SUBMISSION

30 November 2018

Submission to the

NSW Education Standards Authority (NESA) NSW Curriculum Review

APPLIED

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Submission to the NSW Education Standards Authority NSW Curriculum Review

The Australian Academy of Technology and Engineering (the Academy) welcomes the opportunity to provide input into the NSW Education Standards (NESA) NSW Curriculum Review.

Executive summary

The Academy believes firmly that Australia's future prosperity, health, security and well-being will be driven by stronger workforce engagement and performance in areas of the economy underpinned by the STEM (science, technology, engineering and mathematics) disciplines. As a nation, we are failing to encourage sufficient school students to take the senior secondary subjects that underpin further studies or employment in areas that depend on STEM. School education must equip more children to gain STEM knowledge, skills and attitudes through the compulsory years of schooling, and the confidence to pursue STEM subjects in senior school.

While the Academy supports the curriculum, the challenge is in how it is taught and the capabilities and confidence of the teachers. It is critical that teachers are trained to be skilled and confident, as it is a self-assured teacher that makes an inspiring teacher. The focus must therefore be on making every teacher in the system capable and confident, as every teacher is a resource we cannot afford to be without.

With a dense and overcrowded curriculum, it is also important that there is flexibility in how the curriculum is taught. This flexibility must come from the support of the principal through sufficient funding, the reduction of administrative tasks from the line teachers, and ensuring that STEM knowledge and skills are acquired predominantly from within the curriculum rather than reliance on extracurricular activities.

It is therefore imperative that we provide a support system and ongoing professional development for those teachers who find themselves teaching out-of-field, or those who are not confident in a pedagogical style of inquiry-based teaching and learning. Providing teachers with the ongoing professional development and resources to frame the curriculum around relevant, real world themes, and hands-on problem-solving learning will allow teachers to inspire a genuine engagement in STEM by their students. It will also ensure they will have an opportunity to break down the stereotypes surrounding the participation of girls and boy in studying maths and science in consideration of a STEM-underpinned career.

Recommendations

The Academy's recommendations are ordered against the review questions of the Terms of Review.

Purpose of the curriculum

1. Ensure the stated purpose, design, delivery and assessment of the curriculum supports all students to make informed subject choices and achieve to the best of their capabilities in their preferred areas.
2. Frame the goal of school education in terms of students' continuing journey of self-fulfilment and learning, rather than the 'achieving the highest possible ATAR'.

Essential Knowledge, skills and attributes

3. Increase the emphasis on foundational mathematics, science and technology (including design and engineering principles) in the early primary stage curriculum.
4. Increase the visibility of 'engineering' as an area of human endeavour that complements science, technology and mathematics, and highlight its impact in creating the present and defining the future.
5. Strengthen the content and teaching of mathematics, science and technology (including digital technology, design, and engineering principles) during upper primary and compulsory secondary schooling to underpin the desired increase in take-up of senior secondary subjects in these areas.
6. Increase the integration of content and learning outcomes across subjects and topics in mathematics, science, engineering, and technology, and with other subjects, to emphasise the creative and human-centred and environmentally sustainable dimensions of STEM.
7. Ensure that the importance of mathematics as the core analytical and communications tool of physical, chemical and biological sciences, engineering, computing and other quantitative areas is conveyed clearly to students during Stages 4-5 in order to widen their opportunities, and to increase the numbers taking at least 'intermediate' level

1. The Academy is an independent think tank that comprises the leaders in the fields of technology and engineering, who gain Fellowship to the Academy in a highly competitive process. The Academy is one of Australia's four national Learned Academies but uniquely its 800-strong Fellowship come from industry, government and research organisations, as well as academia. Our Fellowship develops trusted, informed and visionary views to persuade decision-makers to implement the most progressive policies on the development of technology for the betterment of Australia and its people. www.applied.org.au

mathematics, (currently Mathematics 2-unit in NSW). Consider making mathematics compulsory within the secondary school certificate.

8. Allow flexibility within the curriculum of senior secondary STEM subjects for teachers to both consolidate fundamental concepts and to illustrate them with selected examples from contemporary human and environmental challenges.

