



**Australian Academy of Technological Sciences and  
Engineering (ATSE)**

**Submission to ACARA: Response to the Draft K-10 Australian  
Curriculum Documents**

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# Australian Academy of Technological Sciences and Engineering

## Submission to ACARA: Response to the Draft K-10 Australian Curriculum Documents

The Australian Academy of Technological Sciences and Engineering<sup>1</sup> (ATSE) welcomes this opportunity to provide input to the Review of K-10 Australian Curriculum documents.

ATSE believes that the current Review is of particular importance, sees the development of the Australian Curriculum as tremendously important for Australia's future and appreciates the opportunity given by ACARA to provide feedback on the draft documents.

### Summary of ATSE's comments

#### ATSE recommends that:

- 1. the timetable for development and planning of the Australian Curriculum embraces a well-considered process that leads to a robust and workable final product that includes systematic future monitoring.
- 2. examples from the history and practice of technology be included in the teaching and learning of all subjects in the Australian Curriculum
  - the structure of the Australian Curriculum provide specific guidelines for time spent in the various subject areas, with specific attention to maximizing time on science and mathematics
  - the Australian Curriculum makes more explicit the links across the curriculum, with particular attention to communication skills
  - the Australian Curriculum addresses specifically the learning of STEM in early childhood education
  - the Australian Curriculum is structured to provide for equity in learning outcomes with particular attention to gender and ethnicity.
- 3. the draft Science curriculum statement be amended to:
  - strengthen the introductory statements to emphasise enjoyment, excitement and passion of STEM education, the critical role of STEM in Australian culture and identity and the critical contribution of STEM to the Australian and global economies and the welfare of our citizens.
  - specify increased breadth, depth and sequential structure
  - provide a more rigorous curriculum, in comparison to current K-10 curricula
  - portray science and mathematics as enablers to enhance students' future studies and life choices
  - include curriculum content that demonstrates the value and opportunities created by careers in STEM and focus on the many outstanding contributions of Australian scientists, mathematicians, technologists and engineers
  - include innovative approaches to students' STEM-related career education.
- 4. ACARA work with stakeholders to develop detailed implementation and evaluation plans and guidelines for the Australian Curriculum, with realistic budgetary allocations.
- 5. a sense of passion should be infused into the Science syllabus into the K-10 curriculum, c.f. the Mathematics syllabus rationale/aims. ATSE encourages a greater emphasis on the importance of the application of science to the economic and cultural advancement of human-kind and suggests that "Science as Human Endeavour" be renamed "Science and its Application as Human Endeavour".

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<sup>1</sup> ATSE was established in 1975 with the mission to promote the application of scientific and engineering knowledge to the future benefit of Australia. ATSE is one of four learned national Academies, which have complementary roles and work together both nationally and internationally. ATSE has about 800 elected Fellows who are the leaders of applied science and engineering across the country. ATSE is comprised of experts from a diversity of professions many of whom have been consulted on this submission.

## **1. Introduction: ATSE's Perspective on Science, Technology, Engineering and Mathematics (STEM) Education.**

ATSE's strong commitment to education in science, technology, engineering and mathematics (STEM) education arises from its mission "to foster excellence in technological sciences and engineering to enhance Australia's competitiveness, economic and social well-being and environmental sustainability".

ATSE's education-related activities are cross-sectoral, ranging from early childhood to postgraduate education. The fundamental premise of these activities rests with the criticality of fostering high participation rates and excellent outcomes in STEM education and of nurturing a community mindset that values both formal and informal STEM education. ATSE is acutely conscious of the significant challenges confronting STEM education and the limited progress in addressing these challenges especially in the K-10 curriculum. ATSE is committed to positioning Australia as a world leader in STEM education, building on the valuable work undertaken currently by STEM educators and initiating new work consistent with contemporary curricula and learning technologies.

There is consensus in the Academy about two overarching priorities for STEM education. One is a focus on developing and retaining scientists and engineers in sufficient numbers to alleviate skills shortages in specific key areas of national significance, to meet economic, environmental and social challenges, and to lead relevant international collaboration. The other is public engagement and universal scientific/mathematical/technological literacy. It is considered imperative for the wider community to be sufficiently informed to effectively participate in debate about safety, reliability and sustainability in its future applications of science and technology.

