Australian Academy of Science

SUBMISSION TO THE

REVIEW TO ACHIEVE EDUCATIONAL EXCELLENCE IN AUSTRALIAN SCHOOLS

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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 outstanding contribution to science.

Executive Summary

A solid grounding in science, maths, engineering and technology (STEM) subjects in primary and secondary education provides the skills required for many current and future jobs, and underpins life skills such as health decision making, personal finance, and technology use and application. All students benefit from a strong grounding in the skills and knowledge that underpin our increasingly technological society, and a significant proportion of students should possess science and mathematics knowledge necessary to enter tertiary education to meet the national demand for STEM-trained professionals.

However, there is evidence that the average performance of Australian students in science and mathematics subjects is falling behind that of students in other developed and developing nations, despite the fact that Australian public investment in education is relatively high.

Improving Australian students' performance in STEM subjects requires sustained and significant efforts from Australian and state and territory governments, as well as from schools, universities and sector-based organisations.

It will require detailed consideration of the way national and international performance metrics are used, an increased culture of evaluation of programs intended to improve student performance, and a focus on supporting new and existing teachers through best-practice, evidence-based programs and training.

With support of the Australian and State government, the Australian Academy of Science has been developing and delivering rigorous teacher professional learning programs and inquiry-based curriculum resources in science and maths for many years. Its flagship *PrimaryConnections* and *Science by Doing* programs are used by over three quarters of Australian schools and school science teachers, and they have been shown to be highly effective in improving student engagement and teacher abilities.

On the basis of this experience and expertise, the Academy is pleased to provide this submission to the Department of Education and Training, and would welcome the opportunity to discuss its views in greater detail.

Key Priorities and Recommendations

The Australian Academy of Science:

- believes all students should possess a level of basic scientific and mathematical literacy
- supports increasing student STEM ability and participation
- supports increasing STEM teaching capacity and quality
- regards headline metrics such as international comparison tests or national metrics as being useful for comparison purposes. They can point to areas of strength and weakness, and can identify areas where a policy response is required.
- underscores the immediate necessity to provide mechanisms to evaluate educational practices and outcomes, and to communicate the results of these evaluations to key stakeholders
- supports a culture of evaluation, where new education programs are measured and reported against national program standards as a matter of course
- supports a culture of continuous professional development for teachers, where teachers are trained in the use of programs that have been shown to be effective
- supports providing incentives for science graduates to gain teaching qualifications
- supports introducing minimum science qualifications for secondary school science teachers
- proposes system enablers be consistent, visible and transparent, with broad support from stakeholders. There must be a rigorous approach to data gathering, analysis, reporting and application.

Background and Context

The Federal Government in July 2017 established a Review to Achieve Educational Excellence in Australian Schools. The review was commissioned to advise the Federal Government on how additional Federal funding should be used by Australian schools and school systems to improve school performance and student achievement.

The review reflects increasing evidence that providing more funding for schools, of itself, does not necessarily improve student outcomes; rather it is a matter of focusing on how the money is spent, not just how much is spent. It will not reconsider the issue of the levels of funding for schools, which has been studied and reported on elsewhere.[1]

In essence, the current review is about the efficiency of (or quality of outcomes from) school spending, rather than the quantum of inputs (expenditure) thereto.

The review is to provide its final report to the Federal Government by March 2018.

[1] Namely, the "Review of Funding for Schools" (2011); also known as the Gonski Review

Responses to Specific Issues

What should educational success for Australian students and schools look like?

- *What capabilities, skills and knowledge should students learn at school to prepare them for the future?*

The Academy considers that students require a solid grounding in science, maths and technology subjects. All students should possess a level of basic scientific and mathematical literacy. Beyond that, a significant proportion of students should possess sufficient science and mathematics knowledge in order to enter tertiary education in order to meet the national demand for STEM-trained professionals.

All STEM-related skills are underpinned by good numeracy and scientific literacy. Primary and secondary education should retain their current focus on science and mathematics.

Fundamental science knowledge should continue to include a coherent understanding of scientific concepts, an experience and trust in the process of scientific inquiry, an appreciation of the history and philosophy of science, and an understanding of how society shapes science and similarly, how science shapes society.

The strong requirement for STEM-related skills is noted in a number of government policy instruments. The *National Science Statement* states "Education in science, technology, engineering and mathematics at all levels ensures that Australians are able to participate in our increasingly science-driven society, whether through employment or in their everyday lives."[2] The Department of Employment predicts a 12.5% growth in professional, scientific and technical services over the next five years and a 25.1% growth in health care services over the same period; these are the fastest growing employment sectors in the Australian economy.[3] These sectors require employees to have a strong grounding in science and mathematics.

The Academy endorses and supports the Education Council's *National STEM school education strategy*[4], with its focus on increasing student STEM ability and participation, on increasing STEM teaching capacity and quality, and on building a strong evidence base.