Curriculum redesign

9. Increase the resourcing and use of authentic inquiry-based and problem-based pedagogies within STEM and other subjects, taking advantage of industry partnerships where appropriate.
10. Explore the use of new educational technologies, including personalised learning systems, to improve the quality of education delivered.
11. Devise reliable ways of teaching, assessing and reporting on students' development of generic skills and attitudes (including communications, collaboration, innovation, emotional intelligence and ethical behaviour) throughout the curriculum.

Other implications

12. Increase and systematise in-service professional development for teachers in STEM subjects and disciplines at all levels of the curriculum.
13. Recruit more teachers for STEM subjects, including from related disciplines and professions, ultimately to eliminate out-of-field teaching at secondary level. The Academy favours secondary subjects being taught by teachers who have a Bachelor's degree qualification in a relevant discipline.

The Academy would be pleased to provide further advice to the NSW Education Standards Authority. Please contact Fern Beavis, on **(03) 9864 0934** or fern.beavis@applied.org.au, or Emeritus Prof. Robin King FTSE, on **0418 823 415** or robin.king@uts.edu.au if you have any further questions.

Introduction

The Academy's declared mission reads: "We apply technology, engineering and science expertise to solve the big issues facing our nation in a fast-changing world". The Academy executes its mission through the expert contributions of its Fellows to projects, commissioned reports, events (conferences, symposia and forums), and submissions to inquiries.

The Academy is not expert in school curriculum design, but its outcomes – well-educated school leavers heading towards STEM (science, technology, engineering and mathematics) careers – are at the foundation to the Academy's mission, and we believe, to Australia's future prosperity, security and health. A strong STEM workforce is at the core of all growing economies worldwide. Data analytics, artificial intelligence, machine learning, the Internet of Things, new materials and manufacturing methods (Industry 4.0) are already transforming many sectors. Australian schools do not currently produce sufficient school leavers motivated to become mathematicians, information technologists, engineers or technicians to meet national needs for many sectors of the economy. We rely very heavily on immigration for these areas.

The Academy is also very concerned that over recent time, Australia's average performance in international mathematics and science surveys (PISA and TIMSS) has slipped. Furthermore, the proportions of senior school students (and especially girls) taking higher levels of mathematics and physical sciences has declined.

The Academy supports the broad principles and content of the national curriculum, and recognises that its implementation poses different challenges in each state and territory. The Academy also recognises that the current New South Wales curriculum is intrinsically sound: this review is for refreshment and updating, rather than for wholesale rebuilding.

The content of this submission is derived in part from the discussion and outcomes of an Academy led Workshop on Inspirational STEM Teaching (November 2015), and series of Position and Action Statements developed by our Education Forum and the experience of running national projects. The Academy's STELR (Science Technology Education Leveraging Relevance) program, for example, has supported science in secondary schools since 2007, and our related project Inspiring Science and Mathematics Education- ISME has developed multidisciplinary science and engineering contexts for Years 6 -10. STELR enhances in school STEM teaching and learning grounded in the cross-curriculum priority of sustainability within real-world context of global warming and utilising a flexible equipment-based approach to inquiry-based learning. This problem-solving approach to learning is further underpinned through the provision of diverse, innovative career profiles. The outcome of the STELR program is increased enrolment in science subjects in years 11 and 12 (see Attachment 1 for details).

The Wonder of Science initiative is designed to promotes a STEM culture in Queensland remote and rural schools through curriculum-based STEM projects (see Attachment 2 for details).

Through STELR, the Academy is one of many groups seeking to redress a slide in STEM teaching and learning in schools. The existence of so many disparate groups is a reflection of wide community concern around the depth and breadth of STEM skills amongst those entering the workforce and tertiary education.

An effective school education system is vital to enable all school leavers to succeed in their future studies and work, and contribute as citizens. Literacy and numeracy are the core learning areas on which other areas rely. Children's innate curiosity and creativity must be encouraged and developed.

Their physical health, values and self-confidence must be nurtured alongside their developing understanding of Australia in the world.

In the Academy's specific areas of interest, namely technological sciences and engineering, school education should ensure that all students should have basic knowledge and understanding of mathematics, engineering, technology and science.

Mathematics develops the skill of quantitative reasoning, the ability to make decisions based on numerical information which is core to participation in modern society. Mathematics is the analytical and communications tool of science, engineering, computing and other quantitative areas. Science builds the method of scientific inquiry. Engineering has created the modern world. School leavers should have facility with contemporary digital technology, and understand the principles of design and systems thinking as creative and rigorous processes that facilitate capacity to manage complexity.

