



Australian Academy of Science

SUBMISSION TO THE

**CONSULTATION ON
VISION FOR A SCIENCE NATION**

FROM THE AUSTRALIAN ACADEMY OF SCIENCE / JULY 2015

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OVERVIEW

The Australian Academy of Science welcomes the opportunity to comment on the suite of strategies and measures outlined in the Australian Government's Vision for a Science Nation consultation paper. Overall, these proposals respond well to the majority of recommendations set out by the Australian Chief Scientist in Science, Technology, Engineering and Mathematics (STEM): Australia's Future, and have the potential to provide significant and lasting benefit to Australia through a comprehensive approach to Australian STEM over the coming decade.

This submission from the Academy provides both a high-level summary and a detailed response to the consultation questions on each of the components of the proposed strategy: 1) Australian competitiveness; 2) education and training; 3) research; and 4) international engagement. The submission makes 20 specific recommendations (summarised on the following page) four of which relate to measures proposed in the consultation document that are not recommended by the Academy, and 16 relating to additional measures that would provide additional value if included in the strategy.

Two overarching recommendations of this submission are:

1. That the final national STEM strategy **must be implemented in such a way as to achieve a true whole-of-government framework and approach to STEM in Australia**. The Commonwealth Science Council is the clear governing body to oversee the strategy and the myriad programs, initiatives and other strategies that will come under or otherwise relate to it; likely with a limited number of additional subordinate governance mechanisms such as a National Advisory Board for international science required. However, **numerous and significant changes and transformations will be required** at the point of delivery of new and existing programs to streamline processes and ensure efficient and enabling interaction with the scientists, business people, students, teachers, government representatives and members of the public who engage with them.
2. That the final national STEM strategy include **clear mechanisms to increase public and private funding for STEM**. Business investment in R&D in Australia sits well below the OECD average, while Commonwealth Government funding for science as a percentage of GDP has been trending down for the past thirty years, and

ABOUT THE AUSTRALIAN ACADEMY OF SCIENCE

The Australian Academy of Science was established by Royal Charter in 1954 to champion, celebrate and support excellence in Australian science, to promote international scientific engagement, to build public awareness and understanding of science and to provide independent, authoritative and influential advice. The Academy comprises more than 500 of Australia's leading scientists, each of whom is elected for her or his personal contribution to science.

declining in real terms from a peak of \$9.8 billion in 2012.

While the STEM strategy presents a significant opportunity to better coordinate and target existing resources, **the long-term objectives of the strategy will not be realised or sustained without mechanisms to steadily increase public and private investment in science—particularly in basic research—over the coming years.**

The elements of the proposed strategy in which the Australian Academy of Science is best able to provide direct assistance to the Australian Government are:

1. **The proposed International Engagement Strategy.** The Academy has substantial experience and expertise assisting the government in the delivery of international scientific exchange programs, and is the Australian representative on the majority of international scientific panels; councils and disciplinary collaborations. It commends the comprehensive, multi-component objectives for international scientific engagement and diplomacy outlined in the consultation document, and looks forward to working closely with Government to achieve them.
2. Development of **high-quality evidence-based curriculum programs for school science students and teachers** as recommended by the Chief Scientist, but not directly addressed in the consultation document with the exception of the proposed Mathematics by Inquiry program. With significant support over several years from the government, the Academy delivers its **PrimaryConnections** and **Science by Doing** programs to a significant proportion of Australian science teachers and students at primary and junior secondary levels and suggests that these programs should play a valuable ongoing role in ensuring high quality science teaching and learning as part of the government's strategy.

SUMMARY OF RECOMMENDATIONS

<p>Australian competitiveness</p> <p>Recommendations: The National Science Strategy should:</p> <ol style="list-style-type: none"> 1. place incentives for commercialisation and globalisation of STEM discoveries as a key focus of the review of the R&D Tax Incentive 2. establish a new program similar to the US SBIR scheme to target funding to Australian SMEs operating in priority areas 3. develop stronger incentives for researchers to become involved with industry and vice versa 4. establish new mechanisms to promote provision and access to novel research and innovation funding 5. prioritise development of new programs and expand existing initiatives to encourage research-industry collaboration 6. provide opportunities and incentives for STEM students and professionals to develop general business skills <p>The Academy does not recommend a high priority be given to the proposals to:</p> <ul style="list-style-type: none"> • map career paths, survey individuals and examine case studies of successful industry-research collaboration • promote entrepreneurial role-models • teach entrepreneurship skills to STEM students and professionals <p>The Academy supports the proposals to amend responsibilities and review membership of the Innovation Australia Board, to establish a new Prime Minister’s prize for science commercialisation, and to review tax incentives for innovation and entrepreneurship.</p>	<p>Education and training</p> <p>Recommendations:</p> <ol style="list-style-type: none"> 7. the construct of STEM does not work well in schools, so priority should be given instead to strengthening teaching and learning in core mathematics and science disciplines 8. the National Science Strategy should embed evidence-based curriculum programs for school science students and teachers at the heart of future school education initiatives <p>The Academy notes that its government-supported school science programs PrimaryConnections and Science by Doing have been adopted by a significant percentage of Australian science teachers and students, and could play a valuable role in the National STEM in school education strategy going forward.</p> <p>The Academy does not recommend:</p> <ol style="list-style-type: none"> 9. STEM subjects should be made compulsory at senior levels 10. changes to the Australian Postgraduate Awards to offer targeted scholarships in priority areas <p>The Academy supports the proposals to implement the national STEM in school education strategy, to establish a national Mathematics by Inquiry program, to broaden the base of community science engagement programs, to encourage greater participation of indigenous students in science and mathematics, to increase STEM graduate employability in vocational training and to coordinate and expand national community science engagement events.</p>
<p>Research</p> <p>Recommendations: The National Science Strategy should:</p> <ol style="list-style-type: none"> 11. ensure an appropriate balance between basic and priority-driven research 12. provide sustainable mechanisms to grow public and private investment in Australian research; possibly by extending the Medical Research Future Fund model to other areas of research 13. provide additional incentives to encourage private industry and philanthropic investment in research <p>The Academy strongly supports the proposals to:</p> <ul style="list-style-type: none"> • develop a 10-year plan for Australian research and research infrastructure • develop a policy to govern open access to publicly funded research outcomes <p>The Academy supports the proposal to continue supporting research with strong industrial application, and to map research capability within the nine national science and research priorities.</p>	<p>International engagement</p> <p>Recommendations: The International Science Engagement Strategy should:</p> <ol style="list-style-type: none"> 14. include a new national advisory board for international science collaboration 15. provide funding of \$20m p.a. for science collaboration through the Global Science and Innovation Collaboration Program (including existing bilateral funds) 16. establish an annual global science and innovation watch report 17. expand Australia’s network of science counsellors 18. expand the ARC Laureate Fellowship program to attract world-leading researchers in priority areas <p>The Academy does not recommend:</p> <ol style="list-style-type: none"> 19. retargeting the Endeavour Scholarship and Fellowship program 20. prioritising new mobility programs for world-leading researchers <p>The Academy supports the proposed international science engagement strategy, science diplomacy strategy, the Asian Area Research Zone and commitments to continue the student visa program and ARC international application eligibility.</p>