ATSE's perspective is that "education" is a key element of infrastructure for the future, endowing the human capital necessary for building the nation's capacity in science and engineering and supports the exposure of all students to some level of STEM education as an essential requirement for Australia's ability to function in an increasingly technological world. As the ATSE President, Professor Robin Batterham said in 2001 during his role as Chief Scientist of Australia, "science... creates the ideas that can transform our lives, grow our exports and enable new markets. It is pivotal in contributing to sustainability, environmental concern and social well-being".

In its own operations, ATSE addresses education-related priorities specifically through its Education Forum and through strong support (both from the Academy as a whole and from Fellows individually) for many activities across Australia, in all sectors of education. At the school level, the ATSE *STELR*<sup>2</sup> curriculum project (referred to in more detail later in this submission) is already demonstrating its value to students' STEM education and career development. ATSE also sponsors and conducts career-oriented initiatives, such as the *Extreme Science Experience* (associated with the Annual Clunies Ross Awards) and initiatives targeting teacher education, such as the development of materials to address the gaps in STEM-related knowledge and skills of students in early childhood pre-service teacher education (building on recommendations made in ATSE's 2002 report on *Science and Technology in the Primary School: A matter of concern*).

## **2. ATSE's comments on the Draft K-10 Australian Curriculum documents**

ATSE is pleased to respond to ACARA's invitation to comment on the Draft K-10 Australian Curriculum documents. ATSE sees the development of the Australian

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<sup>2</sup> *Science and Technology Education Leveraging Relevance:* <http://stelr.org.au/>

Curriculum as tremendously important for Australia's future and is appreciative of the opportunity given by ACARA for many groups and individuals in the Australian community to provide feedback on the draft documents. This is a "once-in-a-generation" opportunity and, as a community, it must be grasped. In this regard, ATSE emphasises that excellent curricula require time both for development and for detailed planning of the implementation and evaluation phases. ATSE is concerned that the development process should not be rushed and recommends that adequate time be allowed for the documents to be finalised and plans to be agreed for implementation and evaluation.

### **Recommendation 1**

**ATSE recommends that the timetable for development and planning of the Australian Curriculum embraces a well-considered process that leads to a robust and workable final product that includes systematic future monitoring.**

The following comments are organised in three sections, covering overall structure and philosophical underpinnings of the curriculum (2.1), comments specific to the Science Draft curriculum document (2.2) and implementation issues (2.3)

Given that ATSE's most direct and immediate experience in the K-10 curriculum area is through the ATSE Science and Technology Education Leveraging Relevance (STELR) Curriculum Project, a year 9, 6-week package. This response will be illustrated with numerous references to ATSE *STELR*.

The primary aim of the STELR project is to address the problem of low participation rates in Physics, Chemistry, Biology and Mathematics at the upper secondary school level.

The *STELR* project also aims to:

- Increase the number of students choosing science and engineering careers;
- Address the skill shortage in technological careers and trades;
- Improve the quality of science classroom teaching practice; and
- Empower students to take a meaningful part in debates about scientific issues that will arise in the future, by giving them the tools they need to critically analyse, assess and synthesise information. Ultimately this will improve the level of science literacy in the community.
- Enable students to apply the scientific method and to gather and analyse and evaluate information when they conduct research, so that their conclusions are evidence-based. Ultimately this will increase the scientific capabilities of the community.

### **2.1 Overall structure and philosophical underpinnings of the curriculum**

ATSE supports the concept of a nationally mandated Australian Curriculum. In previous communications with ACARA, ATSE has expressed concern at the elimination of "technology" as a learning area in the national curriculum, and remains hopeful that technology will be re-instated at some future point. Irrespective of whether this occurs, however, it is imperative for examples from technology to be included in learnings across all subject areas. The Academy is especially supportive of a curriculum with maximum **relevance** to students' lives, particularly in terms of the development and use of modern technologies.

The STELR project aims to increase students' learning by using a relevant context for studying concepts. The relevant context is Global Warming and Climate Change. A curriculum package has been built around greenhouse gases, energy concepts and renewable/sustainable energy resources. One of the most effective ways of reducing emissions of the greenhouse gas carbon dioxide is the widespread adoption

of renewable energy technologies. Students see these technologies as being highly relevant to their adult lives. Renewable energy resources such as solar panels and wind turbines are also excellent vehicles for teaching science fundamentals.