Having a basic but comprehensive background in STEM areas will future-proof students for a world in which a large proportion of future jobs are predicted to require STEM-based skills. A significant proportion of school leavers, certainly no less than at present, must also have the opportunity to gain specialised knowledge and understanding in the STEM subject areas, to satisfy both their personal interests and abilities, and prepare them for future studies and employment in areas of STEM, and beyond.

Our responses to the review questions naturally focus on the STEM areas, but acknowledge the absolute importance of other school learning areas. Whatever form the revised curriculum takes, we see teachers as the central actors of its delivery. We also anticipate that employer peak bodies, professional organisations and learned societies such as the Academy, will continue to be willing to support the school education system. We elaborate these observations further, in response to each of the four questions stated in the terms of reference for the review.

Purposes of school education

School students' education must prepare them for an ever-changing world, in which further life-long education and training will be the norm. The later stages of compulsory school education should allow students to pursue subjects and activities in which they have special interest, capabilities and potential. They must be able to draw on experts to guide their subject choices towards fulfilling their aspirations. The subjects offered must be crafted and continually updated to facilitate pathways to employment and further study. Senior students should be encouraged to see beyond the short-term goal of achieving the best possible ATAR.

» **Recommendation 1** Ensure the stated purpose, design, delivery and assessment of the curriculum supports all students to make informed subject choices and achieve to the best of their capabilities in their preferred areas.

» **Recommendation 2** Frame the goal of school education in terms of students' continuing journey of self-fulfilment, rather than the 'achieving the highest possible ATAR'.

Essential knowledge, skills and attributes as the common entitlement

Stages K – 2: early primary school: the basics

All children are entitled to early year education that develops their literacy and numeracy skills. Literacy should be developed through reading and writing in the national language, and the use of basic digital tools (digital literacy). Equally, numeracy skills (arithmetic operations and number patterns) must be developed, to underpin the development of mathematics and quantitative reasoning.

It is unfortunate that, unlike the other STEM areas, 'engineering' has low explicit recognition in the school curriculum and that teachers and students do not develop a coherent understanding of its central role in human development and its complementary relationships with science, technology and mathematics. This has resulted in a lack of early recognition of engineering as a valuable career option, especially by girls, and requires significant efforts by professional and industry bodies to redress this lack of knowledge as an adjunct to the curriculum.

Knowledge and skills in science, technology and engineering should be introduced and developed from simple observations and measurements (thereby using mathematics) from nature and the built world, and by making models and artefacts, ideally from modern materials and with contemporary tools (as in the Design and Technology strand of the ACARA Technology curriculum). Digital technology (coding) may be integrated into these and other areas of the curriculum. 'Engineering thinking' and methodologies can be introduced.

Furthermore, children should start to acquire generic attributes of inquiry, research, problem solving, communication and collaboration, throughout their primary education years.

» **Recommendation 3** Increase the emphasis on foundational mathematics, and on engineering, technology and science in the early primary stage curriculum.

» **Recommendation 4** Increase the visibility of 'engineering' as an area of human endeavour that complements science, technology and mathematics, and highlight its impact in creating the present and defining the future.

Stages 3-4 upper primary and early secondary school: common curriculum

All of the key learning areas outlined above must continue to reinforce the learning outcomes.

By the end of Stage 4, students must have good literacy skills and solid numerical knowledge and skills. They must understand scientific inquiry and basic scientific principles and facts. They should have knowledge and experience of using digital technology and of design and engineering principles and methodologies.

Many students will form ideas about their own future from Stage 2. These are likely to be heavily influenced by their family, teachers and life experiences. The Academy believes it is in the national interest for STEM subject areas to be strengthened during Stages 2 – 4, by demonstrating the intrinsic dynamism of their principles, rather than their factual 'dryness'.

It is in this phase of schooling that hands-on experimental programs like STELR that are integrated into the curriculum and provide teacher support, work so well (see below). But we also note that, despite their good intent, many supplementary activities in STEM are often not well coordinated with the set curriculum, and are increasingly being offered to teachers and students. These activities are usually aimed at a specific topic, are mostly well delivered and are funded by governments, industry, interest groups, experts and philanthropy. Such activities are most often taken up by confident teachers for the STEM-interested students across some classes, but they are not experienced by every student in that year at an individual school. Such STEM-based extracurricular activities are overwhelming the education system with little evaluation of what outcomes they achieve.