1. AUSTRALIAN COMPETITIVENESS

The Australian Academy of Science commends the Australian Government on the suite of research programs and strategies outlined in response to the Chief Scientist's recommendations.

Of the suggested measures, the Academy is strongly supportive of the proposal to:

- **amend the responsibilities and review the membership of the Innovation Australia Board**, noting that its responsibilities should reflect the priorities of funding allocation and development of new models of research-industry collaboration outlined by the Chief Scientist.

It also supports the proposals to:

- establish a **Prime Minister's prize for science commercialisation**
- **review the tax incentives for innovation and entrepreneurship** as part of the broader review of the taxation system.

The Academy does **not** recommend a high priority be given to the proposals to:

- **map career paths, survey individuals and examine case studies of successful industry-research collaboration** as a primary means to accelerate STEM experts into industry, business and the public sector.

Instead, it recommends that the government considers:

- **developing new programs** (possibly based on international models) **and expanding existing initiatives to encourage research-industry collaboration.**

Further, the Academy:

- suggests that measures aimed at **promoting entrepreneurial role-models** will likely be of limited value in promoting an entrepreneurial culture
- suggests that efforts to teach entrepreneurship skills as part of STEM training would be better directed at **providing opportunities and incentives for STEM students, trainees and professionals to develop the generic and more broadly applicable business skills** that underpin successful entrepreneurship.

The government's proposals do not specifically address the Chief Scientist's recommendation for:

- **stronger incentives for SMEs to commercialise discoveries**, to **develop a national SME growth scheme** based on the US Small Business Innovation Research (SBIR) program, or to facilitate access to novel sources of research

The Academy therefore recommends:

- incentives for commercialisation and globalisation of STEM discoveries should be a **key pillar of the forthcoming review of the R&D Tax Incentive**
- development of a new national scheme, based on the US SBIR program, to target a proportion of overall research expenditure of government agencies to Australian STEM-based SMEs
- development of stronger **incentives for researchers to become involved with industry and vice versa**
- establishment of **new mechanisms to promote provision and access to novel research and innovation funding** through coordination, promotion, research funding and tax incentives.

The Academy looks forward to working with the Australian Government as it undertakes the detailed work required to develop and implement these strategies and associated programs.

1. Do these proposals adequately respond to the Chief Scientist's recommendations—both now and over the longer term?

The measures proposed in *Vision for a Science Nation* respond in part to the Chief Scientist's four recommendations with respect to Australian competitiveness. Specifically:

- 1.1. The Chief Scientist's recommendation to **establish an Australian Innovation Board** is addressed at a high level by the proposal to **amend the responsibilities and review the membership of the Innovation Australia Board**. It should be noted that the Chief Scientist's recommendations regarding this board suggested its focus should be on allocation of funding to identified innovation priorities and research projects, and the design and delivery of new models of research-industry collaboration. These specific focus areas are not directly addressed by *Vision for a Science Nation* and the **Academy recommends that further consultation with relevant industry and science groups will be required to guide the final structure and function of the revised Innovation Australia Board**.

The consultation paper also suggests that the Innovation Australia Board could be asked to identify priorities for innovation, as recommended by the Chief Scientist. While this will be helpful, the Academy notes that innovation is, by definition, difficult to predict, and that a prioritisation process would ideally focus on identifying broad issues or areas (for example, the Energy or Advanced Manufacturing growth sectors) to which funding support could be allocated in such a way as to encourage open, innovative and competitive applications from basic and applied researchers, from industry, and from collaborations between the two.

- 1.2. The Chief Scientist's recommendation to **support translation and commercialisation of STEM discoveries** is addressed in part by existing programs (the Industry Growth Centres, Entrepreneurs' Infrastructure Program and Export Market Development Grants Scheme identified, as well as through the CRC program and other schemes); and by the forthcoming review and reform of Australia's IP regime and R&D Tax Incentive program.
- 1.3. The Chief Scientist's recommendation to **accelerate the integration of STEM experts into industry, business and public sectors** is not sufficiently addressed by the government's proposals. Specifically, while they may have some value, the proposals to examine case-studies, map career paths and survey individuals who straddle

the research-industry divide is unlikely to produce generalisable results given the relatively low base of such individuals and organisations in Australia.

The Academy recommends that instead, **the government focuses on developing new programs and expanding existing initiatives to encourage research-industry collaboration** such as the ARC Linkage scheme, the NHMRC Partnership scheme, the Research Connections element of the Entrepreneurs' Infrastructure Program and the CRC and RDC programs.

In making this recommendation, the Academy notes that while appealing at face value, 'industry-user pays' schemes in other jurisdictions have mostly been unsuccessful, and in some cases have been a positive disincentive to research-industry collaboration. For this reason, incentive-based measures are recommended instead.

