ASERA
AUSTRALASIAN SCIENCE EDUCATION RESEARCH ASSOCIATION LTD

Science Education: Fit for the Future

A White Paper by
The Australasian Science Education Research Association

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About ASERA:

The Australasian Science Education Research Association (ASERA) is a long-standing, respected global community for science education researchers from Australia, New Zealand, and around the world. Committed to high-quality research, ASERA advances science education and research in all contexts and at all levels of education. Through its annual conference and world-class journal, Research in Science Education (RISE), ASERA generates and disseminates evidence vital for bridging the gap between policy and practice. Its research leadership and international connections position ASERA to guide informed, innovative, and future-focused policy and practice in the rapidly evolving global landscape of science education.

Acknowledgement of Country:

ASERA acknowledges the First Nations Peoples as the Traditional Custodians of the lands, skies and waterways on which we live, learn and teach. As the first educators and first scientists, we recognise the deep histories, knowledges, and contributions of all Indigenous Peoples globally. We pay our respects to their Elders both past and present, as well as their future generations of emerging leaders.

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FOREWORD

As the national federation for science teachers, ASTA applauds this timely paper. ASTA proudly supports and aligns itself with ASERA to ensure that education remains a research-based profession that continues to meet the moment that we find ourselves in.

In this era of rapid change, this paper highlights the need for science curricula to remain future-focussed to address a changing world that is rapidly being shaped by AI, quantum technologies, climate change, and mis- and dis-information. Activating a science identity is a necessary and welcome direction.

We look forward to being involved in policy and practice discussions that are aimed at strengthening science literacy and education for teachers and students.

Paula Taylor

President, Australian Science Teachers Association (ASTA)

This white paper is positioned as responding to a 'policy moment': a time when science education policies are due to be renewed in both Australia and Aotearoa New Zealand. Even more urgently, the paper presents a nuanced and evidence-informed response to a critical 'planetary moment': a time when a reimagined science education could play a pivotal role in supporting young people to understand and act on the multiple crises of the Anthropocene. The clear, carefully sequenced recommendations are testament to the insightful, strategic thinking generated by members of ASERA collective. I look forward to seeing these ideas translated into government policy in both nations.

Rosemary Hipkins,

Emeritus Chief Researcher, New Zealand Council for Educational Research (NZCER)

The workforce and broader society are changing faster than can be imagined. On the one hand, the changes wrought by artificial intelligence (AI) will improve national and global productivity and economic output. On the other hand, AI is disrupting jobs from the menial to the most intellectually demanding.

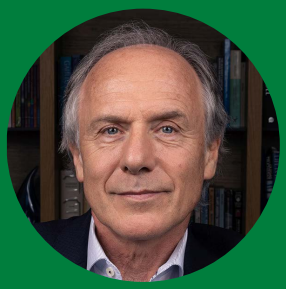
No one knows what new jobs for humans will emerge, but we certainly know that to be successful in the AI driven world young people will need to be critical thinkers. The reality is that you cannot be a critical thinker if you do not have facts and knowledge at your fingertips. No matter how powerful the supporting AI, researchers and industry experts of the future will need to be deeply competent in maths, technology and science so that they can frame the prompts, evaluate the answers and create their own novel solutions to problems.

This means that the obligation to train young people to understand the science of how our world works and the skills to analyse and use what they have learned must continue to be front and centre for curriculum designers and educators. In particular, imparting scientific knowledge and critical thinking skills will be even more relevant in the world of AI. We must never resile from this teaching responsibility.

Ensuring the currency and relevance of science education in a world where knowledge is increasing at a rapid rate and analytic tools such as AI are evolving at a speed that is almost beyond imagination is difficult. It requires energetic and effective research into science education, such as the work that underpins this ASERA report. My congratulations to ASERA and the report authors for describing a modern science education system to suit the needs of our rapidly changing knowledge domain and work environment.

Alan Finkel

Formerly Australia's Chief Scientist, Chancellor of Monash University, and President of the Australian Academy of Technology and Engineering (ATSE).



EXECUTIVE SUMMARY

In a rapidly changing globalised world, STEM education is a critical resource for shaping the future. This future will require an ongoing professional STEM workforce capable of the innovation and technological professional knowledge so central to a contemporary economy. Furthermore the future will necessitate a citizenry with access to, and an appreciation of, scientific knowledge and practices critical for local and global challenges. These challenges include climate change and other global crises, biodiversity loss, energy transition, AI and the fourth industrial revolution, changing perspectives on Indigenous knowledges, a rise in mis- and dis-information about science, particularly on social media, and global health crises. The STEM disciplines are crucial in understanding and responding to these challenges, yet science is undergoing a participation crisis in schools and is increasingly questioned or subverted in popular media.

These wide-ranging challenges require a considered and innovative policy and practice response concerning science education in schools and higher education institutions. The *Australasian Science Education Research Association* (ASERA), through the world leading research of its membership and its connections with the international research community, has an important role to play in advising on policy and practice responses that will render science education 'fit for the future'. The purpose of this white paper is to advocate for and advance policy settings for science education appropriate to the increasingly rapid changes and challenges of the twenty first century, within Australia and New Zealand.

The paper responds to a 'policy moment' resulting from the impending expiration in 2026 of the Australian *National STEM Schools Education Strategy* (Education Council 2015) as well as the New Zealand strategy *A nation of curious minds: He Whenua Hihiri I te Maha* (New Zealand Government, 2014). It seeks to provide direction for the development of a new 'National Science Education Strategy' in each country, capable of providing the policy and practice drivers for science education across all levels, into the foreseeable future.

Within this context, this white paper documents a series of recommendations related to science learning and teaching with respect to 'Policy', 'Practice' and 'Research' fit for the future. These recommendations relate to three distinct areas: Curriculum and Pedagogy; Positioning the Sciences; and Communities of Practice

Curriculum and Pedagogy includes the identification of knowledges (e.g. sustainability, climate change, indigenous perspectives) important for future challenges. The requirements of *Pedagogy* are related to and essential for classroom practices, human relations and the support of learning. The importance of *Assessment* focuses on what should be valued as the purposes of science education.

Positioning the Sciences within society and within different levels of education is framed to highlight the role that science disciplines play in shaping future participation in STEM careers as well as the role that science education can play in positively fostering futures thinking among young people in a world where among other things, AI and quantum technologies are creating diverse ethical dilemmas.

Communities of Practice emphasise the importance of context in teacher professionalism, the need to activate a science identity among the nations' citizenry, especially for females and marginalised groups, and the importance of recognising evidence from multiple sources, spanning socio-cultural, cognitive and neuroscientific fields, in framing policy and practice.

