Review of STEM education in Queensland state schools 2015–2017

Final report 2018

I Science I Technology I Engineering I Mathematics I

Queensland Government

Contents

Minister's message

The study of science, technology, engineering and mathematics (STEM) is undoubtedly a gateway to the future for Queensland students. That's why the Palaszczuk Government will invest more than $56 million in STEM-specific initiatives in 2018.

My aim for the future of STEM in Queensland schools is to continue to engage our young people by integrating education with real-world experiences and opportunities.

After all, STEM is not just about playing with robots and developing code for games; it's about supporting all students to develop the skills they need to thrive in the modern world of work and throughout their lifelong learning journey.

Now is the time to get excited about STEM. It's time to consolidate and scale-up Queensland's STEM capacity.

The *Review of STEM education in Queensland state schools 2015–2017* is helping us to sharpen our focus on this important area of learning.

The review findings build on existing strategic partnerships to promote a culture of positive learning, build teacher capability and deliver targeted programs in STEM education.

We must continue to develop students' digital literacy skills and interest in STEM by using innovative learning tools like modelling, scenarios and simulations in the classroom.

By actively promoting and encouraging participation in STEM, we are giving students the keys to their future and setting them on a path for success.

Not only that, we are laying the foundations for Queensland's strong and prosperous future.

The Hon. Grace Grace MP

Minister for Education
Minister for Industrial Relations

Director-General's message

A strong foundation in the study and practice of science, technology, engineering and mathematics (STEM) is vital for all our students to prosper in a changing global economy.

An estimated 75 per cent of the fastest growing occupations require STEM-related skills and knowledge and Queensland needs to not only keep pace, but be a leader in STEM best-practice.

That is why in 2015 the Queensland Government identified STEM education as a strategic priority for education and commissioned a three-year review of STEM in state schools.

Along with the review, partnerships with industry, universities and researchers have been established to create a shared vision for STEM in Queensland.

One of our priorities is fast-tracking implementation of the Australian Curriculum: Digital Technologies by the end of 2020. This learning area includes two subjects — Digital Technologies, and Design and Technologies.

We are already seeing great results in STEM education, with an increase in the number of schools reporting on Digital Technologies from approximately 20 per cent in 2016 to around 30 per cent in 2017.

Between 2012 and 2017, the proportion of students studying science and maths subjects in Years 11 and 12 also increased in Queensland.

We have implemented exciting STEM initiatives to spark students' imagination and passion, and extend and broaden opportunities for teachers. These include innovative curriculum resources, expanded learning opportunities at virtual academies, grants, competitions and camps.

Following the review, the department will consolidate and scale-up practices and programs already in place to prepare our students for future opportunities in new industries.

Building teacher capability and improving student engagement and achievement in STEM will help deliver world-class education that prepares young people to make their mark in an increasingly complex world.

My sincere thanks to all of the organisations and individuals who provided input during the consultation and survey as part of the review process.

Your involvement is helping us to meet the challenge of how we teach STEM in schools to equip students with skills they need for a successful future.

Tony Cook

Director-General
Department of Education

Executive summary

A strong foundation in the study and practice of science, technology, engineering and mathematics (STEM) is vital for all students to live and prosper in an ever-changing global economy.

In the past three years the Queensland Government has put into action initiatives to promote STEM in Queensland state schools including programs to enhance teachers' knowledge and understanding, and to stimulate student engagement and achievement.

In 2015 the Queensland Government identified STEM education as a strategic priority for the Department of Education and commissioned a three-year review of STEM in state schools. The review addressed the key areas for action in *Schools of the Future: A strategy for STEM in Queensland state schools:* teacher capability, student participation and achievement.

What we found

The review found that STEM education can be strengthened by:

- teachers (particularly primary teachers and junior secondary teachers teaching out-of-field) having access to a range of sustained and specialised professional development to support them to acquire STEM-specific content knowledge and pedagogical practices
- students having positive experiences in STEM throughout their schooling
- targeted STEM programs for under-represented groups in senior secondary
- effective and sustainable professional development programs embedded within the school context and focused on curriculum goals, conceptual knowledge and active learning strategies
- curriculum-based decision-making strategies to assess available STEM resources in the community.

The next steps

Applying the evidence from research and the survey of schools, the review proposes that:

- teachers continue to have access to a range of professional development opportunities
- students continue to have multiple and varied opportunities to engage in STEM learning
- the Australian Curriculum: Digital Technologies and the development of learning and teaching resources continue to be implemented.

The next step will be the delivery and promotion of a comprehensive suite of STEM tools that support schools and teachers to make informed decisions about establishing, maintaining and evaluating partnerships with external STEM organisations. These tools complement and align to the Department of Education's *School Improvement Model*.

Each STEM partnership or cluster is unique. It is shaped by the context of its schools, teacher professional learning strategies and participating partners.

This builds on the strategic partnerships established by the department to develop a shared vision and strategic directions for the development of STEM in Queensland.

The *Review of STEM education in Queensland state schools* has established an explicit improvement agenda that is evidence-based, promotes a culture of learning and is firmly grounded in the school context.

1. Strengthening STEM education in Queensland

Advancing education: An action plan for education in Queensland set the agenda for the next phase for building a world-class education system.

It builds on the reforms that are already providing more opportunities for students to develop the knowledge, skills and qualities they need for the future — early years education, Year 7 transition to secondary school and the Queensland Certificate of Education.

The Australian Curriculum sets out the knowledge, understanding and skills needed for life and work in the 21st century and establishes common standards and high expectations of achievement. The curriculum focuses on teaching and assessment practices and improving student achievement.

The STEM review is a vital part of the ongoing transformation of education in Queensland. It addressed the key areas for action in *Schools of the Future: A strategy for STEM in Queensland state schools:* teacher capability, student engagement and achievement. It is aligned to *#codingcounts: A plan for coding and robotics in Queensland state schools*.