- 1.4. The Chief Scientist's recommendation to **promote an entrepreneurial culture** is addressed in part by the proposed measures, particularly the review of tax incentives for innovation and entrepreneurship. However:
- In relation to **role models**, while the Academy supports the proposal for an additional Prime Minister's prize for science commercialisation, it suggests that successful entrepreneurs are likely to become role models to relevant audiences without the need for government intervention, and that an entrepreneurial culture will be more readily fostered by government through interventions focused on skills and incentives rather than promotion of role models
 - In relation to **skills development**, the Academy recommends that Australian competitiveness would be best served by offering opportunities, incentives and requirements for the development of generic business skills among STEM school and university students, trainees and professionals, rather than attempting to teach entrepreneurial skills per se.
 - In relation to **incentives**, the Academy recommends that the government consider incentives for STEM SMEs and start-ups beyond the taxation system; such as infrastructure support programs offered in Singapore; investment safety net programs in the UK; and payroll support in Canada.

2. Do you consider there are any areas that require more urgent action? Have we missed anything?

There are a number of areas in which the Academy recommends further action.

2.1. In relation to **support for translation and commercialisation of STEM discoveries**, the government's proposals **do not address the Chief Scientist's recommendation for stronger incentives for SMEs to commercialise discoveries and enter global supply chains**, or to **develop a national SME growth scheme** drawing on the US Small Business Innovation Research (SBIR) programme. The Academy recommends that strengthening and targeting incentives for commercialisation and globalisation of STEM discoveries should be a **key pillar of the forthcoming review of the R&D Tax Incentive**, and that a new national scheme should be developed, based on the US SBIR program, to target a proportion of overall research expenditure of government agencies to STEM-based SMEs operating in Australia's innovation and science and research priority areas.

2.2. In relation to **integration of STEM experts into industry, business and public sectors**, the Academy supports the recommendation of the Chief Scientist that government should **develop better incentives for researchers to become involved with industry**, and recommends specifically that such incentives should be considered in the context of the forthcoming Watt Review of Research Funding and Policy.

2.3. The Academy also notes that only 3.5% of Australia's large companies work with universities and public research agencies, compared with 43.2% in Germany, 31.3% in Britain and 22.5% in New Zealand. **For this reason, it is just as important to provide better incentives for industry to engage more strongly with other parts of the research sector.**

2.4. In relation to **promoting an entrepreneurial culture**, the proposals do not directly address the Chief Scientist's recommendation to **facilitate access to novel sources of equity funding** including crowd-funding (recommended by the Chief Scientist) and venture philanthropy (suggested by the Academy). The Academy recommends that measures to achieve greater access to novel sources of funding should be considered within the vision. Such measures could include:

- **coordination** (developing and promoting a portal—possibly as part of www.science.gov.au—to link researchers with personal or commercial investors and donors)
- **awareness raising** among researchers and investors
- **promotion of Australian research opportunities** among international investors as part of the International Science Engagement strategy

- **enhanced tax incentives** to facilitate greater investment and philanthropic giving
- **greater recognition for research institutions** of success in attracting funding from non-traditional sources in research performance metrics.

3. Which of these proposals will have the greatest impact on Australia's STEM performance?

As noted in the consultation paper, Australia's future competitiveness in a rapidly developing global economy will be determined by our ability to transform our industries, our workforce and our innovation system over the coming decades. Most, if not all, of this economic transformation will be underpinned by STEM. The Government's role will therefore need to focus on:

- ensuring high-levels of STEM training in school and tertiary institutions with an appropriate skills pipeline for priority areas and disciplines
- developing a coherent and strategic approach to supporting basic research, translation of research discoveries, entrepreneurialism and business innovation through a suite of highly targeted incentives and funding programs
- promoting greater integration of STEM experts into industry and business, and vice versa
- supporting greater collaboration between research and industry.

These measures will have impact over different timescales: school STEM education will be essential to economic transformation and innovation over the coming decades; whereas an increased level and diversity of tax and other incentives for innovative STEM-based start-ups and SMEs would have a greater impact on encouraging expansion of commercialisation activities in the short to medium term.

4. Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

The primary interests of the Academy lie in championing, celebrating and supporting excellence in Australian science, promoting international scientific engagement, building public awareness and understanding of science, and providing independent and authoritative advice to government and other stakeholders. Many of the Academy's 500 Fellows bridge the research sector with industry and business in commercialisation and innovation. However, the Academy's contribution to Australia's competitiveness as part of the government's proposals would, for the most part, involve provision and advice to government through existing members of the Commonwealth Science Council, and potentially through membership of the revised Innovation Australia Board.

2. EDUCATION AND TRAINING

The Australian Academy of Science commends the Australian Government on the suite of strategies outlined in response to the Chief Scientist's recommendations with respect to education and training.

However, the Academy would like to emphasise that **the construct of STEM does not work well in schools**, where engineering is rarely taught, and technology subjects are taught variably and inconsistently, and not as part of the core curriculum (except in NSW which has a K-6 Science and Technology syllabus). Instead, the Academy **strongly recommends that the school education elements of *Vision for a Science Nation* should focus primarily on the core subjects of science and mathematics.**

Of the government's proposed measures, the Academy is strongly supportive of:

- the **national STEM in school education strategy**;
- the establishment of a **national Mathematics by Inquiry program**;
- working with state and territory governments to extend and broaden the base of community science engagement programs
- encouragement of greater participation of indigenous students in science and mathematics

It also supports the proposals to:

- increase **STEM graduate employability and vocational training**
- work with states and territories to develop a **coordinated approach to science centres** and to **develop a year-round program of community science engagement events.**

The Academy does **not** recommend priority be given to the proposals to:

- **make STEM subjects compulsory at senior school levels**
- **change the Australian Postgraduate Awards** to offer targeted scholarships in priority areas

The Academy also suggests that while measures such as the proposed requirement for **publicly funded research agencies to participate in school engagement programs**, a **database of businesses willing to engage with schools**; and **promotion of citizen science initiatives** may have some value to particular individuals or organisations, they are **unlikely to have a significant impact on improving STEM education and training**, and that effort and resources would therefore be better focused elsewhere.

The government's proposals do not specifically address the need to provide high-quality evidence-based curriculum programs for school science students and teachers. The Academy **recommends that the National Science Strategy should commit to embedding such programs at the heart of future school science and mathematics education initiatives.** These need to include both professional learning to assist teachers to change their practice, as well as complementary curriculum resources which exemplify research-based approaches.

The Academy also suggests that its **PrimaryConnections** and **Science by Doing** programs, developed with significant support from the Australian Government and delivered to a high proportion of Australian science teachers and students at primary and junior secondary levels could play a valuable ongoing role in ensuring high quality science teaching as part of the government's strategy. They each comprise a professional learning component as well as curriculum resources and have evidence of their effectiveness.