By participating in the STELR project students develop their scientific inquiry skills and mathematical skills needed to record, represent data and calculate quantities such as power and efficiency. STELR develops students' inquiry skills through many inquiry-based activities and the training of teachers in the design and implementation of inquiry-based units of work. STELR provides a template for introducing inquiry-based learning into other units of work within the school science curriculum.

If the Australian curriculum restricts the study of renewable energy to years 6, 7 and 8, ATSE feels that a great opportunity is being lost to embed science inquiry skills, science understandings, examples of science as a human endeavor and associated mathematical skills such as the manipulation and interpretation of data in a context that is highly relevant and inspirational to students.

Further, the STELR curriculum package delivered at years 9 or 10 has the capacity to boost the numbers of students taking STEM related subjects at the senior secondary level by showing that these subjects are relevant and lead to rewarding and interesting careers in engineering, applied sciences and technology trades. The effectiveness of the context of renewable energy to achieve this is greatly reduced if the context is only studied at years 6 and 7.

ATSE is strongly supportive of an overall curriculum structure that maximises students' time learning science and mathematics and simultaneously makes clear the links between the different curriculum areas. The latter is of particular importance in relation to students' communication skills, and points to the need for excellence in communication in standard Australian English across all areas of the curriculum.

The STELR Project places emphasis on developing the scientific capabilities of students such as:

- being interested in science,
- engaging in communication of and about science,
- identifying questions, investigating and drawing evidence-based conclusions,
- making informed decisions, and
- being skeptical and questioning claims made by others about scientific matters.

In terms of its overall structure and emphasis, the Australian curriculum must also address a number of shortcomings of past curricula. For example, early childhood education is an area which traditionally has not commanded much attention to STEM. The development of the Australian Curriculum provides the opportunity to remedy this, drawing on some of the recent research on STEM learning by very young children. Similarly, attention to equity issues is also strongly supported by ATSE. The need is paramount for the curriculum to be explicitly inclusive and to address some of the equity shortcomings of the past, particularly in relation to STEM learning outcomes for females and Indigenous students.

## **Recommendation 2:**

**ATSE recommends that**

- **examples from the history and practice of technology be included in the teaching and learning of all subjects in the Australian Curriculum**
- **the structure of the Australian Curriculum provide specific guidelines for time spent in the various subject areas, with specific attention to**

- maximizing time on science and mathematics
- the Australian Curriculum makes more explicit the links across the curriculum, with particular attention to communication skills
- the Australian Curriculum addresses specifically the learning of STEM in early childhood education
- the Australian Curriculum is structured to provide for equity in learning outcomes with particular attention to gender and ethnicity.

## 2.2 Comments specific to the Science Draft curriculum

ATSE supports, in the Draft Science curriculum, integration of the three strands done in STELR, the statements of general capabilities and (as intimated above) the statements of links across learning areas. ATSE is aware of research that demonstrates that student motivation and the overall quality of science/mathematics education (in terms of scope, sequence, breadth and depth) are of critical importance to effective student learning in science and ATSE questions whether these areas are addressed adequately in the current draft<sup>3</sup>.

ATSE also sees curricula in STEM areas as playing a major role in bring about cultural change across the Australian population, to develop a culture that values engineering and science. The Academy regards this as a national strategic priority, linked to initiatives that engender wider appreciation of and national pride in the contribution of scientific and technological achievements to national identity, well-being and progress. Higher visibility for these achievements is essential.

The Australian Curriculum also provides the opportunity to develop new approaches to students' STEM-related career education. Although this is included in the present draft, ATSE considers that it could be strengthened, building on the increased understanding we now have of what motivates students to select and continue studying STEM, on experiences with work-integrated-learning and on the evaluation of initiatives such as *STELR* and the CSIRO *Scientists in Schools* program.

The STELR Project has a careers emphasis, with students researching the career duties, requirements, highlights and study pathways for various occupations, in both engineering and the technical trades. All students at a year level engage in the STELR activities so that all students consider such careers.

These specific concerns within the Academy are captured in the following recommendation

### Recommendation 3

**ATSE recommends that the draft Science curriculum statement be amended to**

- **strengthen the introductory statements to emphasise enjoyment, excitement and passion of STEM education, the critical role of STEM in Australian culture and identity and the critical contribution of STEM to the Australian and global economies and the welfare of our citizens.**
- **specify increased breadth, depth and sequential structure**
- **provide a more rigorous curriculum, in comparison to current K-10 curricula**
- **portray science and mathematics as enablers to enhance students' future studies and life choices**

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<sup>3</sup> The critical role of teachers in ensuring quality STEM education is included under Section 2.3 of this response.