[2] Australian Government (2017): Australia's National Science Statement 2017 (http://www.science.gov.au/scienceGov/NationalScienceStatement/index.html, retrieved October 2017.)
[3] Australian Government (2017): Industry Employment Projections, 2017 Report. (http://lmip.gov.au/PortalFile.axd?FieldID=2787733&.docx, retrieved October 2017.)
[4] Education Council (2015): National STEM School Education Strategy. (http://www.educationcouncil.edu.au/site/DefaultSite/filesystem/documents/National%20STEM%20School%20Education%20Strategy.pdf, retrieved October 2017.)

- *How should school quality and educational success be measured?*

Headline metrics such as international comparison tests (for example, PISA[5] or TIMSS[6] scores) or national metrics (for example, NAPLAN[7] or Tertiary entrance scores) are useful for comparison purposes. Schools or school systems can be analysed according to these metrics and some conclusions may be drawn. These metrics can point to areas of strength and weakness, and can identify areas where a policy response is required.

However, such metrics cannot provide much information about the effectiveness of education interventions. To gain this information there needs to be a rigorous and systematic approach to the evaluation of school programs.

The Productivity Commission inquiry report into the National Education Evidence Base[8] recommended a strategically guided evaluative research program established by a national body. Such a program could provide guidance on the domains that education interventions might address: a framework of metrics from which researchers and practitioners could draw to inform their individual studies. By providing a standardised framework for the assessment of programs by domains, the education research body would provide an evidence base amenable to further interrogation through, for example, meta-analyses and systematic reviews.

Metrics should follow international best practice. They should be simple, sensitive and robust. They should be consistent and reliable. They should have credibility with the practice community and the general community. They should be amenable to independent verification. Importantly, data collected against the metrics should be collated and maintained in a curated data repository, which is publically accessible. Coupled with the approach described above – a standard and versatile set of metrics that can be applied selectively against any given intervention according to its aims – this would provide a broad, coherent and useful evidence base to inform further research and future practice.

The purpose of these metrics is to assess individual programs. They would not be used to assess schools, teachers or students directly; such mechanisms are already in place.

The Academy runs three science and mathematics education programs: *reSolve - Maths by Inquiry*,[9] *PrimaryConnections*,[10] and *Science by Doing*.[11] The Academy has conducted research and evaluation to analyse the impacts of its programs across the domains of student engagement, student awareness, student motivation and participation, teacher confidence and competence, and links and partnerships across the school and the wider community. This evaluation process allows the Academy to state with confidence that these programs are meeting their educational requirements,

[5] The Programme for International Student Assessment (PISA), conducted under the auspices of the Organisation for Economic Co-operation and Development (OECD)
[6] The Trends in International Mathematics and Science Study (TIMSS), conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA)
[7] The National Assessment Program – Literacy and Numeracy (NAPLAN), conducted under the auspices of the Australian Curriculum Assessment and Reporting Authority (ACARA)
[8] Australian Government (2016): National Education Evidence Base – Productivity Commission Inquiry Report. (http://www.pc.gov.au/inquiries/completed/education-evidence/report, retrieved October 2017.)
[9] https://www.science.org.au/learning/schools/resolve
[10] https://www.science.org.au/learning/schools/primary-connections
[11] https://www.science.org.au/learning/schools/science-doing

as well as providing additional positive impacts. Information about the Academy's evaluation processes are available at the program websites.

What can we do to improve and how can we support ongoing improvement over time?

- *How could schools funding be used more effectively and efficiently (at the classroom, school or system level) to have a significant impact on learning outcomes for* all *students including disadvantaged and vulnerable students and academically advanced students?*
    - *What actions can be taken to improve practice and outcomes? What evidence is there to support taking these actions?*

The immediate necessary action is to provide mechanisms to evaluate educational practices and outcomes, and to communicate the results of these evaluations to key stakeholders. Evidence-based practice has been used to great effect in a number of areas, particularly clinical and public health, and overseas in education and social welfare. Models developed by organisations such as the Campbell Collaboration[12] provide for the gathering and assessment of evidence for public good interventions, with mechanisms to clearly demonstrate positive outcomes.

Ideally, there should be a culture of evaluation, where new education programs are measured and reported against national program standards as a matter of course. This culture should be fostered and supported by a National Education Evaluation Agreement and a national education evaluation institution, as recommended by the Productivity Commission inquiry report into the National Education Evidence Base.

Identification of effective teaching programs should be linked directly to teacher professional development. The recent Productivity Commission 5 year productivity report *Shifting the Dial*[13] places a high priority on professional development of teachers, to address the number of teachers who are teaching out of field and to improve the skills and effectiveness of the existing teaching workforce. The report highlights the role a "more rigorous micro evidence base" might play in providing improved educational outcomes by improving teacher effectiveness.

