students need to understand most individual words in order to understand the text as a whole (Castles et al., 2018). Students who struggle with reading tend to have gaps in knowledge or less developed content knowledge (Cabell & Hwang, 2020; Elleman & Compton, 2017) and they are more likely to need highly cohesive and coherent texts to support recall (Smith et al., 2021).

A knowledge-rich curriculum develops background knowledge and vocabulary for all students

Students need to acquire both vocabulary and background knowledge to strengthen their reading comprehension. For students to successfully learn new vocabulary, they should be taught both the definitions of words and the new word meaning within the context of broader meaning associations (Oakhill & Cain, 2019). Background knowledge supports students to understand texts, as they draw on existing schemas to make links (Cabell & Hwang, 2020; Castles et al., 2018), bridge logical gaps, interpret ambiguity (Willingham, 2021) and make inferences within and across texts (Cervetti et al., 2016). Research shows that building background knowledge can help students to improve their comprehension (Elleman & Compton, 2017). As students develop more background knowledge, they are able to comprehend increasingly complex texts (Smith et al., 2021).

More broadly, students draw on a range of knowledge sources to support effective reading and writing, including background knowledge to understand text and generate ideas, metaknowledge to understand the functions and purposes of texts, pragmatic knowledge or knowing about text features, words, syntax and language to create meaning, and procedural knowledge to understand the processes and techniques for reading and writing (Fitzgerald & Shanahan, 2000). Skilled writing requires students to have a deep understanding of audience, purpose and genre, rich content (topic) and vocabulary knowledge, and the ability to plan, draft, evaluate, revise, edit and publish text, from paragraphs to compositions (AERO, 2022; Graham et al., 2019).

A knowledge-rich curriculum is structured to support reading comprehension – and literacy more broadly – by building language competence and deep knowledge, which enables students to understand and engage with more complex subject texts as they progress through their schooling (Hirsch, 2016; Wexler, 2019).



3. Features for designing a knowledge-rich curriculum

This section draws on curriculum research from the past 3 decades, together with the cognitive science evidence base, to identify the key features of a knowledge-rich curriculum. It should be noted that there are limited publicly available evaluations of shared curricula, including in the Australian context. As such, this section is largely drawn from seminal texts, analysis of knowledge-rich curriculum design and case studies from systems, curriculum programs and schools.

Key features of a knowledge-rich curriculum

1. **Selective** – Content is chosen purposefully for each subject, in alignment with a vision of education.
2. **Coherent** – The curriculum ensures content is interconnected across topics, subjects and stages.
3. **Carefully sequenced** – The curriculum is designed to develop deep and broad knowledge over time by building on prior content and gradually increasing complexity.
4. **Specific and clear** – The curriculum explicitly outlines what students are expected to know, understand and be able to do for subjects and topics across all stages.

Selective

Curriculum content should be carefully selected so that students can attain the most relevant knowledge in line with a vision for education (Deng, 2022). In Australia's case, this vision is to enhance excellence and equity and support lifelong learning (Council of Australian Governments Education Council, 2019). Curriculum content should be broad, deep and challenging, so that students develop diverse and rich subject knowledge in schemas, which they can draw on to participate in study, work and life opportunities (William, 2013).

A knowledge-rich curriculum should include purposefully selected content that enables students to build foundational understanding of a subject and make connections within that subject (McPhail & Rata, 2016). For example, in teaching music, 'tonality' is an essential concept, which infers an understanding of 'pitch' and 'chords' (Rata, 2019). The curriculum cannot possibly contain every piece of relevant and important content for each subject, as there is not enough time for students and teachers to work through all the material in depth. As a result, there can be difficult decisions about what to include in the curriculum. This requires a process of 'recontextualisation,' where essential content is identified and processed from the associated discipline into a format appropriate for teaching students at their stage of schooling (Ashbee, 2021). An example would be reviewing and selecting essential content from disciplines such as physics, chemistry and biology to include at appropriate stages in the science curriculum.

There may be greater consensus on what to include for some subjects compared to others, based on the subject structure and how concepts are related (McPhail & Rata, 2016). Curriculum designers should seek specialist subject expertise (informed by the associated discipline, field or specialist subject-based communities) to help determine the essential content, which will guide the structure of subjects in the curriculum (Ashbee, 2021; Young et al., 2014).