The outcome of the review is a comprehensive suite of STEM tools that support schools to make informed decisions about collaborating and evaluating STEM expertise, and establishing a sustainable approach that is achievable in all schools.

The review sets an explicit improvement agenda that is evidence-based, promotes a culture of learning and is firmly grounded in the school context.

Figure 1: Developing STEM-specific knowledge and practice

Building teacher capability to transform STEM learning

- STEM Hub
- Queensland Coding Academy
- STEM Champions
- Specialist STEM teachers
- Step into STEM teaching scholarships
- STEM in Action grants

More students engaged in STEM learning

- Entrepreneurs of Tomorrow program
- Premier's Coding Challenge
- STEM Girl Power Camp
- CSIRO and Indigenous students

Achieving excellence in STEM learning

- Australian Curriculum: Digital Technologies
- STEM Virtual Academies
- STEM-specific curriculum resources

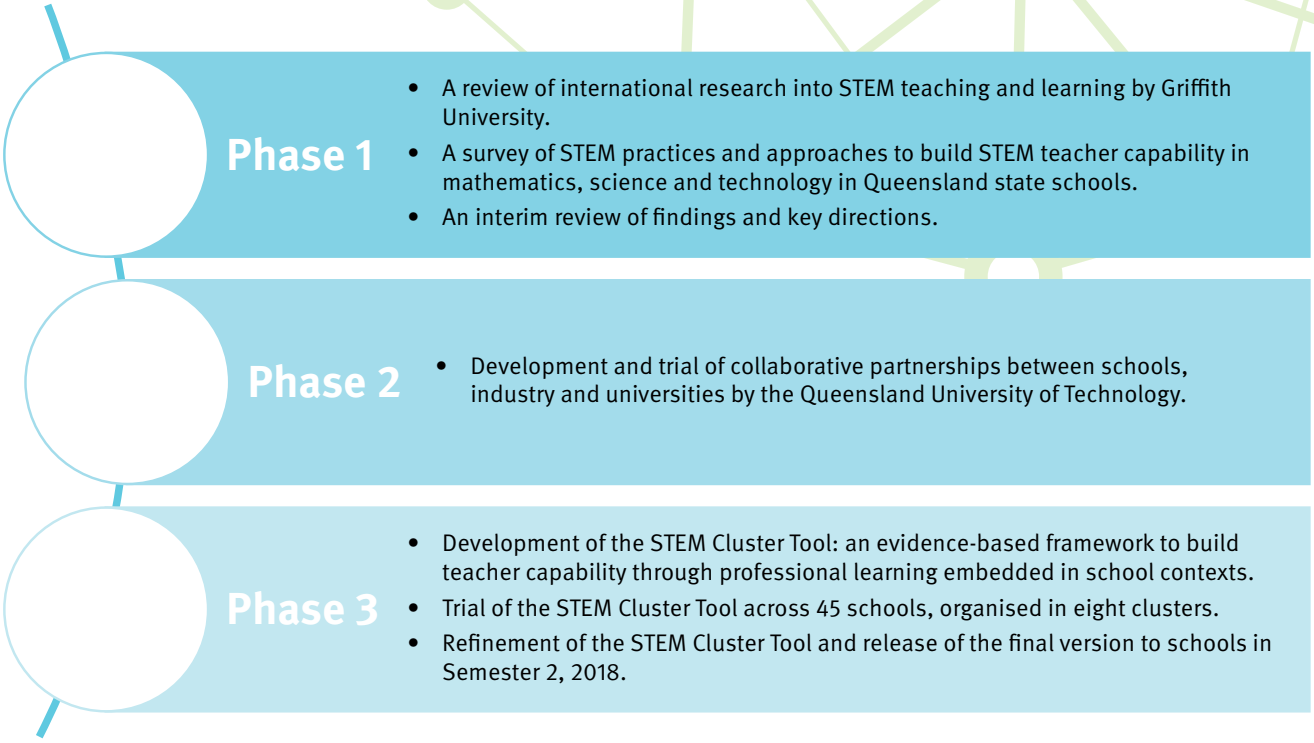
Working Together

- schools will provide world-class STEM learning
- students will be ready for the jobs of the future.

2. The STEM review

This report outlines research findings and activities undertaken by the *Review of STEM education in Queensland's state schools* to determine an evidence-based approach to practices that can be expanded across Queensland.

Figure 2 Review activities



2.1 Research and survey insights

Key messages in the research and survey of Queensland state schools include:

- the knowledge and skills to effectively engage in STEM require development throughout each phase of schooling
- the inter-related nature of science and mathematics require teacher self-efficacy, content knowledge and pedagogical strategies specific to each STEM area and this is particularly relevant for primary teachers
- pedagogical strategies must be relevant to real world contexts, connect students' existing knowledge with new STEM knowledge and include effective use of technologies
- some students are underrepresented in STEM at the senior schooling level, notably female and Aboriginal and Torres Strait Islander students
- effective and sustainable professional development programs are embedded within the school context and focus on conceptual knowledge, active learning strategies and consistency with curriculum goals
- schools most commonly use school-developed professional learning, professional learning communities and clustering with other schools and external STEM partners to build teacher capability in STEM
- schools need strategies for curriculum-based decision making about available STEM resources.

3. Building teacher capability

3.1 What the review found

Teachers (particularly primary teachers and junior secondary teachers teaching out-of-field) require a range of sustained and specialised professional development opportunities to support them to acquire STEM-specific content knowledge and pedagogical practices.

Teacher confidence influences the development and delivery of programs that present concepts, connect students' learning and use context-based or active learning experiences that support students' higher-level thinking and engagement.

STEM is a new and evolving field. In many schools, STEM education tends to focus on science and mathematics. When the four STEM disciplines — science, technology, engineering and mathematics — are offered, schools tend to teach STEM in its disciplines. This approach is appropriate for some STEM learning. However, the inter-related nature of some STEM learning means that a cross-curriculum approach can provide the context to improve learning outcomes.