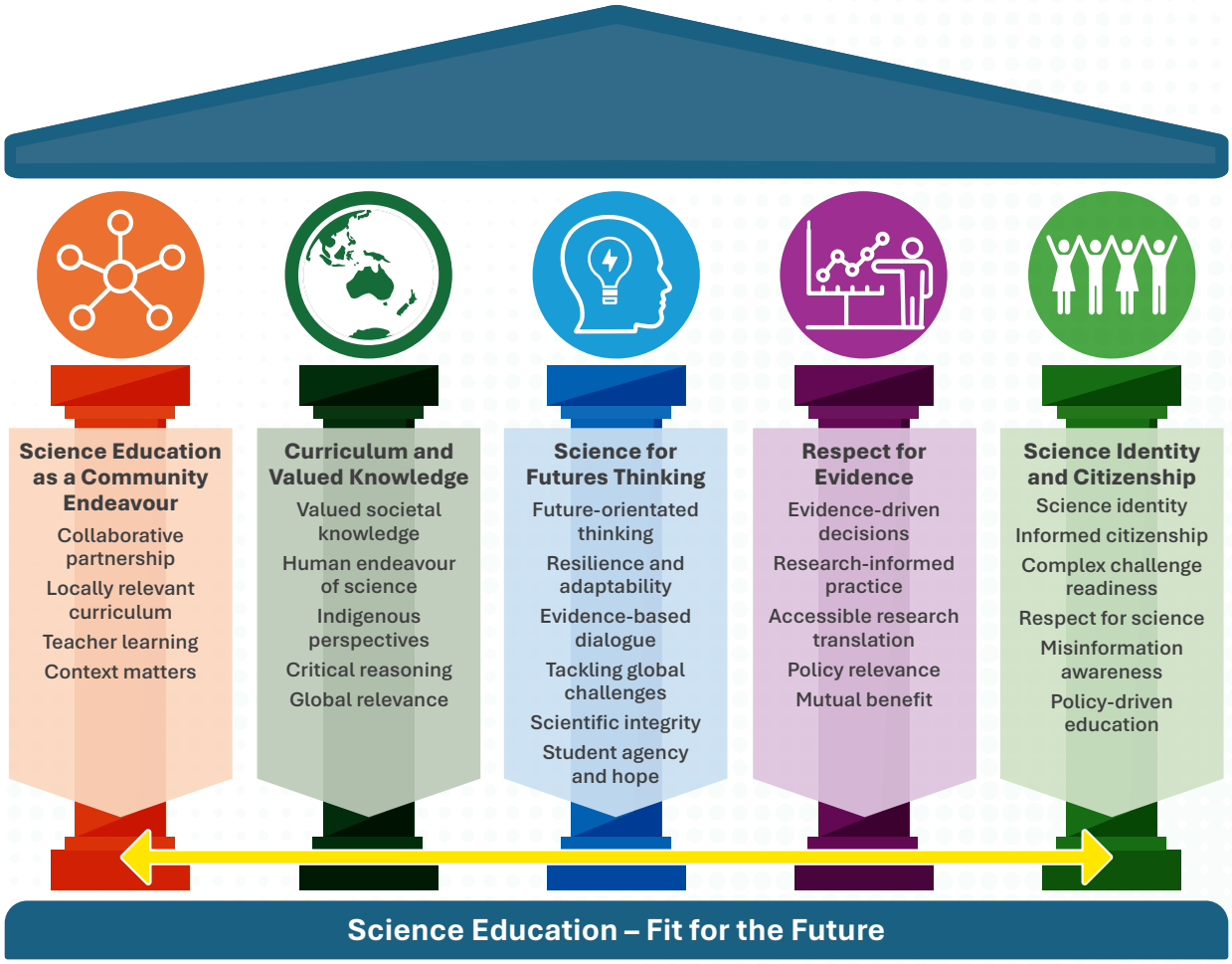
The policy recommendations prioritise developing inclusive and future-focused curricula that prepare students as science-informed citizens capable of critical and creative engagement with global challenges. Policies should enhance students' Science identity,

promote interdisciplinary STEM education, inspire the integration of Indigenous knowledges and align classroom practice with teacher accreditation and professional learning.

In practice, this policy means empowering teachers through evidence-based professional development, mentorship, and collaboration with universities and industry. Teacher learning should focus on both content knowledge (CK) and pedagogical content knowledge (PCK) in each discipline of science, integrating emerging technologies such as AI, and promoting student engagement with critical thinking and decision-making based on deeper knowledges and values.

The research priorities identified call for building diverse and coordinated evidence bases to inform curricula, assessment, and pedagogy. Key areas include climate change education, the integration of emerging technologies, the development of science identity, investigation of teacher identity, instructional models, and Indigenous ways of knowing. Collectively, the advocated strategies aim to foster scientific literacy for all, a culture of innovation across education systems, and strengthening of the research–policy–practice nexus.

The recommendations from this paper can be summarised as five key messages:



OVERVIEW

The Australasian Science Education Research Association (ASERA), whose membership comprises internationally regarded science education researchers and educators, promotes science education and science education research in all contexts and at all levels of education.

Right now, it is apparent that children, young people, and adults across the globe are navigating complex changes to their societies, their environment, and economies because of globalisation, climate change and accelerated technological developments. The knowledge, skills, and tools of science (e.g. Artificial Intelligence [AI], and Quantum computing) are rapidly changing. But what should be the role of science education in relation to these changes? What kind of science education will position children and young people to respond to the challenges they face with hope and with resilience?

The OECD's (2019) position paper, *The Future of Education and Skills 2030: The future we want*, encouraged countries to find answers to two questions:

- What knowledge, skills, attitudes, and values will today's students need to thrive and shape their world?
- How can instructional systems develop these knowledges, skills, attitudes, and values effectively?

How should countries such as Australia and New Zealand respond to these questions in a manner that leverages governments in unified action for science education that is fit for the future? In Australasian science education, we find ourselves at a policy moment that presents both challenges and opportunities. The national decadal plan for the Australian National STEM School Education Strategy, as outlined by the Education Council (2015), is set to conclude in 2026. Similarly, New Zealand's 10-year strategy *A Nation of Curious Minds He Whenua Hihiri i te Maha* (New Zealand Government, 2014), concluded in 2024.

ASERA recognises the opportunity to seize this policy moment to articulate a range of imperatives that must shape the next iterations of national science education policy. These relate to multiple critical components of curriculum design and delivery; content, processes and contexts as well as non-cognitive elements related to science learning and teaching. Indeed, as noted in the rapidly changing landscape of research in science education taking place in Australia and New Zealand (Wang, van Driel & Treagust, 2025), attending to these imperatives is essential for the successful and productive futures of science education and science education research in both countries.

Three cross-cutting themes of strategic significance to the future of Australasian Science Education have emerged from discussions held between the ASERA policy working group members, as well as through a symposium held at the 2024 ASERA 55 conference held in Albany, New Zealand.

The themes are:

1. Curriculum and Pedagogy;
2. Positioning the Sciences; and
3. Communities of Practice.

In this position paper, we explain the significance of each theme and the role that diverse research methods play in enabling an approach to science education that develops scientific literacy and fosters curiosity, confidence, resilience, creativity, innovation and hopefulness in the lives of all young people of Australasia.