Coherent

A knowledge-rich curriculum should be developed as a whole, with all subjects and topics developed simultaneously and connections between content to support coherence in student learning (McPhail & Rata, 2016). A structured, coherent curriculum design can reduce cognitive overload and minimise both gaps and duplication in content. Curriculum design that reflects the links within and across subjects can also support teachers and students to understand how the curriculum builds cumulative learning and knowledge (Niemelä, 2021). This accords with the evidence for how students learn, by building background knowledge which enables students to draw on existing schemas when processing new information.

Coherence within each subject area should also be considered and the curriculum should reflect the knowledge structures of different disciplines (McPhail & Rata, 2016). Subjects with vertical coherence (e.g., sciences) have a hierarchical structure and a clear curriculum progression. Students need to learn foundational concepts first and there are clear prerequisites for further learning (Muller & Young, 2019). On the other hand, subjects with horizontal coherence (e.g., humanities) have a more narrative, contextual approach and there can be more flexibility in the curriculum progression (Muller & Young, 2019). The flexibility of subjects with horizontal coherence may make it harder to agree on the curriculum progression, as concepts can be explored in different orders (McPhail & Rata, 2016).

A coherent curriculum should explicitly link related content across subjects to ensure that prerequisite concepts are taught first (Wiliam, 2013). For example, teaching equations and graphs in mathematics would be a prerequisite to teaching map references in geography, as it enables students to draw on existing knowledge about coordinates (Wiliam, 2013). Mapping content across subjects, topics and stages can support curriculum designers to identify the key components of learning, links between content and the prerequisite subject knowledge students need to be taught to progress (Ashbee, 2021). These links should inform decisions about where to include topics and activities in the curriculum (Wiliam, 2013). Using texts that relate to concepts across subjects can also help to explicitly link concepts and improve student recall, vocabulary knowledge and understanding (Cervetti et al., 2016).

Carefully sequenced

It is important to carefully sequence content across the curriculum and within subjects to effectively teach students. This enables them to build progressive understanding and access increasingly ambitious content over time (Ashbee, 2021; Hirsch, 2016).

The curriculum should establish a strong foundation in the early years (Ashbee, 2021) and build complexity over time through sequencing and pacing content, in line with the evidence for how students learn. Learning is more effective when content is coherent and sequenced, as students progress from novice to more expert learners and access increasingly challenging content (Wiliam, 2013). Through deliberate and careful sequencing of content, students gradually and progressively develop more complex schemas and a deeper understanding of concepts (Almond, 2020).

A knowledge-rich curriculum should be ordered to effectively teach students factual and procedural knowledge for each subject, enabling them to develop related skills and judgement (Muller & Young, 2019; Rata, 2019; Wiliam, 2013). For example, students learning about a mathematical formula should understand why the formula is appropriate to solve certain problems and, as they build competence in applying it, be able to draw on this knowledge to solve unfamiliar problems (Rata, 2019).

Myth: 'A knowledge-rich curriculum does not support independent student learning.'

A knowledge-rich curriculum sequences content to progressively build students' knowledge and skills. As students gain expertise, they also increase time spent on independent problem-solving. Over time, students become more independent learners, who can generate new learning beyond what they've been taught and build new, meaningful connections to ensure success now and in the future.

Specific and clear

The curriculum should provide specific detail about the content and how students' learning is demonstrated. Clear and unambiguous outlines of the content across topics, subjects and years are an important part of a knowledge-rich curriculum (Hirsch, 2016; Percival, 2020). These provide a framework to assess whether content aligns with, and contributes to, students' subject knowledge, understanding and skills. They also provide clarity on the essential content and structure of the curriculum to guide schools and teachers as they enact the curriculum (Wiliam, 2013).

Curriculum design should explicitly outline the 'components of excellence' that demonstrate learning (Ashbee, 2021) by identifying how students get there and how they can apply their learning (Almond, 2020). This ensures there are clear expectations about what students should know, understand and be able to do at each stage of their learning, which supports consistency in what and how students are taught (Wiliam, 2013) and reduces the variance within and across schools. Such an approach aligns with the evidence base for how students learn, including the use of effective instruction techniques, such as explicit instruction, mastery learning, spacing and retrieval and formative assessment.

Myth: 'A knowledge-rich curriculum is overly prescriptive and limits teaching practices.'