5. Do these proposals adequately respond to the Chief Scientist's recommendations – both now and over the longer term?

The measures proposed in *Vision for a Science Nation* do not respond adequately to the Chief Scientist's seven recommendations with respect to science school education (recommendations 1-7). However, they do respond adequately to the four recommendations pertaining to vocational STEM training, uptake of STEM by business, community engagement with STEM and interaction between STEM practitioners and the community.

School education

Taking the recommendations related to **school STEM education as a whole**, the Academy suggests that the **construct of STEM itself does not apply well to school education**. Specifically, engineering is not taught at all in schools outside of isolated elective units and extra-curricular activities, and technology subjects are not core to the curriculum (except in NSW which has a K-6 Science and Technology syllabus) and are defined and taught variably and inconsistently.

For this reason, the Academy recommends that all of the planned strategies and activities relating to STEM in schools should focus primarily on improving student participation and outcomes in the core disciplines of **science and mathematics**.

It further recommends that the major barriers in the present system to doing so are:

- a) insufficient confidence and knowledge of science and mathematics teaching among primary school teachers
- b) insufficient variety of and access to evidence-based curriculum resources and professional learning programs at both primary and secondary levels.

5.1. In relation to teacher training, the government's response to the Chief Scientist's recommendations focuses largely on pre-service teachers: minimum numeracy and literacy requirements; subject specialisations for primary teachers; reviewing graduate level professional standards; and flexible study pathways, among others. While such measures are important, and are supported by the Academy, research indicates that the key impetus for educational reform lies with the teaching profession itself, and that consequently, programs designed to improve science and mathematics teaching must focus primarily on increasing the availability and uptake of professional learning for in-service teachers. The Academy's recommendations pertaining to these issues are

contained in the response to the second consultation question.

- 5.2. In relation to the **proposed national STEM in school education strategy**, the Academy **does not support the proposal to make STEM subjects compulsory at senior levels**. There is little research to suggest this approach will be successful in having a positive impact on STEM, and previous experience has shown that science subjects catering to students with limited interest or aptitude become stigmatising and counter-productive – and the barrier of teacher numbers will in any case make such measures unviable for years to come.
- 5.3. The proposal to work with states and territories to ensure science and mathematics are recognised in the outcomes of the review of the Australian Curriculum are supported by the Academy.
- 5.4. The proposals to provide a **Mathematics by Inquiry program and training in innovation and computer coding** are an **appropriate response to the Chief Scientist's recommendations**, and are strongly supported by the Academy.
- 5.5. The proposal to **require all of Australia's publicly funded research agencies to participate in school engagement programs** could have some value; particularly if focused on outreach to regional and rural schools; and those located in states and territories away from the agencies themselves. However, such a program would only achieve a small penetration into the school sector. Consequently, the Academy **does not recommend that this measure should be a priority**.
- 5.6. Likewise, a **database of businesses willing to engage with schools and students** is unlikely to significantly increase engagement and exposure of students to STEM in the workforce, and is **not recommended as a priority by the Academy**.

Graduate employability & vocational training

- 5.7. The Chief Scientist's recommendations relating to aligning graduate skills and workforce needs are adequately addressed by the proposals to implement the VET reform agenda and to work with business, education providers and philanthropists to expand work-integrated learning and to explore opportunities for improving communication about career opportunities and skills development in STEM.
- 5.8. The Academy of Science **does not recommend changes to the Australian Postgraduate Awards (APAs)** to offer high-value PhD scholarships in priority fields, including STEM. APAs are one of a number of PhD scholarships available to research

students, and are awarded on the basis of academic excellence to students across all fields of research. A number of other research scholarships are already available in priority areas, often supported by industry, and it is unlikely that new categories of APAs would significantly increase the number of students undertaking research training in these areas. **The Academy recommends that the government wait for the outcomes of the review of research training** currently underway, which is examining the issue of industry- and national-priority relevant research training before making any decisions.

Community engagement

5.9. The Chief Scientist's recommendations with respect to **facilitating community engagement with STEM** are addressed in part by the proposed measures. For instance, the proposal to work with states and territories to develop a **coordinated approach to science centres** and to **build on existing regional hubs and develop a year-round program of community science engagement events** will be beneficial for some, as will the proposal to encourage greater engagement in citizen science initiatives.

However, research undertaken by the Victorian Government, CSIRO and the Inspiring Australia initiative suggests that existing science engagement activities are successful primarily in engaging the ~25% of the population who are already actively interested in and engaged with science, but that they have little if any impact on the ~40% of the population who are actively disengaged with or uninterested in science (see [commentary](#)). This suggests that the Australian Government and science communicators need to build on the success of the Inspiring Australia program to broaden the base of existing activities and delivery modalities to engage those Australians and—importantly—their children, who are not already actively interested in STEM. **The Academy recommends that the best way to achieve this is to trial a range of community engagement initiatives that utilise social and other new media platforms.**

6. Do you consider there are any areas that require more urgent action? Have we missed anything?

6.1. The proposed measures **do not give sufficient attention to the need for evidence-based science curriculum programs** to assist teachers to offer engaging primary and secondary school teaching that assist students to develop a broad understanding of the basic principles of

mathematics and science, and to inspire those with interest and aptitude to pursue further secondary and tertiary study. Neither do they address the broader challenge of attracting people with advanced science and mathematics training to choose and remain in teaching careers.

With support of the Australian Government over the past decade, the Academy has developed, and now delivers, the two most widely used inquiry-based learning programs for primary and junior secondary students in Australia.

PrimaryConnections: Linking science with literacy was initiated in the early 2000s and is developing as a self-sufficient business unit of the Academy. The program provides a suite of 34 curriculum-ready learning units for students from Foundation to year 6, other curriculum resources such as interactive teaching resources for use on electronic whiteboards, and a professional learning program for generalist and science specialist primary school teachers based on evidence-based pedagogical principles.