CURRICULUM & PEDAGOGY

01

1.1 Statement Of The Issue or Context

The purposes and practices of science education must adapt to the changing circumstances and needs of 21st-century societies. There have been persistent and growing calls for education more generally to focus on the development of 21st-century or 'STEM' skills. Curriculum and pedagogy are fundamentally implicated in these changes, and contested as multiple demands are made of schools to prepare students for rapidly changing futures. This theme includes: curriculum, representing the focus on what knowledges are appropriate and for what purposes; pedagogy, referring to classroom practices and relations; assessment, including questions of what is valued and how learning is supported; Indigenous knowledges and how they are viewed, reflecting a growing recognition of the need for an inclusive curriculum that values Indigenous perspectives; and sustainability and climate change education, concerning the role of science education in pursuing a sustainable and just future.

1.2 Vision Statement Linking to ASERA

The ASERA research community has a long and internationally recognised history of world-leading research into curriculum and pedagogy, playing a key international role in moving the field forward as our understandings of the teaching and learning process have diversified and deepened and the purposes of education have been progressively widened beyond traditional knowledge transmission models. A key commitment of ASERA researchers is to science teacher education, and research into curriculum, pedagogy, assessment and Indigenous knowledges looks towards establishing new knowledge, informing professional practice and influencing and often advising on policy prescriptions. As the community itself has increasingly expanded beyond our traditional European roots to include researchers from the global south, particularly the Asia Pacific region, ASERA research has increasingly taken on and represented multiple and enriched perspectives on these issues. This can only benefit our future teaching community and the teacher education and research policy settings that drive renewal. Recently, all these foci — curriculum, pedagogy, assessment, Indigenous knowledges and climate change education — have been the subject of political and media contestation around fundamental education and science education purposes. We make no apology that these position statements and recommendations reflect the professional, research evidence-informed views of a community that is a key part of international thinking and policy framing on these issues.

1.3 The Science Curriculum: Key Dimensions & Contestations

Science curricula change and adapt to reflect changing times and changing perspectives on its fundamental purposes. Science education has always had a mandate to prepare the next generation of STEM professionals to attend to the needs of advanced economies, but also a mandate to educate citizens more generally to operate in a critically informed way when interacting with science and technology ideas and processes. Running through these demands is a need to ensure just, equitable access to the important knowledges and practices of the sciences and their relation to societal agendas. The balance between these is frequently contested at a worldview and a political level.

Currently, the Australian Curriculum: Science includes the major themes that one would expect of a contemporary curriculum, at a general level. There are, however, significant omissions, and the detailed framing and translation of a 21st-century curriculum into classroom practice requires further elaboration and support for teachers, particularly regarding the representation of contemporary scientific practices and knowledges. This is needed across all levels from K-12, noting the under-representation of science in Early Years Education frameworks.

Current global research perspectives advocate for a contemporary science curriculum that:

- Develops knowledge of the major canonical ideas of science that both inform the STEM professions and our personal lives and societal practices.
- Engages students with scientific ideas and practices in an informed progression from early childhood through to the end of formal education.
- Develops students' science-related competencies in critical reasoning, decision-making and action, including an appreciation of how science engages with socio-ecological challenges (Dawson, 2025).
- Develops knowledge and competencies relating to the ways science builds knowledge through evidential processes, including peer review.
- Develops skills in searching out and making considered and critical judgments using publicly available scientific knowledge.
- Develops skills in the critically informed use of AI and critical media literacy.
- Engenders knowledge of and respect for Indigenous scientific practices and ways of knowing, and the connection of these to Western scientific practices.

1.3.1 Recommendations

Recommendations for Policy

→ Develop science curricula and resources that focus on preparing young people from the earliest age as both science-informed citizens and future professionals who can engage critically with contemporary scientific thinking, practices, and values, including their interactions with broader social purposes.

Recommendations for Practice

→ Ensure that science teachers have targeted access to professional learning associated with contemporary curriculum developments, including the use of AI.

→ Develop further elaboration and support for teacher educators, translating scientific knowledge and skills into practice in early years settings.

Recommendations for Research

→ Build a curriculum research evidence base that recognises multiple science curriculum purposes appropriate for changing global contexts, across the K-adult education continuum.

1.4 Pedagogy

There has recently been considerable public and policy-framing debate about the relative merits of explicit teaching and inquiry. The presentation of these positions as binary is unhelpful in understanding the findings of a vast body of research in science education focused on effective pedagogies, which indicate a more complex and nuanced position (de Jong et al., 2023; Tytler et al., 2025). ASERA researchers are engaged in research using a variety of well-established methodologies that produce reliable evidence informing both policy and classroom practice. ASERA does not recognise any one pedagogy as pre-eminent, but argues that the question of effectiveness is necessarily an interaction between purposes, pedagogy and context.

The implications for effective pedagogies in science classrooms are:

- Teachers explicitly but flexibly frame the disciplinary knowledge and practices of science. This includes the strategic framing and support of student-led activity relating to conceptual learning, developing inquiry competencies, and reasoning in socio-scientific contexts.
- A structured approach is used to develop student competencies in scientific epistemic practices, involving a mix of student-led and teacher-framed inquiry activities.
- Students are actively engaged in reasoning through the discursive practices of science, including, for example, critically informed questioning, argumentation, modelling, and data analysis (Dawson, 2025).
- Teacher contextual judgments are crucial in stimulating, framing, supporting and extending students' science knowledge and practice.
- Teacher classroom practice is informed by contemporary theoretical advances in learning, using evidence from recent findings of neuro and cognitive science, and from classroom-based studies utilising a variety of methodologies and forms of evidence.
- Classroom practices place a strong emphasis on supporting students to reason using the multimodal languages of scientific knowledge-building practices, involving the generation and interpretation of text, diagrams, mathematical representations, and material artefacts (Pham & Tytler, 2021).
- Teachers engage with students' worlds, interests and language to extend these towards scientific ways of thinking and practising (Duit & Treagust, 2003).
- Science in early childhood engages students' interest and curiosity through a strategic mix of exploratory play and intentionally guided experiences.
- Teaching practices encompass a focus on equitable and socially just access to achievement in science.

1.4.1 Recommendations

Recommendations for Policy

- → Ensure that policy formulation recognises a variety of methodologies and forms of evidence as needed to inform science teacher education and system policy with regard to pedagogical advice and prescription.
- → Develop instructional design recommendations at the system level that flexibly respond to multiple curriculum outcomes, drawing on research evidence generated by the ASERA and wider global science education research community.

Recommendations for Practice

- → Ensure that science teacher educators are supported to recognise, represent and advocate flexible evidence-based pedagogies that reflect a variety of student outcomes and to effectively develop the professional judgments of teachers in responding to students' diverse and complex learning needs.