The inter-related nature of STEM learning means that teachers need to feel confident about the content knowledge and effective pedagogical practices in all areas of science, technology and mathematics curriculum.

The critical role of technologies varies across classrooms. In most primary schools, technologies is taught as a combination of stand-alone and embedded approaches. Coding is now being offered more readily as part of the curriculum. However, in some schools it is still only being offered as an extra-curricular activity.

While the inclusion of engineering components of STEM in schools has been limited, the Australian Curriculum: Technologies requires students to use design thinking to generate and produce solutions in authentic contexts. This provides clear opportunities for links to other STEM learning areas and possible cross-disciplinary approaches. It highlights the importance of teacher content and pedagogical knowledge of Australian Curriculum: Technologies.

3.2 What we are doing

Since 2015 a range of initiatives has commenced that provide opportunities for teachers to enhance their knowledge and understanding of STEM.

Stem Hub for schools, parents and students

The STEM Hub for schools website links school staff to resources and professional development opportunities. It includes online coaching modules to hone teaching skills in mathematics, science and technologies. OneChannel on demand STEM presentations and programs are offered by professional associations and external STEM organisations.

The STEM Hub for parents and students website brings together information about STEM subjects, careers, pathways and events.

Queensland Coding Academy

Coding develops students' abilities to identify needs and create digital solutions. The Queensland Coding Academy makes available virtual classrooms. For teachers there are activities and resources that align to the Australian Curriculum: Digital Technologies and complement Curriculum into the Classroom materials. For students it provides hands-on learning that links to the real world of work and research.

Digital Technologies #qldtechschools initiative

#qldtechschools delivers an ongoing program of support to schools in their implementation of the Australian Curriculum: Technologies by establishing communities of practice aligned to the department's collaborative empowerment model. This initiative includes an induction workshop, web conferences and support by regional STEM Champions to build teacher capability in curriculum knowledge and pedagogical practices in Technologies. It has facilitated collaboration and networking in online and face-to-face contexts and the formation of clusters.

Professional development modules

The department partnered with the Queensland University of Technology (QUT) and Griffith University to develop online modules in seven STEM learning areas for beginning and non-specialist STEM teachers. Since 2016 more than 3000 teachers have completed modules which were offered in primary, junior secondary and senior secondary science, mathematics and technologies.

STEM Champions

Regional STEM Champions work closely with school leaders to support them with whole-school STEM plans including collecting and using evidence to inform decision making, curriculum implementation and professional learning plans and professional learning communities.

STEM champions supporting the regions

The North Coast Region STEM Champion provided ongoing support across the region, enabling schools to prioritise STEM. Schools were supported to complete internal STEM audits and plan for STEM teaching and learning.

The STEM Champion also worked with schools to trial the STEM Cluster Tool. This trial culminated in the development of a cross-curricular STEM unit. Schools report that working with the STEM Champion has enabled greater connections with curriculum priorities, inclusive practices and a focus on the needs of 21st century learners.

Work was also undertaken with principals in the region to build understanding of the Australian Curriculum: Digital Technologies and planning to authentically embed coding and robotics into the curriculum.

The Metropolitan Region STEM Champion's role has included working with groups of teachers across schools to build teaching capabilities in STEM learning areas. This cluster work provides teachers with an opportunity to collaborate, share ideas, create unit plans and engage in professional conversations. Working alongside teachers in these clusters allows the STEM Champion to guide curriculum alignment and ensure quality assessment pieces and unit plans are created, shared, taught and then reflected upon.

Advancing STEM in Queensland state primary schools

All Queensland state primary schools are financially assisted to access STEM expertise that supports their school's improvement plan and make STEM learning more active and engaging. Schools can acquire resources to forge new partnerships or access expertise from local secondary schools, universities and industry.

STEM Quality Assurance Tool

The STEM Quality Assurance Tool assists school leaders to make reasoned decisions about the quality of STEM resources and programs developed by external providers based on the curriculum and departmental priorities.

Step into STEM teaching scholarships

Scholarships to become teachers in Queensland secondary state schools are offered by the Queensland Government to high-achieving, final year teacher education students specialising in one or more of the following: Mathematics B and C, Chemistry, Physics, Industrial Technology and Design (including Manual Arts) and Engineering (including robotics and coding).

STEM Teacher Symposiums

An annual two-day symposium is held in the September school holidays to build a culture of evidence-based practice and showcase the delivery of innovative and high quality STEM teaching and learning in state schools. Local, national and international presenters contribute to the program. Over 200 teachers attended the 2016 and 2017 events and professional resources are available to all state school teachers through an edStudio.

STEM in Action grants

Seven grants of $15,000 were awarded to schools to implement research-informed innovations in STEM education. The grants helped schools develop models of effective practice that were shared across Queensland.

STEM in Action grant promoting innovation in schools

The Aspiring STEM Specialists Network is an example of how the STEM in Action grant has created opportunities for STEM teachers across the state. The grant provided seed funding to support the IMPACT Centre, run by the Brisbane School of Distance Education to develop the network. Funding released staff from the classroom so they could participate in strategic professional learning activities. Aspiring STEM specialists is a professional network designed to inspire, connect and transform the capability of STEM teachers.

3.3 The next steps

Continue existing professional development and capability building opportunities for teachers. Build further professional development opportunities through the development of sustainable, school-based professional learning communities.

4. Increasing student participation

4.1 What the review found

Teachers, especially primary teachers, require support and professional development to deliver active, inquiry-based learning in STEM to sustain student engagement with STEM throughout schooling.
Positive experiences in STEM should begin from the early years.

In senior secondary, stimulating programs that target students who are underrepresented in STEM are needed. Increasing student participation in STEM will need to focus on two approaches.