Additionally, a 2013 report on staff in Australian schools found that around 20 per cent of secondary maths and science teachers are teaching 'out of field' – i.e. they are not qualified to teach the subject.[14] The proportion of schools that have difficulty filling Year 8 maths and science teaching positions is about double the international average.[15] In addition to providing mechanisms for improving the professional development of existing teachers, there should be incentive mechanisms for new science and mathematics graduates to gain teaching qualifications and enter the workforce as teachers. The Academy recommends establishing minimum qualification standards for science

[12] https://www.campbellcollaboration.org/
[13] Australian Government (2017): Shifting the Dial – 5 Year Productivity Review. (https://www.pc.gov.au/inquiries/completed/productivity-review/report, retrieved October 2017.)
[14] Australian Government (2014): Staff in Australian Schools 2013. (https://docs.education.gov.au/system/files/doc/other/sias_2013_main_report.pdf, retrieved October 2017.)
[15] Australian Government (2016): Science and Maths in Australian Secondary Schools. http://www.chiefscientist.gov.au/wp-content/uploads/OCS-Datasheet-secondary-schools_WEB-VERSION.pdf, retrieved October 2017.)

and mathematics teachers, including a tertiary degree in a relevant discipline and postgraduate teacher training.

- *What works best for whom and in what circumstances?*

Inquiry-based learning programs have been demonstrated to achieve greater engagement and better learning outcomes against standard programs.[16] Such programs allow students to make determinations about the problems, challenges and issues they investigate. The greater autonomy provided through inquiry-based learning programs allows students to develop problem solving abilities and self-confidence while improving their subject knowledge and process skills. However, these programs are only effective if teachers are sufficiently trained to teach and guide the inquiry process: students must be supported by their teachers.

The Academy's three education programs are built around an inquiry-based learning model. The results of our evaluations confirm the effectiveness of these programs.

- *What institutional or governance arrangements could be put in place to ensure ongoing identification, sharing and implementation of evidence-based good practice to grow and sustain improved student outcomes over time?*

The Academy supports the recommendations of the Productivity Commission inquiry report into the National Education Evidence Base where they relate to the establishment of a formal education evidence base. Guided by that report, the Academy recommends:

- A National Education Evaluation Agreement between the Federal Department of Education and Training and the State and Territory education departments to provide policy objectives, guidelines and parameters for the evaluation of education programs nationally
- A national institution to:
  - direct and commission evaluative research on education programs
  - verify the quality of existing research
  - provide a framework of program evaluation metrics
  - provide national standards for education programs
  - maintain an evidence base that identifies approaches to improving teaching practices and outcomes
  - communicate the outcomes of research into the effectiveness of education programs.

  This institution should be guided by an independent panel or board of education experts, analysts and stakeholders.

[16] See Buchanan, S., *et al*., Inquiry based learning models, information literacy, and student engagement: a literature review. *School Libraries Worldwide*, 22(2), pp. 23-39, 2016 for a recent review of the literature concerning inquiry-based learning programs. (https://eprints.qut.edu.au/102823/, retrieved October 2017)

- *How can system enablers such as targets and standards, qualifications and accreditation, regulation and registration, quality assurance measures and transparency and accountably provisions be improved to help drive educational achievement and success and support effective monitoring, reporting and application of investment?*

These system enablers must be consistent, visible and transparent, with broad support from stakeholders. There must be a rigorous approach to data gathering, analysis, reporting and application. They must have minimal impact on individuals within the education system (i.e. students or professionals); they must not present a barrier to effective teaching or present an onerous administration burden of on schools and the education system.

- *Are there any new or emerging areas for action which could lead to large gains in student improvement that need further development or testing?*
    - *What are they and how could they be further developed?*

As noted above, the Academy has three programs of inquiry-based education tools. The Academy's award-winning curriculum resources and teacher professional learning programs are based on a guided inquiry-based approach to education. These programs have been based on extensive research with empirical testing as an integral feature of all aspects of resource and professional learning development. In particular *PrimaryConnections* and *Science by Doing* were preceded by comprehensive national research studies. During the development of both programs independent evaluation studies have been undertaken. These studies have continued to validate the value of the programs and their impact. We consider that these programs provide a strong foundation in science and mathematics knowledge, skills and processes.

The Academy will continue these programs by further development of innovative teacher and student resources. We will expand the reach of our education programs to support pre-service and in-service teachers through targeted professional learning programs.

The Academy is happy to provide further information on our inquiry-based education programs and evaluation processes as required.

Are there barriers to implementing these improvements?

- If yes, *what* are they and how could these be overcome?

Time and resources present the largest barriers to the proposed recommendations. It will likely take some time to establish a national education evidence base, with a time scale beyond the normal funding cycles for the education system.

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