Recommendations for Research

- → Build a research evidence base to establish teaching and learning theories and practices that inform a variety of science education competency outcomes, that can inform both teacher education practice and system policy prescriptions.

1.5 Assessment

Assessment regimes must reflect the multiple purposes of science education, but a major focus needs to be on scientific literacy, emphasising the induction of all students into the knowledge and practices of science that will inform them as adults in an increasingly technological world. Currently, there is a sense that a focus on large-scale assessments, while useful for ascertaining strengths and weaknesses in the system, can distort what we know about effective teaching and learning in science for diverse outcomes.

The implications for effective assessment practices include:

- Assessment processes serve the dual purposes of supporting favoured learning outcomes and credentialing students. These are aligned so that summative assessments do not undermine what is understood about quality learning.
- Summative assessments support higher-level thinking and encourage and support students to engage in the discursive practices and major conceptual frameworks of science.
- A crucial aspect of responsive planning and teaching involves teachers monitoring and responding to students' ideas.
- Science assessment practices are framed to support differentiation and to ensure equitable outcomes for diverse populations.
- Science assessment practices focus on the knowledge-building (epistemic) practices of science and not just its knowledge products.

1.5.1 Recommendations

Recommendations for Policy

→ Promote the establishment of system-wide assessment and reporting practices designed to accommodate a variety of science learning outcomes consistent with international best practice, including critical and creative reasoning, decision making and agency.

Recommendations for Practice

→ Ensure that initial teacher education (ITE) courses and professional learning workshops promote differentiated assessment practices reflecting multiple student learning outcomes.

Recommendations for Research

→ Coordinate a systematic research agenda focused on flexible assessment practices that target a variety of science learning outcomes, for system-wide application in ITE.

1.6 Indigenous Knowledges

There are multiple ways of understanding the world around us. Science is one knowledge system that draws upon particular epistemological underpinnings, assumptions, and canonical knowledge structures (Tolbert et al., 2024). Juxtaposed against Science knowledge systems are Indigenous sciences and neo-Indigenous knowledge systems. Indigenous knowledges are "part of the lifeways, knowledges and cultures of Indigenous peoples" and connected to the world around us (Johnson, 2024). Thus, Indigenous Science (or Indigenous ways of knowing) can be described as both a way of being in nature and knowledge about nature. While Indigenous Science is a growing area of research in Australasia and beyond, it has been challenged by some scientists who deem science should be value and culture-free. Stewart (2024) advocates that multiple ways of knowing nature are valuable and that Indigenous knowledges and Science can act as mirrors to hold each other to account. Utilising multiple knowledge systems, including Indigenous knowledges, can support diverse learners, including Māori, Aboriginal and Torres Strait Islanders, and Pacific Islanders, as it enhances relevance, and positions the knowledges as valuable while supporting the development and enactment of epistemic agency for Indigenous and non-Indigenous students (Tolbert et al., 2024). Incorporating Indigenous knowledges into a science program should be done responsibly under the guidance of Indigenous experts and not be tokenistic.

The implications for the representation of Indigenous knowledges include:

- Change is led by Indigenous researchers and experts in the field.
- Indigenous knowledges that are shared are honoured and taken up in value-added, rather than tokenistic ways.
- Educators listen to tribal experts about how they can support Indigenous students best in learning.
- Support is given to non-Indigenous teachers in terms of training and resources to help students learn about different ways of knowing.

- Initial teacher educators model how to teach in culturally affirming ways in science.
- Care is taken by educators and policymakers to not recolonise learning particularly through inappropriately aligning or subsuming Indigenous knowledge systems with scientific conventions.
- Science educators are supported to adhere to Te Tiriti O Waitangi in New Zealand, and other policy documents supporting Indigenous students in both Australia and New Zealand.
- Indigenous ways of knowing are honoured for the insight they bring to relational ways of knowing and valuing the natural world.

1.6.1 Recommendations

Recommendations for Policy

→ Ensure responsible and respectful collaboration between Indigenous scholars and science educators to ensure significant and critically informed representation of Indigenous knowledges in the science curriculum.

Recommendations for Practice

→ Implement curricula in ways that recognise and promote the value of Indigenous knowledges and collaborate with local Indigenous Elders, knowledge holders and Indigenous-led organisations to embed respect for Indigenous ways of knowing in the science curriculum.

Recommendations for Research

→ Support and drive research, and outcomes of research into Indigenous ways of knowing to advocate for policy formulation.

1.7 Climate Change Education & Sustainability

A global survey of science teachers (OUP, 2021) ascertained that 1) only 31% agreed that science was 'fit for the future' and 2) over 90% identified climate change and environmental threats as a key concern. Associated with international concerns about anthropogenic climate change, biodiversity loss, and resource depletion that threaten significant changes to our global systems, is a call to incorporate a strong strand of Climate Change Education into the science curriculum, given that science is profoundly implicated in identifying, monitoring and responding to this Anthropocene polycrisis. It has been recognised (OECD, 2023) that developing science knowledge and practice in these contexts enriches its relevance and can promote enhanced learning outcomes (Monroe et al., 2019).

The implications for embedding climate change education within school science include:

- School science reflects that many contemporary scientists working on climate change-related phenomena are driven by and engage with broader societal needs and agendas, involving competing values and interests.
- The science curriculum engages strongly with reasoning about complex systems, such as those involved with green chemistry, material life cycles and circular economy, or human environment interactions associated with biodiversity threats.

- Dealing with climate change needs to involve a recognition of challenges as socio-ecological in nature and not addressed simply by technical solutions. Thus, the aims of science education include responsible decision making and action that takes account of multiple perspectives and knowledges (White et al., 2024).
- The science curriculum reflects the specific disciplinary ideas and tools related to anthropogenic climate change, but represents these in interdisciplinary ways that acknowledge other knowledge systems and values.

1.7.1 Recommendations

Recommendations for Policy

→ Frame key science concepts and practices in the context of addressing contemporary socio-ecological challenges, including climate change and biodiversity loss, energy transitions, circular economy and misinformation.

Recommendations for Practice

→ Develop targeted professional learning workshops that support teachers to promote student decision-making skills and action in relation to a variety of socio-ecological challenges related to anthropogenic climate change.

Recommendations for Research

→ Build and coordinate research programs focused on Climate Change Education in science across the K-12 spectrum and beyond, as a matter of urgency.