- PrimaryConnections learning modules have been purchased by over 5,770 Australian primary schools (76% of total) and the 31 units developed with Australian Government funding are available freely for all Australian pre-service and in-service teachers from the ESA Scootle website;
- The PrimaryConnections program is known by 85% of primary school teachers;
- PrimaryConnections has an online web membership (comprising teachers, schools and administrators) of over 12,000, and a mailing list of over 23,000

PrimaryConnections has received \$14.7m from the Australian Government since 2004. The \$3.5m in 2014 is improving access to the professional learning program for teachers in regional, rural and remote locations, including those with high Indigenous enrolments. Furthermore, the program has effectively leveraged over \$230m additional funding from state and territory governments that have committed to supporting teachers in its use.

Current Australian Government funding for PrimaryConnections will end in June 2018. The Academy **recommends that the National Science Strategy commits to embedding this valuable and widely used program at the heart of future primary school science education initiatives as the baseline approach.** From this, more sophisticated and innovative pedagogies and resources can be developed as teachers build their competence.

Science by Doing is a comprehensive online science program for years 7 to 10 available free to all

Australian students and teachers and supported by award-winning professional learning modules and a research based professional learning approach. The Australian government has provided \$10.3 million for the development of *Science by Doing*.

Since commencing in mid-2013, *Science by Doing*:

- has 40,000 students registered,
- has one third of all Australian high school science teachers registered;
- had for the months of March 2015 and May 2015, 2.1 million and 2.5 million hits respectively.

On current trends, it is expected that *more than* 50% of Australian high school science teachers will be registered with *Science by Doing* by early 2016, and that it will achieve near full uptake by high school science teachers by 2017.

A national roll out of the *Science by Doing* Professional Learning program for teachers began in 2015. The program involves developing partnerships with educational jurisdictions and sectors and then working with high schools within each jurisdiction and sector.

As with PrimaryConnections, *Science by Doing* is being delivered by the Academy with support from the Australian Government until June 2018. The Academy **recommends that the National Science Strategy should commit to embedding this valuable and widely used program at the heart of future high school science education initiatives.**

- 6.2. The proposed measures **do not address the challenging issue of federal-state relations in science education policy and funding.** The Academy **recommends that the National Science Strategy should encourage state and territory governments to work through the COAG Education Council to achieve agreement on an approach and respective responsibilities for ensuring the highest quality school science and mathematics education.**
- 6.3. The Academy also recommends that the government **should consider mechanisms to improve guidance to students and their parents about the diversity of career options available in STEM.**

measures to increase the skills, confidence and enthusiasm of current primary and secondary school science and mathematics teachers, and to provide them and their students with engaging, evidence-based learning materials that are aligned with the Australian curriculum: Science. Alongside the proposed new Mathematics by Inquiry program, the Academy **recommends specifically that the Academy's government-supported programs PrimaryConnections and Science by Doing should be incorporated closely into the education components of the final *Vision for a Science Nation*.**

8. Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

As an experienced developer and provider of inquiry-based school science learning programs for both students and teachers, the Academy is well-placed to assist the government to develop the planned Mathematics by Inquiry program and support the national implementation of the PrimaryConnections and *Science by Doing* school science education programs.

The Academy is also actively engaged in the promotion of outstanding Australian science and scientists to the Australian community through a range of events, public lectures, media, social media, and through its flagship free online public education and outreach resource [Nova: science for curious minds](#). The Academy is a founding member of the Science Sector Group and would be pleased to work with the government to facilitate a national communication strategy to promote Australian science and scientists. **The Academy would be pleased to work with the government to assist in achieving its broader communications and community science engagement goals in the future.**

7. Which of these proposals will have the greatest impact on Australia's STEM performance?

The Academy suggests that the biggest impact on Australia's STEM performance will be achieved through

3. RESEARCH

The Australian Academy of Science commends the Australian Government on the suite of research programs and strategies outlined in response to the Chief Scientist's recommendations.

Of the suggested measures, the Academy is strongly supportive of:

- the proposal to develop a **10-year plan for Australian research and research infrastructure**
- the proposed development of a **policy to govern open access to publicly funded research outcomes**, noting that this policy will have to operate within the context of broader open data frameworks

The Academy also supports the proposal to:

- **continue supporting research with strong industrial application**, noting the many measures underway and proposed in response to the Chief Scientist's recommendations to increase Australia's competitiveness.

Finally, the Academy **supports the work currently** underway to:

- **Map research capability within the nine identified national science and research priorities and the associated practical research challenges.**

The government's proposals **do not specifically address the Chief Scientist's recommendation** that the national research plan should include support for **basic science in the core STEM disciplines**, and that it should **ensure full support for both the direct and indirect costs of research**; a measure that was also recommended by the National Commission of Audit. These are **critical to the viability and effectiveness of the proposed plan**, and the Academy strongly urges the Australian Government to ensure that these vital elements are incorporated into the plan as it is developed.

In addition, while supportive of the proposed measures with respect to research, the Academy **strongly reiterates the importance of ensuring an appropriate balance between basic and applied research**; noting that discoveries emerging from basic research are the essential foundation of future innovation and prosperity. The Academy also stresses the importance of **providing sustainable mechanisms to grow public and private investment in Australian research** to levels both **commensurate with comparable nations**, and **adequate to ensure optimal capacity to address research priorities and deliver economic and public benefit to Australia.**

The Academy recommends specifically that consideration be given to:

- **extending the valuable model of the Medical Research Future Fund to other areas of STEM research**
- **providing a range of incentives to encourage private industry and philanthropic investment in research.**

The Academy looks forward to working with the Australian Government as it undertakes the detailed work required to develop and implement these strategies and associated programs.

9. Do these proposals adequately respond to the Chief Scientist's recommendations—both now and over the longer term?

The measures proposed in *Vision for a Science Nation* respond in part to the Chief Scientist's five recommendations with respect to research. Specifically:

- 9.1. The Chief Scientist's recommendation to **ensure a long-term plan for science and research** is

addressed at a high level by the commitment - as outlined in *Vision for a Science Nation* - to developing a national plan with a **ten-year outlook for research and research infrastructure**. Once finalised, this plan should provide greater stability and direction for both research institutions and business. However, the Chief Scientist made three specific recommendations that are not addressed in the consultation document; specifically, that the plan should:

- ensure capability in the core sciences and maintain key components of basic research
- support excellent research that provides new ideas and insights to enhance Australian competitiveness
- support the full direct and indirect costs of research.