The first approach is to maintain student engagement in STEM throughout the years of schooling. Associated with this is a focus on the critical times when students make decisions about themselves as learners and what is important for them to know. Typically this is during the transition from primary to junior secondary school, when students make decisions about enrolment in senior STEM subjects, and when young people decide what they will study post-school.

The second approach is to increase participation in STEM of underrepresented groups — girls, Aboriginal and Torres Strait Islander students and students from low socio-economic backgrounds.

4.2 What we are doing

The State Schools Strategy, *Every student succeeding*, underpins regional and school planning to ensure every student receives the support needed to belong to the school community, engage purposefully in learning and experience academic success. This includes ensuring all groups of students typically under-represented in STEM learning and pathways have equitable access to STEM resources, activities and inspiring role models.

A variety of programs are already in place to stimulate student engagement and participation.

Entrepreneurs of Tomorrow school grants

Entrepreneurial skills are essential to drive innovation, productivity and global awareness. This program provided three-year grants to support schools and school clusters to provide opportunities for students to pitch their ideas, work with industry to shape these ideas and develop business plans to solve real-world challenges using innovative digital solutions.

Premier's Coding Challenge

Coding and robotics are important for every student to prepare them for the jobs of the future. In collaboration with industry, this annual competition challenges students to solve a coding and robotics task on a specified theme. Students formulate a digital solution that exercises their skills in critical thinking, creativity, collaboration and innovation.

Robotics for the future

This lending library provides Queensland state schools with access to cutting-edge robotics to build students' interest in coding and apply it to real world scenarios.

Peter Doherty Awards for Excellence in STEM Education

The annual Peter Doherty Awards celebrate the achievements of state and non-state school students, teachers and support officers and organisations that have demonstrated an outstanding and innovative contribution to STEM education in Queensland.

STEM Girl Power Initiative

The four-day camp is held each year. Year 10 girls from across Queensland are nominated to participate in a range of STEM experiences, visit laboratories at universities and research institutions and attend the World Science Festival Brisbane. They are encouraged to become STEM ambassadors in their school and community and inspire others to participate in STEM. Since 2016, 138 Year 10 girls from across Queensland have participated in the STEM Girl Power Camp.

STEM Girl Power Initiative inspiring students

"Thank you for organising such a stimulating and amazing experience for my daughter! She cannot stop talking about the people she met, things she learnt and experienced and how wonderful the whole camp was. From the itinerary, you sure crammed in an unbelievable exposure to STEM for these girls and I am so happy and proud, for my daughter, that she had such an amazing opportunity."

Parent, STEM Girl Power Camp participant

STEM Champions

Regional STEM Champions play an important role in promoting opportunities for students to participate in both departmental and externally developed STEM competitions, camps, workshops, expos, online resources and international tours.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) Indigenous STEM education project

The project is an initiative of CSIRO and the BHP Billiton Foundation. It aims to increase participation and achievement of Aboriginal and Torres Strait Islander students in STEM and build teacher capability. Of the six programs in the project, the following three target Queensland students in primary and secondary school:

- **Inquiry for Indigenous Science Students (I2S2)** focuses on Years 5 to 9 and is based on content descriptions in the Australian Curriculum which can be related to a traditional context and developed into a hands-on, inquiry-based scientific project.
- **PRIME Futures** focuses on Prep to Year 9 and aims to improve student outcomes in mathematics. It uses a train-the-trainer model to increase teachers' capacity to engage with Indigenous students and deliver mathematics education in an Indigenous context. It encourages schools to involve parents and community in mathematics learning.
- **Aboriginal Summer School for Excellence in Technology and Science (ASSETS)** is a nine-day residential program for high-achieving Indigenous Year 10 students with an ongoing leadership and support program to nurture students through Years 11 and 12.

Students Performing Advanced Research Queensland (SPARQ-ed)

SPARQ-ed is a unique educational facility established as a collaboration between The University of Queensland's Diamantina Institute and the Department of Education. SPARQ-ed aims to promote excellence and innovation in biological and biomedical education by delivering world-class specialist programs to Queensland school students and their teachers. These programs are based on a model that brings together personnel and expertise from the education and scientific research communities.

4.3 The next steps

Build on the 4.4 percent increase in the proportion of Queensland students studying science and mathematics in Years 11 and 12 between 2012 and 2017.
Continue to promote multiple and varied opportunities for students to engage in STEM learning and experiences through both departmental initiatives and those of STEM education partners.
Increase student participation in STEM through the development of school-based clusters that link students to the STEM knowledge and skills in their community, STEM professionals and STEM pathways.