POSITIONING THE SCIENCES

02

2.1 Statement Of The Issue or Context

Science and STEM are often positioned by government policy and industry groups as critical to national economic prosperity and technological competitiveness. In contrast, discourses within the science, STEM education, and research communities often align with more inclusive and socially oriented agendas, such as scientific literacy. The continued decline in student interest and enrollment in senior secondary science subjects and university science is a significant issue. This trend can lead to a decline in the number of students pursuing careers in science teaching, which in turn affects the overall quality and availability of science education. Enrolments in STEM-related Vocational Education and Training courses have been falling since 2015 (Department of Industry, Science & Resources [DISR], 2024). Across the university and vocational education and training (VET) sectors, women and other diverse groups are still underrepresented compared to men (DISR, 2024). A critical issue for science education revolves around how science is positioned by policy, research, and schools, and the interaction between competing agendas. This consideration of the positioning of science includes the role of scientific disciplines in shaping school curricula, teacher preparation and specialisation, and the identities of both teachers and students. It also encompasses the cross-disciplinarity within scientific practice that influences schools and initial teacher education (ITE), particularly through STEM initiatives. Additionally, it considers the role of science disciplines as enablers of innovation, especially in relation to critical and emerging technologies that are central to the nation's aspirations for economic diversification, and which are integrated into school curriculum.

2.2 Vision Statement Linking to ASERA

The ASERA research community addresses critical questions about the positionality of the sciences, focusing on whose research is valued and for what purposes. It also examines how schools and universities can be positioned as enablers and drivers in determining and enacting science for the future. Critical to science education research in Australasia is understanding how science and STEM are positioned in political discourse, as well as the challenges and opportunities that arise. ASERA seeks to influence policy on the sciences and how they are represented in educational settings, and to generate research that furthers our understanding of the impact of the sciences on students of all ages, in schools and other educational settings, and the broader community, ultimately leading to transformed educational practice and better-informed societies.

Three foci have been identified within this theme. These are 'role of disciplines', 'role of cross-disciplinary studies' and 'role of sciences in futures thinking.'

2.3 Role of Disciplines

The disciplines have traditionally been the organising subject and curriculum structures for contemporary schooling. "Science" is taught as a composite subject in early childhood, primary and lower secondary years. Subjects also form the basis of accreditation of ITE programs and teachers' subject specialisations, particularly at the secondary school level. There is, however, often a disconnect between the science degree, science education preparation, and the conditions that teachers face once employed. Also, the positioning of science in primary schools and early childhood education is a constant struggle to ensure the quality and quantity of science instruction. Furthermore, most science teachers teach

science disciplines for which they have a limited formal background (teach out-of-field), and many (19%) are not qualified to teach science (AITSL, 2022). Furthermore, early-career teachers are those who are most often teaching out of field (Productivity Commission, 2022; Weldon, 2016).

2.3.1 Recommendations

Recommendations for Policy

- → Ensure that across K-12, sufficient classroom time is allocated for sequences of science teaching focused on conceptual and skill development.
- → Support the implementation of a variety of evidence-based models for the development of teachers of science in early childhood and K-6 settings, including dedicated science specialist teachers, integrated STEM specialist teachers, and professional learning provision for generalist classroom teachers.
- → Implement policies that build teachers' disciplinary backgrounds and strengths by incentivising pathways for non-science teachers to re-specialise in a science discipline.

Recommendations for Practice

- → Develop initiatives to build resilience in the system for early career teachers by creating stronger links between schools and universities, including, for example, mentorship programs, ongoing professional development, and collaborative projects.
- → Support teachers to engage with STEM professionals to integrate contemporary research and industry applications into their teaching practices
- → Foster ongoing relationships between science teacher educators and schools to create opportunities for pre-service teachers to engage with well-informed and resourced science teaching experiences
- → Foster relationships between schools and faculties of education and sciences at universities and TAFE institutions to support authentic, well-informed, and well-resourced science teaching and learning opportunities.
- → Ensure that science content units in ITE are closely aligned with the school curriculum to better prepare teachers for the realities of the classroom.

Recommendations for Research

- → Conduct research to investigate the relationships between science degrees, science education preparation, and the conditions teachers face once employed to identify effective practices, specific gaps, and to develop targeted strategies to address them.
- → Assess how these changes influence teacher preparedness, identity, and commitment to the science subject culture.
- → Investigate the impact of different models of science instruction (such as a dedicated science specialist teacher, an integrated STEM specialist teacher, and a generalist classroom teacher) on the quality and quantity of science instruction in primary schools.

2.4 Role of Cross-Disciplinary Studies

While STEM has sparked interest in cross-disciplinary studies, its effective incorporation into the curriculum has been challenging, typically appearing as project-based learning to tackle an 'authentic' problem. Primary and secondary school STEM (and often STEAM) may focus on disciplinary content, but more often focuses on problem-solving, design activities, and digital technology activities. Despite growing interest in STEM education, a challenge remains in effectively supporting teachers in implementing interdisciplinary or multidisciplinary STEM learning.

2.4.1 Recommendations

Recommendations for Policy

- → Develop a clear framework for interdisciplinary STEM education to ensure consistent but flexible implementation that allows schools to capitalise on teachers' strengths and interests.
- → Encourage policies that support the integration of cross-disciplinary studies in the science curriculum, moving beyond siloed subject offerings.

Recommendations for Practice

- → Provide professional development for teachers to build confidence and competence in delivering cross-disciplinary and project-based STEM education.
- → Implement project-based learning approaches that tackle real-world problems, ensuring that STEM education is relevant and engaging for students.

Recommendations for Research

- → Investigate effective methods for assessing students' conceptual development in STEM projects, ensuring that assessments capture the depth and breadth of student learning.
- → Conduct research to evaluate the effectiveness of different STEM programs and approaches, identifying best practices for curriculum alignment, promoting student engagement, and building and leveraging teacher capabilities.

2.5 Role of Sciences in 'Futures Thinking'

Science is globally recognised as a driver of innovation, with emerging technologies central to national goals for economic growth and diversification. Governments often frame the future in terms of workforce productivity, placing education at the heart of skills development. Yet, this narrow focus can miss the deeper role science education can play in helping young people engage with the future. Today's youth often view the future with anxiety, especially in the face of climate change and technological disruption, including the ethical dilemmas caused by GenAI in science and society (OECD, 2023). Science education can counter this by fostering futures thinking—helping students see the future as a space they can shape through informed action. As Levrini et al. (2020) note, futures studies explore trends and patterns to create possible and desirable scenarios. Science classrooms should also adopt this approach, especially since many students' fears are tied to science and technological change (Rasa & Laherto, 2022). By drawing on interdisciplinary resources, including those that integrate other areas such as the arts, science education can empower students to navigate uncertainty and imagine better futures.

2.5.1 Recommendations

Recommendations for Policy

- → Develop policies that integrate futures thinking into the science curriculum, ensuring that students are equipped with skills for higher-order thinking and future-oriented problem-solving.
- → Incorporate critical and emerging technologies, including GenAI, and future scientific advancements, into the curriculum to prepare students for future economic and technological landscapes.

Recommendations for Practice

- → Develop and implement science curriculum and pedagogy designed to tackle feelings of despondency and directionlessness in some young people in response to uncertain and unimaginable futures.
- → Represent science as future-oriented in the science curriculum, with modelling and prediction as essential to science.