- **include curriculum content that demonstrates the value and opportunities created by careers in STEM and focus on the many outstanding contributions of Australian scientists, mathematicians, technologists and engineers**
- **include innovative approaches to students' STEM-related career education.**

### **2.3 Implementation issues**

The production of an Australian Curriculum document as such will be a significant achievement for ACARA and the Australian community. However, the document will need to be supported by detailed planning of its implementation and evaluation and by support for the development and inservicing of teaching materials. ATSE considers that the challenges of implementation are dominated by four major issues, which to some extent are inter-related:

- Teachers' knowledge and skills in STEM, with implications for both preservice and inservice education of teachers
- Renewal of the workforce, to address the aging of the current workforce and increasing demands placed on STEM educators, in terms of rapidly advancing knowledge
- Wide availability of relevant teaching materials, which can be addressed by supporting the scalability of initiatives such as *STELR* – initiatives which have proven to be valuable but which face major challenges in terms of dissemination and widespread adoption
- Development of support for the use of information and communications technologies in teaching of STEM.

#### **Preservice Teacher Education**

Education research indicates that for the majority of students, their life aspirations regarding STEM are formed before the age of 14. This indicates how important it is that in the upper primary and early secondary school years, high quality mathematics and science teaching engages and captures the imagination of students. The problem seems to be that far too many primary and middle school teachers are on the whole not sufficiently interested or confident in science and its teaching to accord it high priority. The challenge is to ensure that all primary and junior secondary teachers have a trained capacity to present STEM components of the primary and secondary school curriculum, with methods that demystify STEM and present lessons in an engaging, hands-on, inquiry-based manner.

In regard to senior secondary STEM teaching, ATSE notes that for a number of years the issue of secondary teacher shortage has been a concern for school principals across Australia many of whom experienced extraordinary difficulties in obtaining mathematics and science teachers to meet their class needs.

ATSE believes that in order to ensure that primary and middle school teachers are available and equipped to effectively teach STEM subjects, Australian universities should be encouraged to review their Primary and Middle School Education degree programs to ensure that by mandating a minimum number of science and mathematics units to be studied by all students, their graduates will be well informed in regard to STEM subject content and pedagogy.

The universities should also be encouraged to significantly increase the number of candidates entering secondary science and mathematics teacher programs, such as through providing alternative pathways by which science and engineering graduates can enter the teaching profession, through undertaking teacher education alongside

paid work within schools or elsewhere.

### **Inservice Teacher Education**

Continual professional learning is the central means for building capacity and ensuring quality in the existing STEM teaching profession. The rapidly changing nature of science and mathematics, in regard to both content and pedagogy, make it critically important to ensure that all practicing teachers have regular access to coherent professional learning programs. ATSE believes that in order to effectively introduce the Australian K-10 curriculum, new arrangements will be needed to provide high quality, accredited STEM professional development programs. Accredited courses might include the incorporation of real-world STEM into the classroom, inquiry-approaches, and links to STEM careers.

The STELR project provides teachers with a comprehensive set of student activities and a teacher resource that explains the pedagogy behind the activities. It provides teachers with a two day professional learning workshop to improve and develop teachers' skills and understandings. It provides schools with sufficient sets of purpose designed equipment for the schools to run the activities with all students at a year level.

While it may not be the brief of ACARA to address these implementation issues directly, ATSE maintains that responsible, modern curriculum development demands the development of a detailed plan to ensure that these and other implementation and evaluation issues are addressed, with adequate budgetary support.

### **Recommendation 4**

**ATSE recommends that ACARA work with stakeholders to develop detailed implementation and evaluation plans and guidelines for the Australian Curriculum, with realistic budgetary allocations.**

### **Recommendation 5**

**As a general recommendation, ATSE believes that a sense of passion should be infused into the Science syllabus into the K-10 curriculum, c.f. the Mathematics syllabus rationale/aims. ATSE encourages a greater emphasis on the importance of the application of science to the economic and cultural advancement of human-kind and suggests that "Science as Human Endeavour" be renamed "Science and its Application as Human Endeavour".**