5. Lifting student achievement

5.1 What the review found

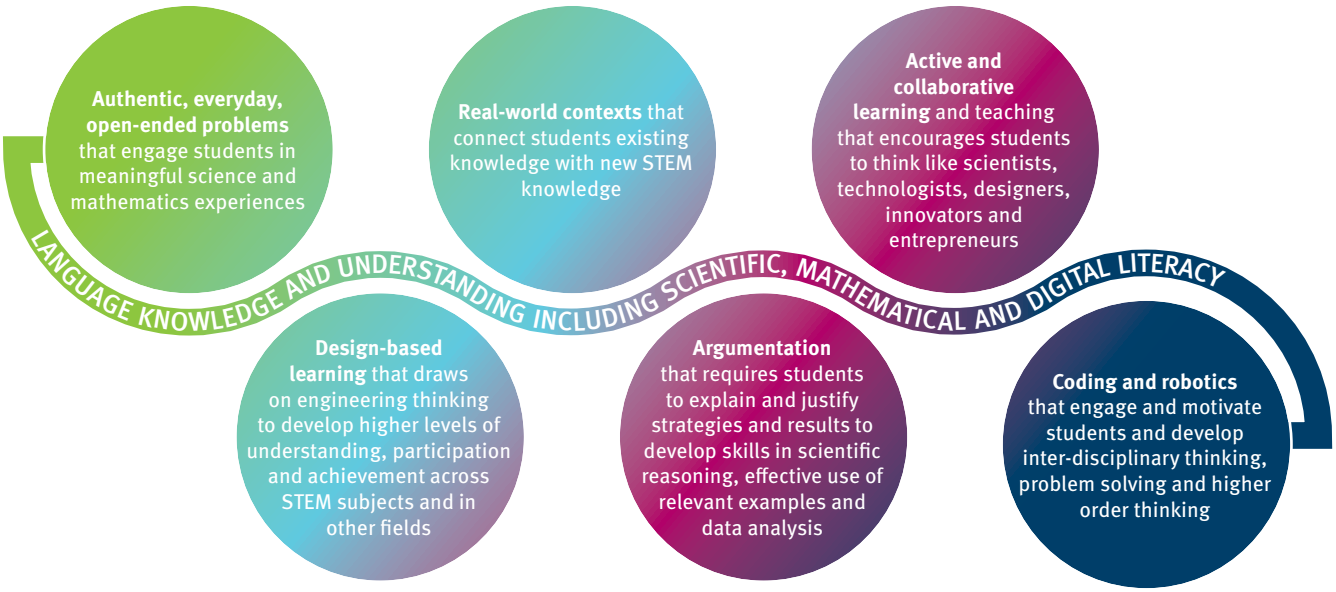
Student achievement is improved when:

- **STEM knowledge and skills are developed throughout the years of schooling**
- **teachers are confident in their content knowledge and use of effective pedagogical practices in all areas of STEM**
- **learning and teaching strategies are active, inquiry-based and student-centred so students recognise that STEM subjects are relevant to them and to society**
- **modelling, scenarios and simulations using technologies and design-based learning are used to facilitate real world examples**
- **language and literacy skills are strengthened to ensure deep understanding of STEM subject content and concepts, and hone skills in analysis and interpretation of evidence, scientific argumentation and effective communication.**

International research and reforms advocate pedagogical practices that promote understanding of the inter-related skills and dispositions that underpin STEM learning and mirror practices of professionals working in STEM fields.

The review found that there is consensus about the educational experiences that increase student achievement in STEM.

Figure 3: Educational experiences that increase student achievement in STEM



5.2 What we are doing

Schools focus on student achievement in STEM through their curriculum and the teaching, learning and assessment practices.

STEM School Reflection Tool and Actionable Playbook

The STEM School Reflection Tool and Actionable Playbook guide preliminary whole-school planning and help schools to reflect on current performance, prioritise areas for improvement and work towards improved student achievement. These two strategic planning tools help to set an explicit improvement agenda that is evidence-based, promotes a culture of learning and is firmly grounded in the school context.

Australian Curriculum

The implementation of the Australian Curriculum Prep to Year 10 by the end of 2020 is essential to the overall strategy to strengthen STEM participation and achievement.

STEM-specific curriculum resources and professional development packages

Professional development packages build teacher knowledge of the Australian Curriculum: Science, Technologies and Mathematics and Curriculum into the Classroom (C2C) resources. C2C provides three levels of planning support for teaching in science, technologies and mathematics: content, assessment and classroom resources. The resources develop the General Capabilities: literacy, numeracy, critical and creative thinking and problem solving.

Digital Technologies #qldtechschools initiative

The Australian Curriculum: Digital Technologies provides practical opportunities for students to be innovative developers of digital solutions using design thinking. It develops their digital literacy as effective users of digital systems and critical consumers of information conveyed by digital systems. Activities delivered through #qldtechschools support teachers to incorporate authentic learning opportunities relevant to their students and school context, and that allow students to demonstrate all aspects of the curriculum.

Queensland virtual STEM academies

A network of virtual STEM academies delivers extension programs aligned to the Australian Curriculum for highly capable students in Years 5 to 9 to inspire passion and aspiration. Using innovative and enabling technologies, the academies build STEM teaching capability through partnerships with universities, business and industry, sharing best practice and innovation.

An example of this is the Global tropics future (GTF) project resulting from a partnership between Thuringowa State High School and James Cook University. This project enriches learning and enhances opportunities for regional and remote students of North Queensland by maximising the potential of gifted students and strengthening outcomes for Indigenous students as they engage with important regional issues and local organisations.

STEM Champions

Regional STEM Champions support teachers to make STEM learning active, engaging and contextualised throughout the phases of learning by developing teacher capability in inquiry pedagogies, critical and creative thinking and opportunities to embed coding and robotics into STEM learning areas.

5.3 The next steps

Build on the 3.1 percent increase in the number of state school students in Years 2 to 9 awarded a C level of achievement or higher in mathematics and science between 2015 and 2017.

Promote the use of the STEM School Reflection Tool as an integral part of the development of a school's STEM plan.

Continue to fast track the implementation of the Australian Curriculum: Digital Technologies and the development of learning and teaching resources.

Support schools to establish professional learning communities that use real world experiences, student-centred learning and provide teachers with the opportunities to build their content knowledge and pedagogical capability in new fields.

6. Establishing partnerships with industry, universities and community

6.1 What the review found

Future STEM partnerships should:

- use inquiry-based learning in real world learning contexts and illustrate how STEM disciplines are inter-related
- consider all local 'STEM capital' for opportunities to interact with a broad range of STEM professionals in industry, local schools and universities
- focus on literacy and digital literacy in scientific and technological practice
- encourage problem-solving, higher-order thinking and creativity
- incorporate a range of technologies
- make professional development of teachers a focus of the partnerships through:
  - building content knowledge in new fields
  - developing pedagogical capability and putting into practice student-centred learning
  - providing opportunities for ongoing mentoring with STEM professionals.

The concept of professional learning communities is not new. Many schools have established partnerships usually in science or mathematics with growing emphasis on technologies and engineering. Queensland universities tend to be the external partners.