The effectiveness and viability of a long-term strategy for Australian research and research infrastructure will depend in large part on the level to which these three key issues are addressed.

- 9.2. The Chief Scientist's recommendation to **develop and implement strategic research priorities** is addressed by the prioritisation and capability mapping process currently underway, and the commitment to biennial review.
- 9.3. The Chief Scientist's recommendation to **support research careers, including collaboration with industry and business** must be addressed at all levels of the research and innovation system, including at the research training level through the government's response to the **review of research training** being undertaken by the Australian Council of Learned Academies (ACOLA).
- 9.4. The Chief Scientist's recommendation to **enhance dissemination of Australian STEM research through open access policies and infrastructure** is addressed to the extent that the government plans to develop a policy to ensure that more publicly-funded research findings are shared openly and made available for commercial and other publicly beneficial use. The issue of open access science is complex, and Australia has fallen behind comparable nations in planning and implementing a whole-of-government response to this issue. Consequently, there is much to be learned from countries like the UK and the US as well as major international collaborations such as the International Council for Science's CODATA initiative. The Academy, in conjunction with its National Committee for Data in Science, looks forward to working with the government as it develops this important plan.
- 9.5. The Chief Scientist's recommendation to **provide support to encourage and enable quality research to problems identified by industry** will be addressed through a range of proposed and existing schemes such as the ARC Linkage scheme, the NHMRC Partnership scheme, the CRC and RDC programs, Industry Growth Centres and CSIRO, amongst others. The Academy commends these valuable initiatives but **reiterates the importance of ensuring a balance between applied, industry-driven research, and the basic, investigator-driven research** that acts as the engine room from which

subsequent innovation, industrial breakthroughs and publicly beneficial discoveries emerge.

10. Do you consider there are any areas that require more urgent action? Have we missed anything?

10.1. As noted at 1.1, the proposed measures do not specifically address the Chief Scientist's recommendations to:

- ensure capability in the core sciences and maintain key components of basic research
- support excellent research that provides new ideas and insights to enhance Australian competitiveness;
- support the full direct and indirect costs of research.

Noting that some of these issues are subject to current reviews, the Academy strongly recommends that the national plan for research *must* address these critical issues to provide an effective framework and direction for research in Australia over the coming decade.

10.2. The Academy also notes that significant time and intellectual effort is expended each year by researchers in the development of applications to Australia's research funding agencies. Approximately half of applications across all schemes are judged through peer review to be sufficiently rigorous, innovative and feasible to warrant funding, but less than one quarter are funded due to limited resources, resulting in many high quality research concepts being lost. This is indicative of a significant mismatch between the size and capacity of Australia's research workforce and the resources available to support them; and also represents a significant opportunity cost for Australia in the many high quality and potentially beneficial research programs that do not go ahead. Alongside the valuable measures outlined by the Chief Scientist and the government in its response, the **Academy strongly recommends that the National Science Strategy needs to include a mechanism to allow for significant and sustained growth in research funding from public and private sources.**

11. Which of these proposals will have the greatest impact on Australia's STEM performance?

As part of an overarching STEM strategy, a 10-year national plan for research and research infrastructure has the capacity to deliver stability, security and focus to Australia's research enterprise, and as a consequence, to the current and future industries that depend on the outputs of Australian and international research for their growth, diversification and prosperity.

The two major challenges to the success of this plan will be:

1. to ensure the **right balance between industry or priority-driven research that can deliver benefits in the immediate future, and the basic, investigator-driven research in core STEM disciplines** that is much less predictable in terms of outcomes, but which is essential to growth and prosperity in the longer term
2. to ensure inclusion of **mechanisms to increase public and industry research funding to a level comparable with competitor countries**, and sufficient to effectively deal with the current and longer-term challenges that will require research solutions. The Medical Research Future Fund (MRFF) is a very welcome mechanism that has the potential to achieve this funding growth and security for medical research, and **the Academy recommends that the MRFF model should be extended to other areas of research in STEM.**

In addition, the Academy notes that a number of countries that are investing in science and technology at a higher rate than Australia have longer planning horizons that allow programs to bed down and have a visible impact and have rolling review processes that enable proper evaluation and adjustments as required to make the programs more effective.

12. Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

The Academy does not directly engage in research, however it takes a strong interest in science and research issues.

4. INTERNATIONAL ENGAGEMENT

The Australian Academy of Science commends the Australian Government on the suite of international science and innovation engagement and diplomacy strategies and programs that have been proposed in response to the Chief Scientist's recommendations.

Of the suggested measures, the Academy is strongly supportive of:

- the proposed **International Science Engagement Strategy**
- the **Science Diplomacy Strategy**
- the **Global Science and Innovation Collaboration Program**.

It also supports the proposals to:

- **continue the student visa program**
- **ensure the ARC Fellowship program remains open to international applicants**
- **develop an Asian Area Research Zone**

The Academy does **not** recommend priority be given to the proposals to:

- **retarget the Endeavour Scholarship and Fellowship program**
- **establish new mobility programs targeting world-leading researchers.**

Instead, it recommends that the government consider:

- **revising and expanding the existing ARC Laureate Fellowship program** to attract more world-leading scientists to Australia on a long-term basis in areas of research and innovation priority
- **expanding the existing suite of international science and research exchange programs targeting early- and mid-career researchers** (the cohort in which these programs deliver maximum benefit to Australian science and innovation). The Academy is well positioned to assist the Australian Government to coordinate and run these programs as required.

The government's proposals **do not specifically address the Chief Scientist's recommendation to establish a fund for stronger international collaboration through government-to-government science and research linkages**. Therefore, the Academy recommends that:

- the proposed **Global Science and Innovation Collaboration Program be implemented** with funding of approximately **\$20m per annum over 10 years** to support **bilateral and multilateral science and innovation partnerships** with priority partner countries and **respond to new government-to-government collaborative opportunities as they arise** (this program should incorporate existing funds for bilateral science and research with India and China which together have funding of \$7.5m per annum).