In proposing this rebalance of the curriculum, the Academy would not wish to see it more crowded. Rather, we envisage a curriculum in which more knowledge and skills are gained and stronger generic skills and attitudes are demonstrated, by ensuring that content and activities across the curriculum as a whole serve multiple learning goals.

Recommendation 5. Strengthen the content and teaching of mathematics, science and technology (including digital technology, design, and engineering principles) during upper primary and compulsory secondary schooling to underpin the desired increase in take-up of senior secondary subjects in these areas.

Recommendation 6 Increase the integration of content and learning outcomes across subjects and topics in mathematics, science, engineering, and technology, and with other subjects, to emphasise the creative and human-centred and environmentally sustainable dimensions of STEM.

Stages 5-6 secondary school: divergence and specialisation

By the end of Stage 4, school students have diverse and divergent interests, academic abilities, personal attributes (such as self-confidence) and aspirations. They have to make subject choices that ideally to open-up (rather than constrain) opportunities that match their interests and perceived needs.

The forms of such opportunities – and the post-school pathways to them – are likely to change considerably over the two decades that a school curriculum is expected to be applied, especially in the STEM fields. Having a range of subjects available is in students' general interests, especially if they facilitate success in further study and employment.

As noted earlier, the Academy places less value on 'attaining a high ATAR' than on ensuring that students make subject choices that maximise their post-school opportunities. The current trends in Year 12 mathematics subject enrolments raises particular concern.

Many current occupational and professions areas rely on having graduate entrants from degrees that require school-level preparation in mathematics and science. Most NSW universities specify at least 2-unit Mathematics (Mathematics Advanced from 2019) as the 'assumed knowledge' or 'prerequisite' for entry into the standard BEng (Hons) degree in engineering, and for entry into most bachelor's degrees in science, computer science, economics, and other quantitative fields. This level of mathematics opens a very wide range of opportunities, yet in recent years, a declining proportion of students, and especially women, are taking it. At the same time, enrolments in the lower level of mathematics subject (Mathematics General) have increased. The Academy would wish to see all students take and succeed in some mathematics in their Stage 6 schooling.

» **Recommendation 7** Ensure that the importance of mathematics as the core analytical and communications tool of physical, chemical and biological sciences, engineering, computing and other quantitative areas is conveyed clearly to students during Stages 4-5 in order to widen their opportunities and to increase the numbers taking at least 'intermediate' level mathematics, (currently Mathematics 2-unit in NSW). Consider making mathematics compulsory within the secondary school certificate.

Where possible, the mathematics curriculum should draw on examples from other learning areas, to demonstrate its use and value. Understanding statistics and probability is increasingly important. Computer tools should be used to increase the understanding of mathematical principles and techniques, as well as to facilitate calculation and data analysis.

Current senior science subjects are well-intended, but are packed with content. They must continue to cover fundamental principles and where possible be illustrated with contemporary developments. Students need to experience how science is done, though experimentation or simulation. But we would argue that not everything needs to be covered, and it is better to teach only part of the defined curriculum, but to greater depth, rather than skimming the surface of a wide range of topics. From learning something in depth, students will be able to translate their learning processes to other areas.

Senior secondary subjects in engineering, computing and technology should also be available, to reflect their importance. These subjects offer great opportunity to explore practical and creative dimensions, through coding, design, build and test activities, as well as their theoretical underpinning. As for the science subjects, the curriculum must allow for technological change, and allow teachers flexibility in topic choice.

» **Recommendation 8** Allow flexibility within the defined curriculum of senior secondary STEM subjects for teachers to both consolidate fundamental concepts, and to illustrate them with selected examples from contemporary human and environmental challenges.

University degree study is not for all school-leavers, but being able to reason quantitatively, or interpret the outcome of software-driven instrumentation are everyday requirements in many practical occupations. Stages 5-6 must have suitable subjects for students aiming towards technical or applied science roles, and post-school study in the VET sector. Suitable VET certificate subjects should be available to secondary school students, and attributed in their leaving certificate.

Each school should be able to shape the senior curriculum to the needs of its students, drawing on its community context and support, including from industry partnerships.