Generally, the main purpose for the partnerships is the opportunity to contextualise learning and enhance students' engagement through real world examples of the role of STEM in society.

However, research consistently shows that the role of the teacher in STEM learning, engagement and achievement is pivotal and that pedagogy is the most significant influence on maintaining student interest.

The challenge is for ongoing and relevant development of teacher capability so that teachers in all phases of schooling feel confident about their STEM knowledge and use of effective STEM pedagogical practices.

6.2 What we are doing

The department promotes partnerships to support the development of STEM in Queensland. Schools and STEM industries have demonstrated their readiness to collaborate and foster opportunities for engagement.

STEM Industry Partnerships Forum

The forum facilitates a strategic consultation process between the Department of Education and industry and employer representatives, universities and research organisations. The forum aims to:

- develop a shared understanding and vision for STEM education in Queensland
- share best practice and research in STEM education and school-industry engagement across the state
- communicate key messages for educators and parents about school-industry engagement
- ensure Queensland state school students have skills aligned to employer needs and can participate fully in STEM pathways.

As a result of ongoing collaboration with STEM industry, research and employer stakeholders, the following key messages have been identified:

- STEM skills are highly valuable when they are transferable from school
- STEM learning can be enhanced with industry applications and contexts
- teamwork, communication and problem solving are highly valued skills
- teacher capability is enhanced through effective partnerships with industry
- STEM industries have developed high quality career resources to be shared.

STEM Cross-Sector Reference Group

The reference group aims to share information about STEM education resources, activities and events in Queensland. Its members include the non-state schooling sectors, universities, teacher professional

associations, the Queensland Curriculum and Assessment Authority (QCAA), Queensland Museum, the Queensland Chief Scientist and the Department of Science, Information Technology and Innovation.

Promoting partnerships

The department promotes a number of partnerships offered by universities and research organisations:

- **Queensland University of Technology STEM high school engagement program** offers curriculum-linked workshops. Students and teachers learn skills for the future as they program robots.
- **James Cook University** gives students in Far North and North Queensland access to a broad range of STEM educational experiences and workforce participation options.
- **Queensland Museum's** World Science Festival Brisbane includes a range of curriculum-linked educational programs which underpin the Museum's commitment to support and foster STEM literacy, and to inspire and enrich lifelong learning.
- **CSIRO and the BHP Billiton Foundation Indigenous STEM Education Project** aims to increase participation and achievement of Aboriginal and Torres Strait Islander students in STEM and build teacher capability.
- **Queensland Minerals and Energy Academy (QMEA)** Gateway to Industry Schools program is a partnership between the Queensland Government and the Queensland Resources Council. It offers a range of STEM-related programs to broaden knowledge of the sector for teachers and students in Years 7 to 12 and provides pathways into the resource sector and related careers.
- **Wonder of Science** program is promoting a STEM culture in Queensland schools — where students understand the importance of STEM and believe that STEM education and careers are accessible. The program uses strategic partnerships that link schools, universities, industry groups, non-profit organisations and government agencies.

Wonder of Science engaging teachers and students

Building teacher capability and impacting student achievement were key priorities in the partnership between the North Coast Region and Wonder of Science. The STEM Champion supported clusters of schools to engage with the science curriculum in a way that showcased inquiry pedagogy. At its conclusion data showed that deepening understanding of the science curriculum and engaging with Young Science Ambassadors from leading universities supported improved teacher pedagogy and student engagement.

STEM Clusters

The review commissioned QUT to analyse Australian and overseas models of school partnerships or school clusters and STEM-related businesses and community organisations that lead to improving teacher capability and student learning outcomes.

The research found that local communities are rich in STEM capital or STEM-related resources and expertise. This ranged from farms, mines and transport companies to medical institutes, universities and government organisations.

It also found that while schools often have a number of short term or ad hoc partnerships, they tend to lack a framework for coordinating, sustaining and evaluating these partnerships.

STEM Hub pilots

As proof of concept, QUT established two pilot STEM Hubs in 2016 — in Townsville as an example of a regional setting and at Moreton Bay as an example of a metropolitan setting.

The hub aims to "encourage[s] schools to identify the STEM capital (i.e. the knowledge, experiences, resources and relationships) within the community and employ it to the benefit of students, teachers and other partners" (QUT 2016, p.3).

Based on the experiences of the pilot hubs, QUT delivered a draft framework with principles to guide the development of clusters of schools with partnerships between industry and educational institutions.

Schools accessing STEM expertise in the community

Left: *Students from William Ross State High School measuring tyre skid marks as part of the Physics of the Forensic Crash Unit with Senior Sergeant Rob Nalder from Queensland Police Service.*

Below: *Jacquie Quigg and Justin Cleland from the Queensland Ambulance Service talking to Moreton Bay STEM Hub teachers about the range of science, mathematics and technology concepts involved in paramedic response.*

STEM partnership benefits

External STEM partnerships that include school staff, students, industry and parents working together can help to build a culture that promotes STEM Learning.

Students engaged and achieving

Students engage in authentic inquiry-based learning with STEM researchers, practitioners and industries.

Students gain positive experiences from access to real world experimental investigations that are examples of the role of STEM in society.

Students interact with STEM professionals and use technologies that develop their digital literacy.

Students link school learning to STEM careers.

Schools empowered and active

Schools build teacher capability through professional learning that is embedded within the school context and consistent with curriculum goals.

Schools make evidence-based decisions and establish collaborative partnerships with other schools and external STEM experts such as industry and universities.

Schools establish sustained partnerships based on their local STEM capital or the knowledge, experience, resources and relationships within their community and use it to the benefit of students, teachers and other partners.

Schools strengthen internal links across STEM disciplines.

Schools have access to STEM professionals and equipment to demonstrate scientific practice.

Schools develop, implement and strengthen their STEM Cluster plan building on existing school practices.