A knowledge-rich curriculum sets out what every student has a right to know. Teachers can and will make decisions about how this content is taught. The specificity and clarity of a knowledge-rich curriculum reduces the burden on teachers to identify the knowledge needed for students to achieve high-level learning outcomes, as is required in a skills-based curriculum. As a knowledge-rich curriculum aligns with how students learn, it supports effective teaching practices, which enable students to acquire and retain new knowledge by providing opportunities for practise, review and retrieval. Having a transparent and shared understanding of what knowledge students should have at each stage also enables teachers to better identify knowledge gaps and effectively assess students' learning.

4. Enablers to effectively enact a knowledge-rich curriculum

Schools enact the curriculum in line with jurisdictional curricula and syllabuses and the Australian Curriculum, which are used to develop classroom teaching programs and inform whole-school curriculum planning. Many factors contribute to variance in how the curriculum is enacted in schools across Australia, including school sector, jurisdictional guidance and support materials, and different school approaches to curriculum planning, pedagogy and professional learning. This section draws on curriculum research to identify the enabling factors required for schools and teachers to effectively enact a knowledge-rich curriculum.

A knowledge-rich curriculum needs to be accompanied by effective teaching practices that engage students in their learning and enable students to attain the knowledge set out in the curriculum (McPhail & Rata, 2016). Effective teaching practices – like mastery learning and spacing and retrieval – complement a knowledge-rich curriculum by supporting students to progressively attain more complex knowledge and understand how different aspects of their learning are related (AERO, 2023a; Wiliam, 2013). These practices should be accompanied by formative assessment for identifying students' knowledge gaps to successfully teach new content (AERO, 2023a).

Teachers should be supported in using effective teaching practices to enable a knowledge-rich curriculum to have its intended impact on student learning. The literature identifies 3 key enablers:

- professional learning to develop pedagogical content knowledge
- quality support materials
- whole-school approaches to curriculum delivery.

Box 2 outlines how Japan delivers a knowledge-rich curriculum.

Box 2: A specific and coherent knowledge-rich curriculum in Japan

Japan is consistently noted for high PISA scores, with 2022 PISA results showing very high achievement levels in mathematics, reading and science, as well as high levels of student wellbeing (OECD, 2023).

The Japanese curriculum, set centrally by the Japanese Ministry of Education, is highly specific, coherent and incorporates the features of a knowledge-rich curriculum previously outlined in this report. Content is intentionally structured to ensure coherence and build subject knowledge within and across grades. Key concepts and skills that students should acquire at each grade level are explicitly defined to 'maintain a uniform level of school education throughout Japan' (Magee et al., 2018; Nakayasu, 2016). All students are supported to build and retain knowledge through a national tutoring program, 'Chiiki Mirai Juku'. This program ensures that all students can access and understand each aspect of the curriculum before progressing, thereby enabling continuous building upon prior knowledge each year.

The Japanese curriculum is also revised periodically in response to student results. The 2 most recent revisions – in 2013 and 2020 – have further increased subject-matter rigour and instructional time. These changes have correlated with improved student outcomes in both PISA and Trends in International Mathematics and Science Study (TIMSS) assessments (National Center on Education and the Economy, 2023a; OECD, 2023).

Professional learning to develop pedagogical content knowledge

Teachers' pedagogical content knowledge (the 'what and how' of teaching) is important for effective teaching and learning (Baumert et al., 2010; Ingvarson et al., 2014). If teachers do not have the underlying expertise in the subjects they are teaching, they will be limited in their ability to teach to the intended depth of the curriculum (Office for Standards in Education, Children's Services and Skills [Ofsted], 2019). This aligns with research that suggests that both teachers' content knowledge and use of evidence-based pedagogical practices are important to enable a knowledge-rich curriculum to be taught with fidelity (Neuman & Danielson, 2021).

A meta-analysis of efforts to improve Science, Technology, Engineering and Mathematics (collectively known as 'STEM') instruction found that, on average, interventions had a larger impact on student learning when they incorporated both professional development and new curriculum materials, compared to interventions that only included one of these components (Lynch et al., 2019). Professional learning was particularly effective when it focused on improving teachers' pedagogical content knowledge and/or how students learned the content (Lynch et al., 2019). This suggests that student learning is more likely to improve when a knowledge-rich curriculum is complemented by professional learning that is focused on teachers' pedagogical content knowledge and use of evidence-based teaching practices.

Quality support materials

Effective teaching is enabled by quality support materials rich in the content students need to know and apply (Black & Wiliam, 1998). Quality support materials have the following features: they support the use of evidence-based teaching practices, provide comprehensive and detailed guidance, embed assessment to check for student learning and are easy for teachers to use (Hunter & Haywood, 2023). They identify the specific knowledge that students should be taught, including facts, concepts and procedures, and take a cumulative approach where knowledge in each year builds on the knowledge acquired in earlier years.