By the end of Stage 6, through curriculum content and activities, all students should have the capability for further guided and independent learning, knowledge and skills for effective collaboration, a wide range of communication skills, and sound values.

How can the curriculum be redesigned and presented to better support teaching, learning, assessment and reporting?

Redesign and presentation of the curriculum to better support teaching

The teaching of the three Cross-curriculum Priorities (Sustainability, Asia and Australia's Engagement with Asia, and Aboriginal and Torres Strait Islander Histories and Cultures) and the seven General Capabilities (Literacy, Numeracy, ICT Capability, Critical and Creative Thinking, Personal and Social Capability, Intercultural Understanding, and Ethical Understanding), together with the individual learning specifications across Years 7-10 of the Australian Curriculum, present a complex task for teachers. Achieving multi-dimensional learning outcomes is particularly challenging in STEM subjects. In these areas the focus and engagement should be on re-conceptualising the STEM curriculum focus towards human and environmental concerns, and on new disruptive technology and design. These challenges are further exacerbated when teachers find themselves teaching out-of-field, discussed further in the response to Question 4.

The Academy believes here that 'less could be more', in the sense that excessive curriculum documentation can reduce the teachers' scope for innovation and customisation. Their focus should be on each child and student's learning needs, in the context of a flexible curriculum framework built around sound literacy and numerical skills. The curriculum materials must be gender-neutral.

Teachers clearly need to be supported by access to specialists and frameworks of specified Year or Stage achievement levels, and corresponding sets of supporting teaching and assessment materials to engage and inspire students.

Redesign and presentation of the curriculum to better support learning

Successful curriculum design is both a 'top-down' and 'bottom-up' process. External bodies such as the Academy can contribute best to overall outcomes specification, as outlined earlier, and through programs such as STELR, can contribute to implementation. Education theory supports engaging students in STEM subjects by means of active pedagogy.

The tendency for many schools to be poorly supported with experimental equipment for science, technology and engineering subjects, combined with an inadequate number of specialist teachers, has led to the support of external bodies and extra-curricular activities, referred to earlier.

The Academy's STELR program is one such in-curriculum program of active learning that appeals to students' appreciation of the relevance of the STEM in their lives, which can often be under-appreciated despite living in an engineered world[2]. For over 10 years, the STELR program has demonstrated that students are more engaged when knowledge-based disciplines such as STEM are couched in contexts that are relevant to their lives. We outline the program here to suggest that, ideally, its principles and practices should be mainstreamed within all Australian schools to good effect.

The modules developed by the STELR program engage most students' interests in issues such as climate change, water security and sustainability, and shows them that mathematics, engineering, technology and science are crucial to addressing these issues. Modules can also be adapted to utilise in-demand technologies such as coding, robotics and data analysis.
The hands-on, inquiry-based and problem-based activities encourage deeper learning of the principles of the disciplines, and interdisciplinary thinking. The STELR equipment is designed to increase the fun and effectiveness of hands-on activities. Students' work is also authentic, requiring them to work both independently and collaboratively, ask their own questions and devise ways to find the answers (whether by research or by conducting investigations), analyse data, and produce plans, reports and presentations that mirror what working scientists and engineers do in their careers and in further learning. Overall, the approach leads students' to discover solutions to

2. STELR has ensured all its industry career material which is embedded in the STELR modules and lessons have gender balance, further, STELR has a good representation of take up in girls only schools and there are a number of learnings from STELR regarding the engagement of both girls and boys in science and maths.

authentic and complex problems.

Lessons learned from STELR include the importance of having high-quality equipment sets that are appropriate to the investigation, are easy to use by all students, give reliable results and do not break. The STELR program also aligns with the national curriculum, and is adaptable to individual state requirements, with teachers being shown how STELR activities apply to the STEM learning areas. As it not an extra-curricular or elective program that appeals to the 'already converted', all students at the year level participate in the program, not just select students. The program thus reaches students from cultural minorities, and girls, and other groups that are traditionally underrepresented in STEM programs. The support and training provided to teachers acknowledges that many are teaching 'out-of-field'.

Over 200 NSW schools have already acquired one or more class sets of STELR equipment and use them in several subjects and at multiple year levels. The sets are adaptable to a changing curriculum as they teach fundamental principles of a range of knowledge-based disciplines and fundamental skills that will be needed in the jobs of the future.