Teachers upskilled and confident

Teachers increase their self-efficacy and content knowledge by developing or refreshing their understanding of industry and research applications of curriculum concepts.

Teachers engage in professional development to strengthen curriculum and pedagogical knowledge specific to each STEM area, such as inquiry-based learning and scientific and digital literacies.

Teachers have access to mentors in industry and STEM research organisations.

Parents assured and participating

Parents are assured that STEM learning connects to the real world.

Parents are confident that their children are well-prepared for the emerging jobs of the future.

Parents develop a shared vision for STEM education.

Community and industry involved and sharing

Non-school partners develop a shared vision for STEM education.

Non-school partners develop closer links to schools and teachers as they engage local students in authentic experiences.

STEM researchers, practitioners and industries nurture future STEM professionals.

Establishing clusters of Queensland state schools

The STEM Cluster Tool expanded on the QUT research. Forty-five schools in eight clusters used the draft tool to establish professional learning communities to build teacher capability in STEM by sharing expertise and developing external partnerships.

The approach demonstrated the features of effective professional development programs identified in the literature review of international best practice in STEM education and confirmed in the survey of school principals, that professional development should be:

- school-developed, embedded within the school context and conducted over a sustained time period
- consistent with curriculum goals
- focused on conceptual knowledge and active learning strategies.

The feedback from the trial schools was extremely positive and there was agreement that the tool supported their decision making.

What is the STEM cluster tool?

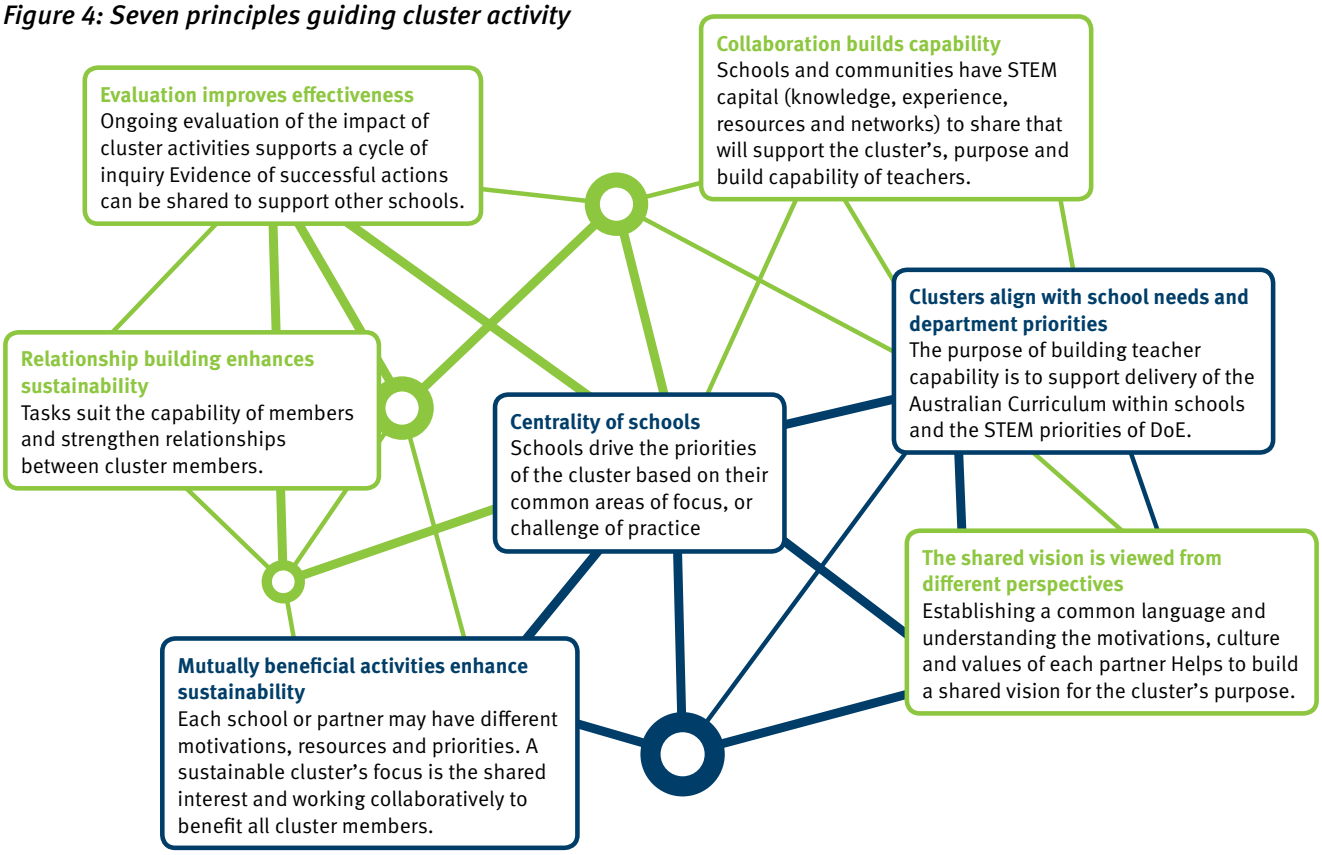
The STEM Cluster Tool is a framework to build teacher capability through professional learning that is embedded within the school context. It supports schools and teachers to make informed decisions about setting up, maintaining and evaluating partnerships with external STEM organisations that address a common problem of practice and lead to improved student outcomes.

The composition of each STEM cluster is unique because it is shaped by and embedded within the context of its schools, the teacher capabilities and professional learning strategies that will be its focus and the sorts of partners that are available.

The framework builds upon the STEM School Reflection Tool and is based on seven principles and four stages of activity.

The seven guiding principles (derived from QUT, 2016) set out clear parameters within which the cluster will operate based on the centrality of schools.