Recommendations for Research

- → Conduct research to assess the impact of futures thinking in the science curriculum on students' preparedness for future challenges and their engagement with science.
- → Investigate the effectiveness of integrating critical and emerging technologies into science education and its impact on students' skills development and career readiness.

COMMUNITIES OF PRACTICE

03

3.1 Statement Of The Issue or Context

Sustainable science learning takes place within, and alongside different communities of practice, be they early childhood, primary, secondary and/or tertiary education centres, university research teams, centres of innovation, business and industry and Government departments. The issues and concerns raised in previous sections of this document all occur within a specific context. Environmental, historical, cultural, and social factors, along with individuals' needs and differences, interact with the processes of science teaching and learning at all levels of education (i.e., early childhood through to tertiary). These factors cannot be ignored when framing a science education policy that is fit for the future. Science education aims not only to develop future scientists but also to improve scientific literacy within society. Consequently, responsible decision-making within any future science education requires recognition and understanding o f the multitude of learning contexts, in addition to the variety of pedagogical processes involved.

3.2 Vision Statement Linking to ASERA

ASERA is a model example of a community of practice where members are both engaged in and informed by research practices and outcomes in the field of science education. ASERA members use a range of quantitative, qualitative, and mixed-methods approaches to produce quality research that contributes to ensuring that all individuals (from early childhood to tertiary) have equitable access to an evidence-informed, robust science education. Our members provide research leadership through mentoring, supervision, teaching, and dissemination of our research. Research contexts range from global (e.g. large comparative studies) to local (e.g. a single teacher). Initial teacher education now, and in the future, is a particularly important context for many ASERA members as they use their research findings and knowledge to prepare future generations of teachers and support teachers of science. With this collective expertise, ASERA members need to have input into public debate and future policies impacting science education.

Three foci have been identified within this theme. These are 'fostering teacher professionalism', 'activating a science identity' and 'valuing evidence'.

3.3 Fostering Teacher Professionalism

There are multiple facets to developing science teacher professionalism. Important to initial teacher education (ITE) and early career teachers is the acquisition and application of pedagogical content knowledge (PCK) specific to a discipline of science. First proposed by Shulman (1986, 1987), pedagogical content knowledge is at the heart of ways by which teachers in the process of teaching transform content to make science content knowledge (CK) accessible and comprehensible to their students. The development of PCK is a valuable indicator of science teacher expertise (van Driel et al, 2014, 2023). Consequently, serious attention needs to be given to teacher professionalism that is grounded in teacher practice that not only values science discipline-specific content knowledge (CK) but also science pedagogical content knowledge (PCK) that builds teacher capacity and quality learning. Recognising these knowledges and backgrounds in relation to science is critical, particularly within the senior years of secondary science teaching (e.g., Senior Chemistry, Senior Physics, other), where graduate teachers are more likely to leave the teaching profession within the first five years.

One example of a professional learning opportunity that has been shown to enhance pre-service teachers' views of STEM and their science teaching is the provision of a brief STEM industry engagement experience within studies of science curriculum (Aldous et al., 2024). By bringing together different communities of practice (viz pre-service teachers, university research scientists, university departments of science teacher education, secondary schools, STEM businesses and industry and government departments) in the solving of an identified science industry problem meaningful to students in schools, deep learning was promoted, science identity enriched and teacher professionalism enhanced.

3.3.1 Recommendations

Recommendations for Policy

- → Ensure that science teacher education policy recognises and values the need for teachers of science to be skilled in science content knowledge (CK) and science pedagogical content knowledge (PCK).
- → Develop a program of targeted support, including resource development and professional learning, to enhance the content and pedagogical content knowledge of teachers of science.
- → Ensure that any resource development initiatives focused on science teaching and learning have a strong emphasis on teacher professionalism and learning.

Recommendations for Practice

- → Enhance teacher PCK by providing professional learning opportunities for early career and in-service science teachers to increase their capacity to know, decide and select the enactment of a range of pedagogies relevant to science learning and teaching appropriate to context.
- → Develop instructional advice and resources to support teachers of science that reflect science education research into topic-specific aspects of PCK.
- → Ensure that for each discipline of science, training in both science CK and science discipline-specific PCK takes place and is a necessary requisite of teacher registration for the purposes of enabling the practice of science teaching to take place successfully.
- → Enhance teacher CK by providing professional learning opportunities for early career and in-service science teachers to grow their knowledge base, keeping abreast of new scientific developments for the purposes of enriching science teaching and learning and engaging students.

Recommendations for Research

- → Develop programs of research investigating the relationship between teacher CK and PCK in science learning and teaching, early career teacher retention, students' future career trajectories and science identity.

3.4 Activating a Science Identity

Prospering nations, research has found, are among those whose citizens understand and value scientific knowledge, who are able to draw on and use this knowledge in their personal lives, who can apply science knowledge in community decision making and in pursuing science-related careers. In essence, their citizens have and can activate a self-sustaining identity with science. This begs the question, "How can we get children and young adults to grow in a science identity"?

Expressed simply, the concept of identity involves knowing who you are and where you belong (OECD, 2022). This is no different to developing an identity in science. Identity can be built through community, influential others, and the recognition of one's own abilities by oneself and others (Kim & Sinatra, 2018; Vincent-Ruz & Schunn, 2018).

Having a well-developed science identity is known to play a pivotal role in students' subject choices and future career trajectories (Vincent-Ruz & Schunn, 2018). This is particularly the case for girls and other under-represented groups within science (Kim et al, 2018). Consequently, any activity that works to build science identity must activate personal understanding about who one is in the world of science, as well as provide a sense that one can belong in the field of science.

There is an abundance of research evidence that the early and primary years are important in the development of science identity and future aspirations in science (Hobbs et al., 2017; Tytler & Ferguson, 2023).

3.4.1 Recommendations

Recommendations for Policy

- → Promote the activation of a science identity among citizens, beginning in early childhood and continuing throughout adult life.
- → Support and fund evidence-based models of best practice that effectively foster positive science identity in all students, from early childhood through to tertiary education.

Recommendations for Practice

- → Activate science identity development at all levels of schooling to support students' subject choices and long-term career pathways, particularly for girls and other underrepresented groups.

Recommendations for Practice

- → Develop programs of research into supporting science identity development for all students to ensure equitable access to science career choices.

3.5 Valuing Evidence

Neither within education generally, nor in science education, can the notion of one size fits all be applied to educational purposes and classroom practices. Curriculum and pedagogy in science must focus on multiple competencies (OECD, 2023), including conceptual, procedural, and epistemic knowledge, as well as the ability to design, analyse, and interpret scientific investigations, and to seek out, critically analyse, and make decisions drawing on scientific reports. Consequently, a diversity of approaches to science curriculum development and pedagogy is needed, based on multiple evidence bases involving a variety of theoretical perspectives and associated research methodologies. This variety is essential if we are to develop a responsible and expert teaching force with a rich understanding of science teaching and learning.