Finally, the Academy recommends that consideration be given to the following specific measures:

- establishment of a **national advisory board for international science collaboration**, chaired by the Chief Scientist, and responsible for **providing cross-government coordination and investment advice on relevant programs and strategies**
- establishment of an annual '**Global Science and Innovation Watch**' report to provide an evidence-base to inform decisions by policy makers across the science and industry sector
- continued support for and **expansion of Australia's network of science and innovation counsellors and attachés** in priority countries and regions
- establishment of an **Australian Science and Innovation Envoys program** to lead delegations of leading Australian researchers and industry representations to key international partners
- new initiatives to facilitate **expanded science and innovation engagement ranging from science school education to research and industry collaboration in the Asia Pacific region**

The Academy looks forward to working with the Australian Government as it undertakes the detailed work required to develop and implement these strategies and associated programs.

13. Do these proposals adequately respond to the Chief Scientist's recommendations—both now and over the longer term?

The measures proposed in Vision for a Science Nation respond adequately to two of the Chief Scientist's four recommendations with respect to International science, and in part to one. Specifically:

13.1. The recommendation to establish an **international strategy for science, research and education** is covered by the proposed **International Science Engagement Strategy** and **Science Diplomacy Strategy** and by the forthcoming **National Strategy for International Education**.

13.2. The recommendation to **leverage STEM in international diplomacy** is covered at a high level by the proposed **Science Diplomacy Strategy**. The Academy has a number of recommendations regarding the detailed focus of this strategy, and looks forward to working with the government as it is developed

13.3. The recommendation to **unlock flows of knowledge and research talent** is covered in part by the suggested actions under the heading 'Supporting exchange of knowledge and research talent', specifically:

- the commitment to ensuring the **continuity and competitiveness of the student visa program** is a positive and appropriate response to the recommendation
- the commitment to ensuring **ARC Fellowships remain open to international applicants** is well advised
- the suggestion that the **Endeavour Scholarships and Fellowships program could be retargeted** to attract world-leading experts for short-term visits and to facilitate regional exchanges is **not endorsed** by the Academy. The long-standing purpose of this program is to showcase the Australian higher education sector and to enable high-achieving students from Australia and abroad to study in Australia and internationally. While there is a clear need to support both emerging and world-leading researchers and technical experts to work in Australia and with Australian collaborators, it is recommended that these objectives should be achieved through other measures.
- the suggestion to implement **new researcher mobility initiatives** based on international models is worthy of careful consideration. However, the Academy notes that Australia has a long and successful history of promoting

international mobility among early and mid-career researchers through a range of **international exchange programs**, and that Australia's relative isolation presents unique challenges to formal mobility programs for more senior researchers. Specifically, many of the world's leading scientists from the Northern Hemisphere are less willing or able to travel to Australia than they are to closer countries, and this is unlikely to be affected greatly by formal mobility programs. In contrast, other leading international researchers are attracted to Australia for personal reasons, and these individuals are often able and willing to undertake scientific visits irrespective of formal exchange programs. Consequently, the Academy recommends that:

- international mobility for **early and mid-career researchers** should be addressed through **continued and expanded international exchange programs**;
- international mobility for **leading international researchers** should be addressed by **revising and expanding the Australian Laureate Fellowship program administered by the ARC** (see 14.9).

13.4. The proposed Global Science and Innovation Collaboration Program indicates a strong intended focus on international industry science engagement, and as such, does not respond directly to the Chief Scientist's recommendation to **establish a fund for strong government-to-government linkages as a basis for international science collaboration**.

The Academy recommends that this program should be structured in such a way as to ensure expanded support for government-to-government science linkages with a funding target of **\$20m per annum** (i.e., 0.22% of Australian Government science expenditure). It further recommends the **program should incorporate the existing Australia-India Strategic Research Fund and the Australia-China Science and Research Fund**, and provide **opportunities for new government-to-government science linkages with identified priority countries, as well as a mechanism to respond to new opportunities through a competitive application process**. Funding for collaborative programs should have a longer time frames (five years or more with funding ramping up over time and with appropriate periodic review points). Implementing international programs often takes time and this requires programs to have realistic timeframes to achieve significant outcomes.

Table 1: Australian Academy of Science recommendations for international science engagement and diplomacy

	Recommendation	Alignment with proposed actions	Suggested resourcing
Improved governance			<i>Annual</i>
1	Establish a national advisory board for international science collaboration, chaired by the Chief Scientist, to provide coordination and guide investment across all areas of government and the broader Australian science and innovation community	Not addressed by the proposals	\$1m
Improved competitiveness			
2	Establish a program for early to mid-career researchers to establish partnerships with international leaders in their field, building the networks Australia needs for future innovation	Not addressed by the proposals	\$2m
3	Facilitate collaborative innovation projects to deliver industry and economic benefit for Australia through research links with overseas companies and capabilities	Addressed through the proposed Global Science and Innovation Collaboration Program	\$10m
4	Establish strategic partnerships determined by existing Australian Government priorities and cooperation agreements, supplementing and aligned with existing bilateral strategic partnership funds for India and China	Not specifically addressed by the proposals; recommended by the Chief Scientist as a fund for stronger government-to-government linkages.	\$20m
Improved awareness			
5	Task the advisory board for international science collaboration to develop an annual 'Global Science and Innovation Watch' report to provide an evidence base on international trends and developments to inform decisions by policy makers and across the science sector	Not addressed by the proposals	\$750K
6	Continue to support and expand Australia's network of science and innovation counsellors and attachés in Australian embassies in priority countries and regions around the world	Not addressed by the proposals	\$3m
7	Establish a prestigious new program of 'Australian Science and Innovation Special Envoys', responsible for working with leading researchers and business people to promote Australian science around the world	Not addressed by the proposals	\$1.5m
Improved diplomacy			
8	Develop targeted programs to provide scientific support to assist Australian foreign aid policy objectives, including capacity-building programs between learned academies in Asia, particularly in support of school science education in developing countries	Addressed at a high level by the proposed Science Diplomacy Strategy	\$2m
9	Take an active role in the Asia-Pacific science and innovation community	Addressed at a high level by the proposed Asian Area Research Zone; noting that this should include the Pacific countries	\$1m

14. Do you consider there are any areas that require more urgent action? Have we missed anything?

The Academy commends the Australian Government on its commitment to supporting the vital international aspects of Australian science and innovation as part of its National Science Strategy, and looks forward to working closely with the government as the International Science Engagement Strategy is finalised.