Figure 4: Seven principles guiding cluster activity



Preliminary whole school planning guided by the STEM School Reflection Tool and the STEM Actionable Playbook will help schools identify focus areas for improvement as clusters. The STEM Cluster Tool identifies four stages of activity: getting started, making decisions, working together and improving collaboration. At each stage, guiding questions provide conversation starters within, and between schools, as they form STEM clusters, suggested approaches outline the steps, actions or activities that may be undertaken, and example resources suggest a range of supporting resources from which schools can select those appropriate to their specific context.

Figure 5: Activities for cluster development

How to use the STEM Cluster Tool

1. Getting started	2. Making decisions	3. Working together	4. Improving collaboration
Identify the focus of building teacher capability through sharing expertise with other schools. Determine an appropriate evidence-based approach .	Collaborate with other schools and relevant external partners to develop a co-ordinated STEM Cluster plan that aims to build teacher capability.	Organise and implement the program of planned activities with cluster partners and collect evidence of impact.	Evaluate implementation and impact of activities to determine future approaches. Consider collaboration processes and potential partnerships to strengthen the cluster plan.

STEM Cluster Tool promoting effective collaboration

"The cluster began with four special schools and expanded to five when it gained momentum. It's been quite an amazing journey to see the growth in our team because our problem of practice is actually about implementing the curriculum and differentiating that curriculum for students with disability. We started engaging in STEM from our perspective — what would it look like for students in our school? We have never worked in collaboration and in conjunction with special schools so closely on a key learning area as we have done with this project.

I think being the cluster school team coordinator and using the process documents, the inquiry cycle and STEM Cluster Tool, have enabled me to keep us on track and have a consistent approach and process to engage our team in some pretty amazing things that are going to happen in the future for children with disabilities. I don't think we would be here without the knowledge that we now have and the goals that we are setting for ourselves and our teams without the driver of the STEM Cluster Tool project."

Natalie Bufi, Head of Curriculum, Claremont Special School

Alignment with other Department of Education resources

The STEM Cluster Tool aligns to the Department of Education *School Improvement Model*. It uses language common to cycles of inquiry and the Standards of Evidence to guide schools in: maintaining their focus, making evidence-based decisions and evaluating outcomes.

Building and sustaining effective STEM clusters is underpinned by the collaborative empowerment model, *Every student succeeding: State schools strategy 2018-2022*.

STEM Champions

Regional STEM Champions facilitate collaboration between clusters of schools and universities, businesses and industry to enhance STEM teaching and learning programs. STEM Champions also promote participation in STEM learning and events in schools and across their communities.

The ability to broker partnerships is key to raising the profile of STEM in the Far North Queensland Region where the STEM Champion connects schools with external agencies and stakeholders. This includes promoting departmental initiatives such as #qldtechschools which lead to sharing of practice and increasing the quality and confidence of teachers delivering Australian Curriculum: Technologies. Connecting schools with professional associations has nearly doubled participation in local robotics competitions. The establishment of the Inspiring Australia Cairns STEM Hub was a direct result of the STEM Champion bringing together key stakeholders with far-reaching benefits for schools and the whole community.

6.3 The next steps

Continue existing professional development opportunities for teachers to build their STEM knowledge and pedagogy.

Continue to promote multiple and varied opportunities for students to engage in STEM learning.

Continue to fast track the implementation of the Australian Curriculum: Digital Technologies and the development of learning and teaching resources.

Encourage schools to use the STEM School Reflection Tool and the STEM Cluster Tool to form school-based partnerships linking teachers and students to the STEM knowledge and skills in their community, STEM professionals and STEM pathways.

Showcase and scale-up models of best practice in partnerships to internal and external stakeholders.

7. Conclusion

Since 2015 the Queensland Government has put into action initiatives to promote STEM in Queensland state schools. Research consistently shows that student engagement and achievement in STEM is strongly connected to the teacher's knowledge and pedagogical practices across all the STEM disciplines. There is consensus that authentic, active, inquiry-based learning increases student engagement and achievement in STEM.

Strategic forums and groups have been established to set a shared vision and direction. A variety of opportunities have been developed for schools, students and their parents/carers, including online learning resources, pathways information, competitions to enthuse and excite outstanding students and activities to engage underrepresented groups such as girls and Aboriginal and Torres Strait Islander peoples.

Teachers have had opportunities to enhance their knowledge and pedagogical practices through scholarships and professional development. The review of STEM in Queensland state schools builds on this momentum.

The review proposes a collaborative, school-based model informed by the STEM Cluster Tool for coordinated and sustainable approaches to building teacher capability, strengthening school-industry engagement and ultimately improving student outcomes in STEM.

Improving student engagement and achievement in STEM at school and throughout their lives requires a range of strategies across all years of schooling and in all disciplines of STEM.

The department's suite of STEM materials provides strategic and practical school-based approaches to support the teaching and learning of STEM as an integral part of school improvement in STEM. Importantly, it places building teacher capability in STEM at the core of improving student participation and lifting student achievement in science, technology and mathematics.

Find out more

Public resources

- *Advancing education: An action plan for education in Queensland*
  advancingeducation.qld.gov.au/Pages/default.aspx
- Schools of the future: A strategy for STEM in Queensland state schools
  advancingeducation.qld.gov.au/our-plan/Pages/Schools-of-the-future.aspx
- #codingcounts supporting plan
  advancingeducation.qld.gov.au/codingcounts/Pages/default.aspx
- Department of Education Public, STEM
  education.qld.gov.au/curriculum/school-curriculum/stem
- STEM Hub for parents and students
  learningplace.eq.edu.au/cx/resources/file/5da759ed-285d-4132-b8e8-58198109fb03/1/index.html

Department of Education internal resources

- STEM OnePortal
  intranet.qed.qld.gov.au/EducationDelivery/Stateschooling/Teachingquality/Pages/STEM.aspx
- STEM Hub for Schools
  learningplace.eq.edu.au/cx/resources/file/0fc6062c-a582-4c7b-9313-dc453c8d8901/1/index.html

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