3.5.1 Recommendations

Recommendations for Policy

- → Develop policies that value and leverage multiple evidence bases to advocate for layered teaching strategies targeting 1) a variety of learning outcomes, 2) differentiated learning needs of students, and 3) different contexts in science.
- → Develop alignment between policies related to science classroom practice, teacher registration and accreditation requirements for tertiary institutions offering science teacher education courses.

Recommendations for Practice

- → Ensure science teacher education practices include the explicit representation of multiple research evidence bases that inform different science education purposes, multiple competencies, and the differentiated needs of students and schools.
- → Promote research as a valuable tool for schools by empowering teachers and school leaders to act as co-researchers who generate knowledge about practice, learning, leadership, and curriculum.

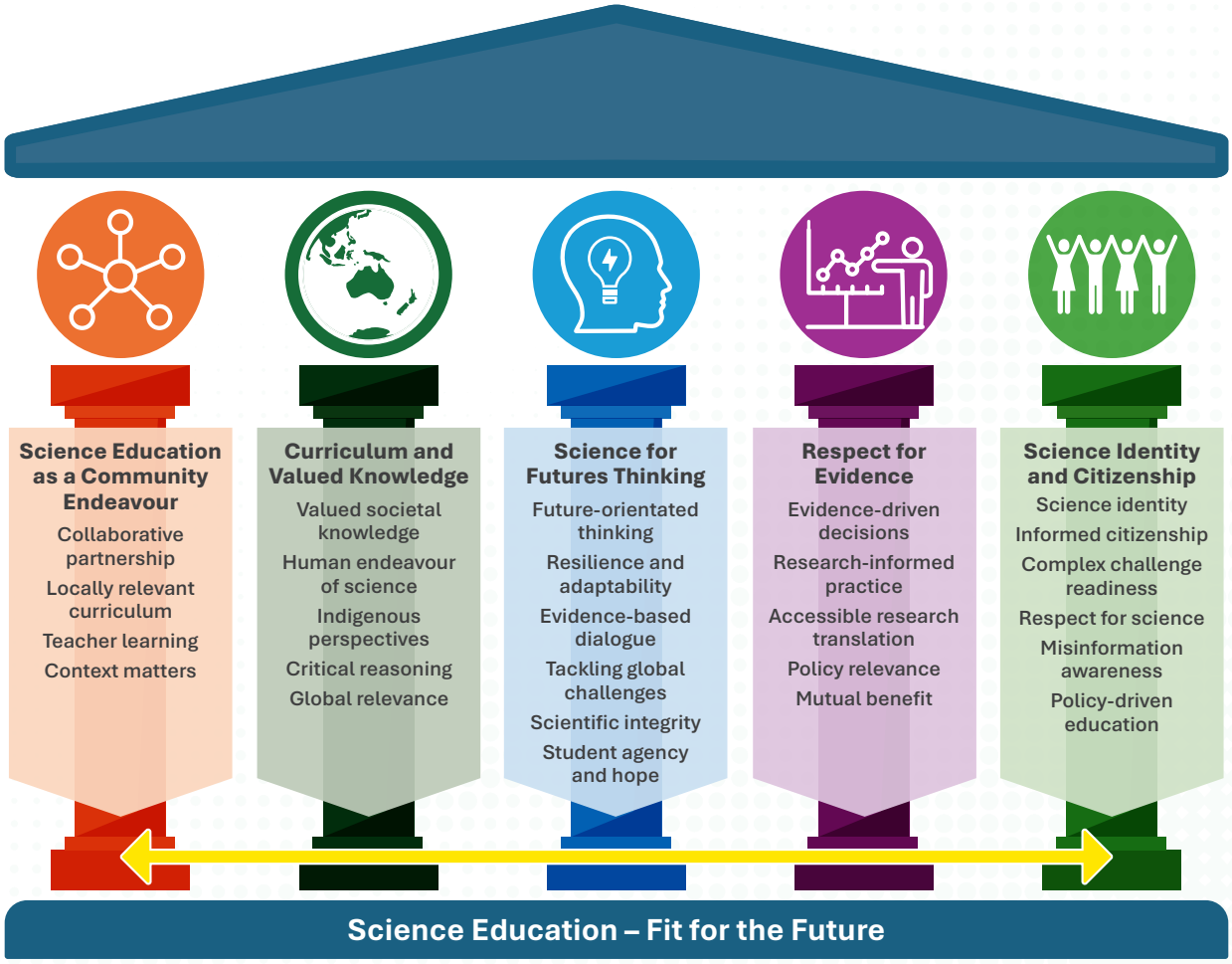
Recommendations for Research

- → Value and promote diversity in science education research, including traditional and emerging methodologies and contemporary theoretical perspectives from multiple fields, including socio-cultural theories, cognitive science and neuroscience.

CONCLUSION

This White Paper outlines strategic recommendations for a science education fit for a future marked by multiple global and local STEM-related challenges. Focusing on Australia and New Zealand, it outlines policy, practice, and research priorities aimed at strengthening science education through collaborative curriculum development and research. These strategies seek to future-proof science education across all levels of schooling by helping students connect science to their personal lives and the wider world, fostering active participation and a sense of belonging, and equipping them with the knowledge and skills to contribute as STEM professionals or citizens to help shape a positive future.

The recommendations from this paper can be summarised as five pillars of a science education that is fit for the future:



Pillar 1. Science Education as a Community Endeavour

Science education is strengthened through collaboration among schools, communities, governments, universities and scientific organisations, including business and industry. Locally relevant curriculum must be co-developed with young people's needs and lived experiences in mind. Teacher professional learning is essential, especially in out-of-field areas, due to changing demands and purposes of the science curriculum. Context matters – local realities, shared goals, and the collective expertise of all stakeholders must inform curriculum decisions. Elevating the status of science educators and promoting evidence-informed, enriched teaching approaches strengthens its relevance and impact.

Pillar 2. Curriculum and Valued Knowledge

Science curriculum must reflect the knowledge, skills, and practices valued by society and the science community. It should portray science as a human endeavour and include diverse perspectives, especially Indigenous knowledges and the multiple perspectives that inform contemporary STEM challenges. The curriculum must evolve in response to rapidly changing global contexts, empowering students to think deeply, reason critically, and develop the science competencies necessary to make informed and responsible decisions in their work and lives.

Pillar 3. Science Education for Futures Thinking

Science education must play a vital role in preparing students for uncertain futures by fostering higher-order thinking, resilience, and adaptability – skills essential for tackling global challenges such as climate change, AI, and misinformation. Science needs to encourage respectful dialogue, collaboration across diverse views, and evidence-based reasoning. By engaging with future-oriented problems, students can develop agency and hope. An informed science education equips them to enter debates with integrity, applying knowledge and understanding of how evidence is used to shape decisions and solve complex, real-world issues.