The Academy is also aware of the rapid changes and innovations that are taking place in educational technology, much of which has an emphasis on tailoring learning to the individual student. New pedagogies should be trialled, evaluated and where appropriate, mainstreamed.

STELR also focuses on careers, showing students what is involved in future STEM-based jobs and careers, their study pathways, be they through university or vocational education. STELR has developed both written and video profiles of female and male role models from a range of cultural backgrounds in rewarding and varied careers, including those who have engaged in multiple career paths across industry, government services and academia, to engage and inspire students. Such tools should be a core to every learning area.

This approach could contribute to redressing community concerns about school students' poor preparation for employment. Industry-school partnerships, as recommended in the recent report[3] of the Education Council for STEM, should also be taken up. In all learning areas, skills in communications and collaboration, understanding respect for others and self, are explicit or intrinsic in the teaching methods. (Most senior school students also have some paid employment, so are not unfamiliar with the world of work.) Without assessment or reporting for these areas of generic skills and attributes, senior secondary students evidently, and sensibly, focus on their knowledge-based subjects. The Academy suggests that the review consider this area, as it could improve students' self-confidence and self-efficacy in their chosen field, and their employability and transition to further studies.

» **Recommendation 9** Increase the use of authentic inquiry-based and problem-based pedagogies within STEM and other subjects, taking advantage of industry partnerships where appropriate.

» **Recommendation 10** Explore the use of new educational technologies, including personalised learning systems, to improve the quality of education delivered.

» **Recommendation 11** Devise reliable ways of teaching, assessing and reporting on students' development of generic skills and attitudes (including communications, collaboration, emotional intelligence, innovation and ethical behaviour) throughout the curriculum.

The implications of any new approach to curriculum design

Overall, the Academy would wish to see the school curriculum enriched, at all levels, with material and activities in mathematics, technology, engineering and science that children enjoy, and that they can relate to their own experience and personal aspirations, and engagement with their community. Documentation for this may be sourced from media. Their horizons may be expanded by using sources such as the UN Sustainable Development Goals and national Grand Challenges.

As at present, early year schooling should use activities to develop multiple and cross-discipline goals, including in numeracy, scientific inquiry, engineering methodologies, technological skills, cooperation and presentation capabilities. In later school years, there should be an increase of focus on experiential and inquiry-based learning in the STEM areas (including digital technologies, engineering principles and design), and an increase in cross-subject learning. Moving into Stage 6, there should be increased attention to generic skills and attributes, as discussed above.

The strong subject orientation of Stage 6 is one of the strengths of the Australian school education system, not least in NSW. Subject choice is embedded in the national curriculum and is implicit in progression to tertiary education and employment. The range of available subjects is very wide, perhaps too wide. However, all school leavers should gain a balanced education, including some mathematics, possibly a subject from the science, engineering and technology group.

All such changes, and indeed all improvements, to the implementation of the current curriculum will depend on teachers. The Academy has some concerns in this area.

The Australian Council for Educational Research (ACER) found that approximately 26 per cent of teachers at Years 7-10, and approximately 15 per cent of teachers at Years 11-12 were teaching a subject out of their field[4] of expertise and training. Research by the Academy and others has shown that inquiry-based and project-based teaching and learning requires teachers who are confident in the specialist subjects they teach. Teaching across areas similarly implies adequate knowledge of those

3. Optimising STEM Industry-School Partnerships: Inspiring Australia's Next Generation Final Report, Education Services Australia, 2018

4. Weldon, Paul R. (2016). Out-of-field teaching in Australian secondary schools. (Policy Insights; n.6). Melbourne: Australian Council for Educational Research (ACER).

areas. For secondary teaching, not having a prior degree in the subject area, is likely to limit the ability of teachers to explore complex problems in subject matters that may arise with inquiry-based or project-based learning.

The current body of teachers are dedicated to their students and their learning, but they are also relatively under-supported and underpaid, compared with graduate peers in other professions. Many leave teaching after only a few years.

The Academy supports any effective method to improve the enrolment of school leavers and mature entrants into teacher education at all levels. For secondary school teaching, the Academy strongly supports recruitment of graduates from mathematics, engineering and science degrees into postgraduate teaching qualifications. In addition, we consider that teachers must have regular and intensive in-service career development in new pedagogy and subject material.