Widespread use of quality support materials can reduce variance in what students are taught, support staff planning and prompt professional development (Ashbee, 2021). This enables greater consistency in how a knowledge-rich curriculum is taught within schools and across the wider education system.

The availability of quality support materials also frees up teacher time, which could instead be used to develop subject knowledge and pedagogy planning. The majority of Australian teachers and school leaders report not having enough time to plan high-quality lessons (Hunter & Sonneman, 2022). The provision of quality support materials – including assessment aligned with the curriculum – was identified as a key opportunity to save teacher time (Hunter & Sonneman, 2022).

Whole-school approaches to curriculum delivery

While quality support materials should be provided to schools with a knowledge-rich curriculum, a whole-school approach to curriculum delivery is still required to ensure that all teachers understand the knowledge and skills students are expected to attain and how that learning will be assessed. A whole-school curriculum approach should include program mapping within and across subjects and clearly outline unit plans and lesson materials (Hunter & Haywood, 2023). It should include a shared

pedagogical approach, which supports consistency in teaching and learning and lower variance in how students are taught (Hunter & Haywood, 2023). Whole-school approaches to curriculum delivery should include enough detail to ensure that all teachers know when to teach each topic and how to teach it.

School leadership is integral to curriculum delivery, however, research also shows the importance of distributed curriculum leadership across school staff to support the sustainability and consistency of curriculum across all stages and subjects (Ofsted, 2019). Adopting a whole-school approach to delivering the curriculum ensures teachers are effectively collaborating so that all students in the school have access to the same learning opportunities. Collaboration within a school is also correlated with better student outcomes when introducing new curricula accompanied by professional learning (Lynch et al., 2019).

Whole-school planning for curriculum delivery increases transparency and visibility about what students are learning, which enables school leaders and teachers to maintain the same high expectations for student learning (Magee et al., 2018). This facilitates stronger linkage between school assessment and the curriculum and supports consistency in teacher judgement against intended learning outcomes (Magee et al., 2018).

Box 3 outlines how Singapore's knowledge-rich curriculum is complemented by a range of these elements, including systematic professional learning and quality curriculum materials.

Box 3: Shared materials and continuous improvement in Singapore

Providing schools with a knowledge-rich curriculum to facilitate subject mastery and aligning with research-based effective teaching practices has bolstered Singapore's international recognition as a high-achieving education system (Magee et al., 2018). The national curriculum, developed by the Ministry of Education, is organised into comprehensive subject syllabuses, incorporating subject objectives, detailed learning outcomes, recommendations on pedagogical approaches and assessment criteria. It also includes 'Desired Outcomes of Education', which are clearly defined attributes that the Ministry aspires for every student to possess by the time they complete their formal education (Ministry of Education, Singapore, n.d.).

Singapore assists teachers to enact the curriculum by providing a national Student Learning Space (SLS): a continually updated library of curriculum-aligned resources created by dedicated teams. Since its enactment in 2013, the SLS has been extended to all schools. Students in Grades 1 to 12 have SLS accounts for independent resource access and teachers can create lessons using templates and compiling SLS materials, optionally sharing them with their colleagues (National Center on Education and the Economy, 2023b). The Ministry of Education also maintains a carefully curated list of approved textbooks for guidance, subject to rigorous quality control, ensuring that the materials selected by schools align perfectly with the national curriculum.

The system prioritises professional development and continuous improvement with an approach centring on 'professional development groups' and a structured, staged improvement cycle. Clear, explicit curriculum standards and learning objectives support professional learning by providing a benchmark for what students should know and be able to do. This facilitates the alignment of teaching practices and provides a framework for prioritising the key content that students need to learn at all levels of schooling (Magee et al., 2018).

Conclusion

To uphold Australia's commitment to educational excellence, equity and lifelong learning – as articulated nationally by the Mparntwe Declaration – curriculum design must be underpinned by the cognitive science on how students learn. A knowledge-rich curriculum, which structures learning and teaching so that all students can access shared knowledge at the same stage of their learning, provides an important step towards achieving Australia's educational goals. As students acquire broad and deep subject knowledge, they are increasingly able to perform complex tasks and apply skills in context, like critical and creative thinking and problem-solving. Supported by effective teaching, a knowledge-rich curriculum sets students up with the knowledge and skills they need to succeed in life.



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