Pillar 4. Respect for Evidence

Respect for evidence must underpin school decision-making and classroom practice. Science education research should be practical, context-driven, and directly relevant to schools. Science teachers, as professionals and scientists, bridge theory and practice and are vital partners in co-creating knowledge. Co-research partnerships foster mutual benefit, translating research into accessible formats that inform classroom practice and policy. These collaborative efforts create new knowledge, enhance teaching, and align shared goals with local contexts.

Pillar 5. Science Identity and Citizenship

Science education plays a crucial role in students' development as informed citizens and future professionals. It helps activate a science identity, shaped by context and curiosity. Students must be equipped to address complex global challenges such as climate change, biodiversity loss, AI, and misinformation. We need citizens who understand and respect science, not just practitioners but advocates.

This white paper reflects ASERA's call for urgent policy responses. Science education must evolve to meet societal needs and inspire young people to shape the future.

It's not an option to just keep doing the same thing!

REFERENCES

Aldous, C. R., Aviyanti, L., Dunlop, A., Palumbo, K., & Stephenson, H. (2024). *Improving student interest in STEM through pre-service teacher industry engagement: Bridging the gap* (Research Report No. 5). Flinders University Press. https://doi.org/10.25957/n5tj-jm35

Dawson, V. (2025). Using socioscientific issues to teach argumentation to Year 7 science students in a low socioeconomic rural Australian school. *Research in Science Education, 55*, 1–16. https://link.springer.com/article/10.1007/s11165-024-10224-y

Department of Industry, Science and Resources. (2024). *STEM equity monitor data* [Data set]. Australian Government. https://www.industry.gov.au/publications/stem-equity-monitor

de Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J. D., Hmelo-Silver, C. E., & Zacharia, Z. C. (2023). Let's talk evidence: The case for combining inquiry-based and direct instruction. *Educational Research Review, 39*, Article 100536. https://doi.org/10.1016/j.edurev.2023.100536

Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education, 25*(6), 671-688.

Education Council. (2015). *National STEM school education strategy 2016–2026*. Australian Government. https://www.education.gov.au/australian-curriculum/resources/national-stem-school-education-strategy

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning. *Educational Psychologist, 42*(2), 99–107. https://doi.org/10.1080/00461520701263368

Hobbs, L., Jakab, C., Millar, V., Prain, V., Redman, C., Speldewinde, C., Tytler, R., & van Driel, J. (2017). *Girls' future—Our future: The Invergowrie Foundation STEM report*. http://www.invergowrie.org.au/girls-future-our-future-the-invergowrie-foundation-stem-report/

Johnson, S. (2024). The importance of learning with/on/from land and place while honouring reciprocity in Indigenous science education. *Cultural Studies of Science Education, 19*, 163–187. https://doi.org/10.1007/s11422-023-10205-z

Kim, A. Y., & Sinatra, G. M. (2018). Science identity development: An interactionist approach. *International Journal of STEM Education, 5*, Article 51. https://link.springer.com/article/10.1186/s40594-018-0149-9#citeas

Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research, 88*(4), 589–625. https://doi.org/10.3102/0034654318779957

Levrini, O., Tasquier, G., Barelli, E., Branchetti, L., & Turrini, A. (2021). Recognition and operationalization of future-scaffolding skills in climate change education. *Science Education, 105*(2), 281–308. https://doi-org.ezproxy-f.deakin.edu.au/10.1002/sce.21612

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: A systematic review. *Environmental Education Research, 25*(6), 791–812. https://doi.org/10.1080/13504622.2017.1360842

New Zealand Government. (2014). *A nation of curious minds: He Whenua Hihiri i te Maha*. https://www.mbie.govt.nz

OECD. (2022). *Trends shaping education 2022*. OECD Publishing. https://doi.org/10.1787/6ae8771a-en

OECD. (2023a). *PISA science framework 2025*. OECD Publishing. https://pisa-framework.oecd.org/science-2025/

OECD. (2023b). OECD *digital education outlook 2023: Towards an effective digital education ecosystem*. OECD Publishing. https://doi.org/10.1787/c74f03de-en

Oxford University Press. (2021). *The evolution of science education*. https://www.oup.com.au

Pham, L., & Tytler, R. (2021). The semiotic function of bridging representations in solution chemistry. *Research in Science Education, 51*, 1–19. https://link.springer.com/article/10.1007/s11165-021-10022-w

Prain, V., & Tytler, R. (2022). Theorising learning in science through multimodal representations. *Research in Science Education, 52*, 805–817. https://doi.org/10.1007/s11165-021-10025-7

Productivity Commission. (2022). *Review of the National School Reform Agreement*. Australian Government.

Rasa, T., & Laherto, A. (2022). Young people's technological images of the future. J*ournal of Futures Studies, 10*, Article 4. https://link.springer.com/article/10.1186/s40309-022-00190-x

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Stewart, G. (2024). Mātauranga Māori and the school of science. *Te Kaharoa, 16*(1). https://doi.org/10.24135/tekaharoa.v16i1.406

Tolbert, S., Hipkins, R., Cowie, B., & Waiti, P. (2024). Epistemic agency and Indigenous knowledge in school science. *International Journal of Science Education*. https://doi.org/10.1080/09500693.2024.2356229

Tytler, R., & Ferguson, J. (2023). Student attitudes, identity, and aspirations toward science. In N. G. Lederman et al. (Eds.), *Handbook of research on science education* (Vol. 3, pp. 158–192). Routledge.

Tytler, R., Prain, V., & Salimpour, S. (2025). Going beyond a singular "science of learning" framework. *New Zealand Journal of Educational Studies*. https://doi.org/10.1007/s40841-025-00414-1

van Driel, J. H., Berry, A., & Meirink, J. A. (2014). Research on science teacher knowledge. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2, pp. 848–870). Routledge.

van Driel, J. H., Hume, A., & Berry, A. (2023). Exploring the frontiers of socioscientific issues. In N. G. Lederman et al. (Eds.), *Handbook of research on science education* (Vol. 3, pp. 1123–1161). Routledge.

Vincent-Ruz, P., & Schunn, C. D. (2018). The nature of science identity. *International Journal of STEM Education, 5*, Article 48. https://doi.org/10.1186/s40594-018-0140-5

Wang, X., van Driel, J., & Treagust, D. F. (2025). The changing landscape of science education research in Australia and New Zealand. *Research in Science Education*. https://doi.org/10.1007/s11165-025-10308-3

Weldon, P. R. (2016). *Out-of-field teaching in Australian secondary schools* (Policy Insights, Issue #6). Australian Council for Educational Research. https://research.acer.edu.au

White, P. J., Ardoin, N. M., Eames, C., & Monroe, M. C. (2024). Agency in the Anthropocene. *The Lancet Planetary Health, 8*(2), e117–e123. https://doi.org/10.1016/S2542-5196(23)00271-1

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