The Academy will continue to support schools and teachers through STELR and other projects, and through activities of many of its Fellows in programs such as CSIRO's STEM Professionals in Schools. While it can be argued that the existence of these programs indicates system-wide shortcomings in the provision of mathematics, engineering, technology and science education in our schools, the reality is that they will always be beneficial to connect teachers and students to the fast-moving worlds of science, technology and engineering. We envisage that a revised NSW curriculum will continue to benefit from the support of organisations such as the Academy, and their practioners working in STEM fields and occupations to which more school students will aspire.

» **Recommendation 12** Increase and systematise in-service professional development for teachers in STEM subjects and disciplines at all levels of the curriculum.

» **Recommendation 13** Recruit more teachers for STEM subjects, including from related disciplines and professions, ultimately to eliminate out-of-field teaching at secondary level. The Academy favours secondary subjects being taught by teachers who have a Bachelor's degree qualification in a relevant discipline.

Attachment 1

STELR – the Academy's solution to enhanced STEM teaching and learning

The Academy has long recognised the issues highlighted in its submission to the NSW Education Standards Authority's (NESA) review of the NSW curriculum. To address these issues, in 2008 the Academy developed the STELR (Science Technology Education Leveraging Relevance) program for secondary school science under the guidance of Dr Alan Finkel.

In the decade that STELR has been running, it has been taken up by over 700 schools across Australia, New Zealand and Asia, with some 134,000 students participating in the program each year. Over 900,000 students have so far benefitted from the STELR program.

Of the 624 secondary and 376 combined schools in NSW, 220 schools utilise STELR and have at least one class set of at least one type of STELR equipment.

STELR concentrates on framework stages four and five of the New South Wales curriculum, with the aim of increasing the number of students studying STEM subjects at years 11 and 12. It has also produced materials that support senior subjects such as the Investigating Science Depth Study.

To support the curriculum packages, STELR has produced 20 curriculum modules comprising over 280 lessons, 100 hands-on activities, 30 career profile videos, and 60 written career profiles. Many modules are supported by kits that include Academy designed and Australian manufactured equipment to facilitate inquiry-based, hands-on and minds-on learning. The main sets are Renewable Energy, Wind Energy, Solar Cars and Sustainable Housing.

STELR Renewable Energy or Wind Energy equipment sets are currently being used by schools as a part of the RDA Hunter's ME program. This STEM program is being rolled out across New South Wales.

STELR is now expanding to support primary schools. The module, Electricity and Energy, supports stage three physical science while the module, Day in the Life of a Seven-Year-Old, introduces stage one students to STEM careers.

STELR supports teachers

In the Academy's submission to NESA, it has been identified that teachers in Australian schools need a deep understanding and pedagogy of the subjects they are teaching.

To provide teachers with support and training, professional development programs for in-service teachers are delivered by STELR around New South Wales, with the STELR website also providing additional support through videos on how to use STELR equipment.

The support and training provided to teachers acknowledges that many are teaching 'out-of-field'.

The STELR program thus addresses problems in STEM teaching by providing teachers with resource materials that help them engage the students in authentic, real life scenarios.

STELR supports the NSW curriculum

STELR acts to enhance the curriculum rather than overcrowd it. STELR does not add anything new to the curriculum for teachers to teach. Rather, it reflects the current curriculum to provide greater impact in teaching and learning.

STELR has produced modules to meet areas of greatest need, especially in the physical sciences where many teachers lack deep understanding and confidence. The modules deliver science knowledge and develop inquiry-based learning skills by concentrating on Science, Maths, and Design and Technologies learning areas.

The whole program is embedded in a relevance model, using the three cross curriculum priorities, and all STELR modules are designed to develop the seven general capabilities of the curriculum: Literacy; Numeracy; Information and Communications Technology Capability; Critical and Creative Thinking; Personal and Social Capability; Ethical Understanding; and Intercultural Understanding. This encourages teamwork, students to ask questions, a fun learning environment, and a fully supported and trained teaching environment.

The program uses career profiles and case studies from contexts that show students that science and maths are relevant to their lives. Many of these contexts involve sustainability issues such as climate change, water security, renewable energy and energy efficient housing. For example, modules such as Carbon Dioxide Friend or Foe? involve Aboriginal and Torres Strait Islander examples, case studies and career profiles. These have been written using the eight Aboriginal Ways of Learning.