The Academy of Science publications [Internationalisation of Australian Science](#) (2010) and [Australian science in a changing world: Innovation requires global engagement](#) (2011) provide a comprehensive rationale for a strategic approach to international science engagement. They also make specific recommendations as to what that strategy should entail; based in part on the recommendations of the [2010 House of Representatives Standing Committee on Industry, Science and Innovation inquiry into Australia's International Research Collaboration](#).

As illustrated in Table 1, the recommendations made in these earlier reports cover many of the proposed international actions outlined in *Vision for a Science Nation*. However, they also go beyond these proposals in relation to the need for improved international awareness and exposure of Australian science (recommendations 5-7), and the need for an appropriate governance framework that would allow whole-of-government coordination of the International Science Engagement Strategy, the related Science Diplomacy Strategy, and the Global Science and Innovation Collaboration Program. The recommendations in Table 1 also indicate at a high level the resourcing required to support these initiatives over a 10-year timeframe. The Academy specifically recommends that the following actions should be incorporated into the government's strategy:

14.1. Establish a national advisory board for international science collaboration. This body would be responsible for providing whole-of-government coordination of Australia's international science and innovation engagement and diplomacy activities. The Academy recommends that it should be chaired by the Chief Scientist and include senior representatives from science, industry and from relevant Government portfolios

14.2. Establish a program for early to mid-career researchers to establish partnerships with international leaders in their field. Existing programs provide limited support for Australia's emerging researchers and innovators to establish international networks and collaborations. A formal structured program would help the next generation of Australian research and innovation leaders to build the networks Australia needs for future innovation

14.3. Establish a fund to support strategic partnerships determined by existing Australian Government priorities and cooperation agreements. As discussed previously and as recommended by the Chief Scientist, support is required to establish and maintain strong government-to-government linkages as a basis for international collaboration. The Academy recommends the proposed **Global Science and Innovation Collaboration Program** should be structured in such a way as to enable continuation of Australia's important bilateral science relationships with key countries and regions such as India and China, to establish new relationships with priority countries in the region and elsewhere, and to respond to new opportunities for government-to-government collaboration as they arise. This fund should also provide support for Australian researchers and innovators to access critical international infrastructure not available in Australia.

14.4. Establish an annual 'Global Science and Innovation Watch' report. This is required to provide a regular update to the government and other key stakeholders on key international trends and developments in the research and industry fields and sectors that are of vital importance to Australia's current and future scientific and economic interests. It is recommended that this report draw on Australia's network of international science and innovation counsellors (14.5) as well as other local and international experts, and that it feeds into strategic foresighting and program design, implementation and evaluation across government. It is proposed that this report should be a key annual output of the national advisory board for international science collaboration discussed at point 14.1.

14.5. Continue to support and expand Australia's network of science and innovation Counsellors and attachés in Australian embassies in priority countries and regions around the world.

14.6. Establish a prestigious new program for 'Australian Science and Innovation Special Envoys'. This program is required to allow high-profile individuals to work with leading researchers and business people in order to promote Australian science to relevant markets around the world. It is recommended that this program should be a key feature of the proposed Global Science & Innovation Collaboration Program.

14.7. Take an active role in the Asia-Pacific science and innovation community. The Academy recommended that Australia should explore mechanisms to fully engage with key partner countries and organisations including APEC and ASEAN, and that this collaboration should extend to Pacific countries.

14.8. **Revise and expand the Australian Laureate Fellowship Scheme** to allow Australian science organisations to increase the number of world-leading Australian and International researchers attracted to Australia to establish and lead high-profile research centres and programs in areas of national importance.

15. Which of these proposals will have the greatest impact on Australia's STEM performance?

Each of the international measures proposed in *Vision for a Science Nation* will have an important impact on Australia's STEM performance, provided that they are incorporated into a comprehensive strategic approach with a governance structure that will allow effective coordination across the several government agencies that will have responsibility for the various components.

Of the proposed actions, **the greatest impact on Australia's STEM performance will be delivered by funding to support Australia's engagement in a range of bilateral and multilateral science partnerships.** Such a program would ideally provide structured opportunities for Australia to engage with and leverage funding from international programs such as Horizon 2020, which has total funding of €79 billion and provides significant engagement opportunities for countries such as Australia in exchange for minimal contribution.

It would also provide opportunities for Australia to engage in new government-to-government science and innovation partnerships with priority countries in the Asia Pacific. Importantly, such relationships would generally commence with meetings of experts to identify opportunities for bilateral or multilateral collaboration. In designing such a program, **it will be critical to overcome a limitation of previous international engagement programs by ensuring support for subsequent meetings to consolidate identified opportunities and seed funding for projects in identified priority areas of mutual interest.**

Finally, a program could be implemented in such a way as to:

1. encourage active involvement of Australian scientists **in the major multilateral international scientific institutions such as UNESCO and the International Council for Science, and in global scientific observational and research programs of special relevance to the Southern Hemisphere**
2. strengthen the **beneficial application of international Earth system observation and research through improved and enhanced environmental information, forecast and warning services for the Australian community.**

In contrast, the proposals that will potentially deliver the least impact are:

- retargeting of the Endeavour Scholarships and Fellowships
- new researcher mobility schemes for senior researchers.

16. Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

The Australian Academy of Science is party to a number of formal agreements with international science academies and is a member of the InterAcademy Panel – the global network of science academies, the InterAcademy Council, and the Association of Academies and Societies of Science in Asia. The Academy is also responsible for Australia's representation on the International Council for Science and its international scientific unions and interdisciplinary bodies. These formal bodies provide direct access to the science portfolios and decision makers of all of Australia's key international partners, and as such the Academy is ideally placed to support the government in all future science engagement and diplomacy activities.

The Australian Academy of Science has the capacity to assist the Australian Government to achieve its goals with respect to international STEM performance as an effective and efficient administrative organisation for parts of the proposed international program. In particular, **the Academy has a long and successful track-record of working with the government to support international exchanges and workshops.** Through its Fellowship of Australia's leading scientists, the **Academy also has the capacity to nominate leading experts to relevant panels and committees, and to support the government in the establishment of bilateral and multilateral partnerships with numerous potential partner companies around the world.**

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