STELR impact

Independent evaluation shows:

- Students are more engaged in STELR lessons compared with regular science lessons.
- STELR teachers, especially those teaching out-of-field, are more confident through in-service training, mentors, teacher manuals and step-by-step lessons.
- Increased enrolments are regularly reported in STEM subjects at Year 11 in STELR schools.
- STELR students are more scientifically literate - even if not pursuing STEM in later years.

The Academy's solution

The Academy would like to see an education system that enhances the STEM capability of schools and to enhance STEM learning for all students. The Academy believes that every child deserves to benefit from the STELR approach.

STELR has a solid record of accomplishment, with 100 per cent of STELR schools continuing to engage in the program. It works, and it is proven to be successful and scalable by building general capabilities over time in a cumulative manner.

With a class set of STELR Renewable Energy, Solar Car and Sustainable Housing kits costing $12,000 per school, an investment of $11M by the NSW government would provide these kits to the 780 NSW government secondary or combined primary and secondary schools that do not have any of STELR kits, and to "top up" the schools that do not have all types of STELR kits. This includes provision of in-service training for teachers.

Attachment 2

Wonder of Science 2018

Wonder of Science is a program operated through the UQ Graduate School.

The number of schools participating in Wonder of Science in 2018 increased by 10% to 48, and in those schools the number of classes participating rose by 48% to a total number of 208. More than 4,500 school students and more than 100 university RHD students are involved in Wonder of Science this year.

Wonder of Science involves students in a collaborative STEM inquiry project for the duration of a school term. As part of this, Young Science Ambassadors – typically PhD students recruited from leading Queensland universities support teachers and students with their projects and promote the wonder and excitement of science.

The program culminates with a regional student conference, where representative teams of students present their research and critically analyse the projects of their peers. Winning regional teams are then invited to the Wonder of Science State Conference where champion teams are chosen for each year level 5 to 9.

The Wonder of Science initiative

The Wonder of Science initiative is promoting a STEM culture in Queensland schools and communities by inspiring students to engage in rigorous, real-world STEM learning and to aspire for excellence in STEM. It encourages students to consider the exciting and diverse career pathways possible through STEM.

Through the Young Science Ambassador program Wonder of Science demonstrates the potential of STEM and supports teachers to develop quality teaching and learning programs in STEM. The Wonder of Science approach:

- Develops deep understanding of STEM concepts in students
- Promotes problem-solving skills, including critical, creative, collaborative and ethical thinking
- Develops the student capabilities required to achieve and succeed in a rapidly advancing and changing world.

There is a particular focus on rural, remote and Indigenous students who would not ordinarily receive the same level of support as those in the South-east of the state.

As well as improving school student engagement and achievement in STEM, Wonder of Science is also positively impacting the PhD students, improving their career prospects through enhanced science communication and soft skills. In addition, some of these students are moving into teaching careers following completion of the PhD studies.

Wonder of Science key strategies

STEM INQUIRY - challenging, real-world tasks aligned to the Australian Curriculum: Science and Technologies. Teachers are central to the inspiration of future generations – Wonder of Science provides a one-day professional learning program for teachers prior to implementation in their school, as well as teaching and learning guides.

YOUNG SCIENCE AMBASSADORS - inspirational PhD research students are passionate and knowledgeable stem role models for both teachers and students. The ambassadors are inspiring role models for both students and teachers, who describe them as “bringing STEM to life”.

STUDENT CONFERENCES - aspirational regional and state student showcase events. In addition, students have the opportunity to participate in ‘Speed-meet-the-Scientist’ activities and workshops. Winning teams receive medals and a trophy for their school, and the State Champions receive individual pennants and a giant school pennant.

STRATEGIC PARTNERSHIPS – Wonder of Science promotes partnerships between schools, universities, industry groups, non-profit organisations and government agencies. The involvement of industry and environmental partners in the program helps to convey the importance and diversity of STEM careers. A key benefit for partners is the potential for their enhanced profile in communities and schools. For example, the partnership with the Queensland Office of the Chief Scientist, involves early career researchers who accompany Young Science Ambassadors into regional Queensland centres for community STEM events. The Flying Scientist program is designed to address the shortage of science-related events convened outside South-east Queensland.